# 2017 BIOTA MONITORING REPORT

## Penobscot River Phase III Engineering Study

## Penobscot River Estuary, Maine

Prepared for:

**United States District Court**

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## EXECUTIVE SUMMARY

In January 2016, the United States District Court for the District of Maine (the Court) selected Amec Foster Wheeler Environment & Infrastructure, Inc. (Amec Foster Wheeler) to conduct the Penobscot River Phase III Engineering Study, to identify and evaluate potential and cost-effective measures to remediate mercury in the Penobscot River Estuary (the Estuary). The project area is shown on **Figure 1-1**. The geographic area to be addressed within the Phase III Engineering Study is described by the Court as follows: “The evaluation will focus in particular on the region from the site of the former Veazie Dam south to Upper Penobscot Bay, including Mendall Marsh and the Orland River."

The Penobscot River in northern Maine is the second-largest river in New England, with an estuary of 90 square kilometers. A chlor-alkali plant located in Orrington, Maine, released mercury into the Penobscot River starting in 1967. The amount of mercury released annually decreased between 1970 and 1982, and decreased further when the plant was closed in 2000. However, elevated levels of methyl mercury measured in sediments and biota led to legal action by the Maine People’s Alliance in 2000. This group joined with the Natural Resources Defense Council to bring a lawsuit, pursuant to the imminent and substantial endangerment provision of the Resource Conservation and Recovery Act. As part of the engineering study to identify and evaluate potential effective and cost-effective measures to remediate mercury present in the Penobscot River, biota were monitored in 2016 and 2017 to determine current concentrations and to better understand potential changes, or lack of changes, in biota concentrations since sampling events conducted primarily between 2006 and 2012.

This report describes the results of biota monitoring for total mercury (mercury) and methyl mercury in the Penobscot River Estuary in 2017. Biota data are used for: 1) documenting patterns of mercury concentrations in biota; 2) documenting temporal patterns of mercury concentrations in biota to evaluate the potential for recovery of biota; 3) understanding the relationship of sediment to biota at the various trophic levels; and 4) assessing the potential for risk to ecological and human receptors based on mercury concentrations in sediment and biota within the Penobscot River Estuary. This report focuses solely on documenting spatial and temporal patterns of mercury in biota. The risk assessment uses biota data to understand the sediment-to-biota relationship and assess the potential for risk to potential receptors.

Twelve species/groups were selected to represent various trophic levels of terrestrial and aquatic species. Low trophic level species (typically collected as composite samples) are represented by terrestrial insects, spiders, polychaetes, and blue mussels. Mid- and upper trophic level species are represented by two species of songbirds, one waterfowl species, one shellfish species, and four fish species. Historical data for most of these species were collected between 2006 and 2012, with the exception of the waterfowl species, for which samples were collected as recently as winter 2014. The addition of 2016 and 2017 data provides an update on tissue concentrations. Long-term monitoring for representative species is recommended to increase the robustness of the statistical analyses for particular sampling areas and to better understand the distribution, trends, and bioaccumulation of mercury concentrations. Recommendations for long-term monitoring will be provided in the Alternatives Evaluation Report.

Overall, mercury concentrations in aquatic biota (lobster, blue mussel, rainbow smelt, eel, tomcod, and mummichog) in the Penobscot River either are generally decreasing (0.2 to 6.5 percent annual decline), indicating the potential for some natural attenuation, or are not changing. Blue mussels at two locations and red-winged blackbirds at most locations had increasing mercury concentrations (0.4 to 2.2 percent annual increase). Aquatic low trophic level species (one shellfish species) and terrestrial mid-trophic level species (two songbird species) tended to show limited or no change in concentrations through time. Upper trophic level species (four fish and one shellfish species) showed more reduction through time in mercury concentrations than aquatic low trophic level or terrestrial mid-trophic level species. Biota collected in the areas of Mendall Marsh and South Verona tended to have higher mercury concentrations than in other parts of the Penobscot River Estuary. This tendency depended on the species analyzed. For many species, mercury concentrations decreased with distance downstream.

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## ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| µL | microliter |
| Amec Foster Wheeler | Amec Foster Wheeler Environment & Infrastructure, Inc. |
| BFK | Bucksport/Fort Knox |
| BO | Brewer to Orrington |
| COC | chain of custody |
| Court | United States District Court for the District of Maine |
| DMR | Department of Marine Resources |
| EPA | Environmental Protection Agency |
| ES | Estuary |
| Estuary | Penobscot River Estuary |
| Eurofins | Eurofins Frontier Global Sciences, Inc. |
| Ln | natural log |
| MM | Mendall Marsh |
| MS | matrix spike |
| MSD | matrix spike duplicate |
| ng/g | nanograms per gram |
| NOAA | National Oceanic and Atmospheric Administration |
| OB | Orrington to Bucksport |
| OV | Orono to Veazie |
| PI | Porcupine Island |
| PRMS | Penobscot River Mercury Study |
| PRMSP | Penobscot River Mercury Study panel |
| QAPP | Quality Assurance Project Plan |
| QC | quality control |
| $R^2$ | coefficient of determination |
| SDG | sample delivery group |
| SE | southeast |
| SOP | standard operating procedure |
| SW | southwest |
| W | wetland/marsh platform |

# 1.0 INTRODUCTION

## 1.1 PURPOSE SCOPE, AND OBJECTIVES

In January 2016, the United States District Court for the District of Maine (the Court) selected Amec Foster Wheeler Environment & Infrastructure, Inc. (Amec Foster Wheeler) to conduct the Penobscot River Phase III Engineering Study, to identify and evaluate potential and cost-effective measures to remediate mercury in the Penobscot River Estuary (the Estuary). The project area is shown on **Figure 1-1**. The geographic area to be addressed within the Penobscot River Phase III Engineering Study is described by the Court as follows: *"The evaluation will focus in particular on the region from the site of the former Veazie Dam south to Upper Penobscot Bay, including Mendall Marsh and the Orland River."*

This Biota Monitoring Report describes the results of biota monitoring for mercury in the Estuary in 2017. The purpose of the monitoring is to continue documentation of patterns of mercury concentrations within the Estuary, with the objective of evaluating the potential, or lack thereof, for recovery of the system given current conditions and historical trends. This work is being carried out concurrently with the development of an engineering feasibility evaluation for the remediation of the Estuary.

The Penobscot River in northern Maine is the second-largest river in New England. The Estuary has a surface area of approximately 90 square kilometers (35 square miles) and extends 35 kilometers (22 miles) southward from Bangor to approximately Searsport, Maine, with Penobscot Bay extending farther south (**Figure 1-1**). A chlor-alkali plant located in Orrington, Maine, released mercury into the Penobscot River starting in 1967. The amount of mercury released annually decreased between 1970 and 1982, and decreased further when the plant was closed in 2000.

Elevated concentrations of methyl mercury measured in sediments and biota led to legal action by the Maine People's Alliance in 2000. This group joined with the Natural Resources Defense Council to bring a lawsuit, pursuant to the imminent and substantial endangerment provision of the Resource Conservation and Recovery Act, against HoltraChem Manufacturing Company, LLC and Mallinckrodt, Inc. The Court ruled in the plaintiffs' favor in July 2002, and ordered an independent scientific study, later named the Penobscot River Mercury Study (PRMS), and appointed the Penobscot River Mercury Study Panel (PRMSP) to complete the PRMS. The PRMSP monitored mercury levels in sediment, surface water, and various biota between 2006 and 2012 (PRMSP 2013a). Sediment, surface water, and biota monitoring data were presented in the 2012 monitoring report (PRMSP 2013b) and the 2014 black duck report (PRMSP 2014).

The collection of 2016 and 2017 biota discussed in this report continued the monitoring conducted primarily between 2006 and 2012 by the PRMSP. A Draft Biota Monitoring Plan was prepared by Amec Foster Wheeler and initially issued to the Court on June 7, 2016 (Amec Foster Wheeler 2016a). The Biota Monitoring Plan was revised in October 2016 as a result of comments from the litigants. The Biota Monitoring Plan was updated and submitted in March 2017 for the 2017 field season as a result of additional comments from the litigants and field observations from July 2016 to February 2017 (Amec Foster Wheeler 2017a). The Biota Monitoring Plan detailed the collection of blood and tissue from birds, tissue from fish and shellfish, tissue from terrestrial and aquatic invertebrates, and sediment samples co-located with biota. The 2016 Biota Monitoring Report focused on the biota monitoring activities and the resulting data for the sampling period of July 2016 through February 2017 (Amec Foster Wheeler 2017b). Sediment and surface water monitoring is addressed in separate monitoring reports prepared by Amec Foster Wheeler (Amec Foster Wheeler 2017c and 2018a).

This 2017 Biota Monitoring Report focuses on the biota monitoring activities and the resulting data for the June 2017 through September 2017 sampling period. Additional black duck samples were collected in winter 2018 and will be included in the final draft of this 2017 Biota Monitoring Report. The 2017 biota monitoring results presented in this report are used in conjunction with the historical data to assess temporal patterns of total mercury (hereafter termed mercury) and methyl mercury concentrations in the biota of the Estuary and associated reference areas.

# 2.0 SAMPLING APPROACH AND METHODS FOR BIOTA

Amec Foster Wheeler developed and implemented the Biota Monitoring Plan (Amec Foster Wheeler 2017a) for the sample collection of various species of biota in the Estuary. Priority was placed on species that provide the most information about potential system recovery and human health risk, given available historical data. In addition, to support temporal and spatial trend analysis, priority was placed on locations that have sufficient historical data availability and that encompass the historical PRMS collection range of the species. Data was collected for:

- Terrestrial Invertebrates
  - Spiders (order Aranae)
  - Terrestrial insects (class Insecta)
- Birds
  - Nelson's sparrow (*Ammodramus nelsoni*)
  - Red-winged blackbird (*Agelaius phoeniceus*)
  - American black duck (*Anas rubripes*)
- Aquatic Invertebrates
  - Polychaetes (*Glycera* spp. and *Nereididae* spp.)
  - Blue mussels (*Mytilus edulis*)
  - American lobster (*Homarus americanus*)
- Fish
  - American eel (*Anguilla rostrata*)
  - Atlantic tomcod (*Microgadus tomcod*)
  - Rainbow smelt (*Osmerus mordax*)
  - Mummichog (*Fundulus heteroclitus*)

**Table 2-1** lists the species collected by location. The study reaches are generally denoted in the sample identification using the reach acronyms (OV: Orono to Veazie; BO: Brewer to Orrington; OB: Orrington to Bucksport; ES: estuary; MM: Mendall Marsh; W: wetland/marsh platform). **Figure 2-1** depicts the Estuary biota locations and the reference biota location for the eel. **Figure 2-2** depicts the reference biota locations for the other species. Sections 2.1 through 2.4 describe the methodology for sample collection, Section 2.5 describes laboratory data deliverables, and Section 2.6 discusses statistical methods. **Table 2-2** lists the analytical methods.

The appropriate state and federal permits for collection of each species were obtained from Maine Department of Marine Resources (DMR), Maine Department of Inland Fisheries and Wildlife, United States Fish and Wildlife Service, United States Geological Survey, and National Oceanic and Atmospheric Administration (NOAA) (**Appendix A**).

## 2.1 TERRESTRIAL INVERTEBRATE AND SPIDER SPECIES

Spiders and terrestrial insects were included in the sampling program to establish a baseline for monitoring future remedial action effectiveness. Terrestrial insects often include larval stages that develop in the sediment, such as in Mendall Marsh. Spiders commonly prey on terrestrial insects. Many avian species rely on spiders and terrestrial insects (adult and larvae) as common prey items during breeding and brood rearing.

### 2.1.1 Terrestrial Insect and Spider Collection Procedures

Terrestrial insects and spiders were captured from representative sample areas using hand nets, aspirators, and pitfall traps, and were collected using tweezers and sample collection containers. (See Spider and Insect Sampling Standard Operating Procedure [SOP] S-11 in the draft Penobscot River Estuary Phase III Engineering Evaluation Quality Assurance Project Plan (QAPP) [Amec Foster Wheeler 2016b].) The positions were collected at sample locations using a Trimble R1 paired with an electronic data collector, which provided sub-meter accuracy. Coordinates were recorded and visually verified on base maps in ArcGIS 10.3 (ESRI 2014). The terrestrial insects and spiders were separated to the lowest taxa possible into the appropriate sample containers. Collection continued until an adequate composite mass (by weight) was obtained for laboratory analysis. Sample weight was measured using a digital scale with 0.1-gram accuracy. Samples were placed on ice during the collection of additional insects/spiders. Sample identification numbers and date of collection were recorded on the field data record (**Appendix B-1**).

### 2.1.2 Terrestrial Insect and Spider Sample Processing

Samples were placed in labeled sample containers in a designated sample cooler containing dry ice for transport from the field and to the laboratory. No further processing was performed. Samples were shipped via chain of custody (COC) procedures on dry ice to Eurofins Frontier Global Sciences, Inc. (Eurofins) in Bothell, Washington. Terrestrial insect and spider samples were analyzed for mercury by the United States Environmental Protection Agency (EPA) Method 1631e and methyl mercury by EPA Method 1630 (**Table 2-2**).

### 2.1.3 Terrestrial Insect and Spider Sample Quantity

The goal was to collect and analyze five composite samples of terrestrial insects and five composite samples of spiders at each location. The final number of samples submitted to the analytical laboratory was determined by the types and mass of insects or spiders collected. A minimum target mass of 1 gram of tissue was to be collected per sample (0.5 gram for mercury and 0.5 gram for methyl mercury). Five composite terrestrial insect samples were collected at each of three locations, for a total of 15 composite terrestrial insect samples from the Estuary and five composite terrestrial insect samples from the reference location on the Pleasant River near Addison, Maine. Similarly, five composite spider samples were collected at each of three locations for a total of 15 composite spider samples from the Estuary and five composite spider samples from the reference location on the Pleasant River near Addison, Maine. See **Table 2-1** for sample locations and quantities.

## 2.2 Bird Species

The three bird species that were sampled historically (red-winged blackbird, Nelson's sparrow, and American black duck) were sampled again in 2017.

The red-winged blackbird is a migratory species that eats spiders, insects, and seeds in wetland habitats, thus representing a mid-trophic level species. The Nelson's sparrow is a migratory species that eat spiders, insects, snails, and seeds in wetland habitats, similar to the red-winged blackbird, and thus also represents a mid-trophic level species. Nelson's sparrows and red-winged blackbirds nest and forage in wetland habitats, like the marsh platform.

The American black duck was sampled because this species overwinters and forages in aquatic habitats such as small coves and shallow water areas like the intertidal areas, thus representing a mid-trophic level species. Black ducks migrate south from Canada and typically arrive in the Estuary in September/October. American black ducks are included as a biota species that provides a potential route of human exposure. Humans hunt ducks in November and December and eat the muscle tissue, with the breast tissue composing a substantial portion of the duck tissue consumed. Sampling black ducks in the winter months of January and February provides a conservative estimate of exposure from wintering at the site. Black ducks were sampled in winter 2018 and results will be presented in the final version of this report.

### 2.2.1 Songbird Collection Procedures

Nelson's sparrow and red-winged blackbirds were captured using mist nets (see Avian Mist Netting SOP S-8 in the QAPP) using standard handling methods and techniques. Mist nets had a mesh size designed for the target bird species. Nets were set in flyways based on topography and knowledge of bird habits, as well as audible clues of the presence of birds in the sample area. The team monitored the nets every 10 to 20 minutes to remove the birds quickly to limit escape, tangling, stress, and injury. Birds were removed from the mist nets by a trained bird handler taking care not to injure or stress the bird. The birds were immediately taken to the bird processing location to process and release the birds as quickly as possible, in order to reduce stress on the bird. Sample identification numbers and date of collection were recorded on the field data record (**Appendix B-1**). Photographs of songbird collection and sample processing are presented in **Appendix B-2**.

### 2.2.2 Songbird Sample Processing

Processing occurred in proximity to the mist nets for visual monitoring and to minimize the stress to the birds from transport from the capture to the processing site.

#### *2.2.2.1 Songbird Blood Collection*

Songbird blood was collected from the inner brachial artery at the elbow of the wing using a 27-gauge needle and 70-microliter (µL) capillary tubes. Capillary tubes were capped when full or when the blood stopped flowing. A small wad of cotton and/or styptic powder was applied with hand pressure held on the puncture spot to stop the bleeding. A maximum of three capillary tubes of blood was collected for analysis. The 70 µL capillary tubes of blood for each bird were placed in a labeled plastic tube for protection, and then placed on dry ice for transport to the field station. Needles were deposited in a sharps container for disposal. Samples were shipped via COC procedures on dry ice to Eurofins. Samples were analyzed for mercury by EPA Method 1631e.

#### *2.2.2.2 Songbird Biometric Data Collection*

The following bird biometric data were collected and recorded for each bird sampled:

a. Bird band number;

b. Wing chord: Measurement from the wrist to the tip of the longest primary flight feather, in millimeters;

c. Tail measurement: Measurement of the length of the rectrices/tail feathers, in millimeters;

d. Fat and molt: Determined by blowing on body, wing, and skull to expose furcular hollow (fat) and pin feathers (molt);

e. Breeding status: Presence of cloacal protuberance or brood patch was observed and noted while determining fat and molt;

f. Age: Determined by stretching the wing outward and looking for molt limits and feather wear; and

g. Bird weight.

Each bird was released near the site of collection after each individual was banded, measurements were recorded, a blood sample was collected, and photographs were taken (if necessary). Coordinates were collected for each mist nets using a Trimble R1 paired with an electronic data collector, which provided sub-meter accuracy. Coordinates were recorded and visually verified on base maps in ArcGIS 10.3 (ESRI 2014).

### 2.2.3 Songbird Sample Quantity

No more than three 70 µL capillary tubes of blood were collected per bird. A total of 57 Nelson's sparrow samples were collected from four sample locations, and a total of 17 red-winged blackbird samples were collected from three sampling locations. See **Table 2-1** for sample locations and quantities.

### 2.2.4 American Black Duck Collection Procedures

Black ducks were captured by wire traps and rocket nets (see Sampling of Breast Muscle Tissue and Blood from Ducks SOP S-11 in the QAPP) using standard protocols and techniques for bird handling. Birds were removed from the traps and nets by a trained bird handler taking care not to injure or stress the bird. The birds were then immediately taken to a bird processing location to process and release the birds as soon as possible, in order to minimize stress.

#### *2.2.4.1 Wire Traps*

Amec Foster Wheeler biologists worked with Maine Department of Inland Fisheries and Wildlife biologists to set traps. Traps were baited with corn and left open at collection sites to accustom the ducks to finding food at the site, allowing free access into and out of the baited trap. After ducks began to willingly enter the open traps to eat the bait, the traps were rebaited and set. Set traps have a narrow entry that allowed the ducks to enter, but not exit, the trap. When ducks were present, the sample crew "pushed" the birds into the trap box to extract the ducks one at a time into travel crates. The crated birds were taken to the processing area.

#### *2.2.4.2 Rocket Net*

The net was accordion-folded along one edge, concealed with seaweed, and attached to the ground. The projectiles were metal cylinders with threaded caps on one end and ports for gasses to escape on the opposite end. The cylinder projectiles were launched using black powder and an electric charge controlled by the operator in the blind using a trigger box. When triggered, the net was launched over the ducks and captured the ducks. Once captured, the ducks were transferred out of the nets and into travel crates as soon as possible to minimize injury and stress.

The crated birds were taken to the processing area. Captured ducks were processed similarly whether captured by wire trap or rocket net.

The positions of the traps at sample locations were recorded using a Trimble R1 paired with an electronic data collector, which provided sub-meter accuracy. Coordinates were visually verified on base maps in ArcGIS 10.3 (ESRI 2014). Sample identification numbers and date of collection were recorded on the field data record (**Appendix B-1**). Photographs of duck collection and processing are presented in **Appendix B-2**.

### 2.2.5 American Black Duck Sample Processing

#### *2.2.5.1 Duck Blood Collection*

One leg of the duck was wiped with alcohol prior to the use of the 27-gauge needle to collect blood. Duck blood was collected from the vein near the ankle using 70 µL capillary tubes. Capillary tubes were capped when full of blood or when blood stopped flowing. The target was three to five capillary tubes of blood per duck.

Once sufficient blood was obtained from the vein, pressure was briefly applied to stop the bleeding. Ducks were banded, aged, and sex determined prior to release. The capillary tubes were placed in a labeled plastic tube for each bird sample and placed on dry ice for transport to Eurofins. Samples were analyzed for mercury by EPA Method 1631e (**Table 2-2**).

## 2.3 AQUATIC INVERTEBRATE SPECIES

Polychaetes, blue mussel, and American lobster were sampled in 2017.

Polychaetes are a common prey item for many fish species, lobsters, and the black duck. While polychaetes were only collected from the top few inches of sediment, these organisms burrow through many layers of sediment and potentially integrate mercury concentrations from these layers, dependent on life history traits.

Blue mussels are commonly monitored along the East Coast of the United States, including the Penobscot region, allowing comparison to mercury concentrations in other systems. This species is an indicator of sediment concentrations due to the species life history traits and diet (Casco Bay Estuary Partnership, 2007).

Lobsters are commonly consumed and are a potential source of human exposure to mercury in the Penobscot River. There is a substantial amount of existing and recent data on mercury contamination in lobsters in the upper reaches of Penobscot Bay. In 2014, Maine DMR designated a lobster fishing closure area in part of Penobscot Bay, in response to elevated mercury concentrations, halting the harvest of lobster from the mouth of the Penobscot River to a line from Fort Point to Wilson Point (**Figure 2-3**). The DMR collected lobsters in 2014 and 2015 for mercury tissue analysis (MCDC 2016). Based on the mercury results from samples collected in 2014, the DMR expanded the closure area south in 2016 to a line from Squaw Point to Perkins Point (**Figure 2-3**).

### 2.3.1 Polychaete Sample Processing

Polychaetes were collected within approximately the top 0.25-foot interval of sediment (see Polychaete Sampling SOP S-15 in the QAPP) using a hand shovel or stainless steel spoon. Each sediment grab sample was placed in a stainless-steel bowl. The sediment was broken into peds or clods using a stainless-steel spoon to locate the polychaetes. The sediment sample area was expanded laterally with the shovel, a stainless-steel spoon, or clam rake within the top 0.25 foot of sediment to continue locating polychaetes until the target mass was collected. Polychaetes were removed from the sediment using gloved hands and transferred to a sample container. The weight of the polychaete sample was recorded. The polychaetes were placed in sample containers with laboratory-prepared saline water and stored in a cooler until processed. Sample identification numbers and date of collection were recorded on the field data record (**Appendix B-1**). Coordinates were collected for each sample location using a Trimble R1 paired with an electronic data collector, which provided sub-meter accuracy. Coordinates were recorded and visually verified on base maps in ArcGIS 10.3 (ESRI 2014).

### 2.3.2 Polychaete Collection Procedures

The polychaete samples in laboratory-prepared saline water were recorded for date of collection and allowed to depurate on wet ice during shipment to the Amec Foster Wheeler laboratory in Gainesville, FL for identification. The laboratory-prepared saline water was used to allow the polychaetes to depurate the sediment from the gut. After identification and any necessary sorting, the sample container was drained and the polychaetes were rinsed with laboratory-provided deionized water before returning the polychaetes to the sample container. The mass of the composite polychaetes was recorded from the post-depuration samples. Sample weight was measured using a digital scale with 0.1-gram accuracy. The depurated polychaete samples were preserved in a cooler containing dry ice. Samples were shipped via COC procedures on dry ice to Eurofins. Polychaete samples were analyzed for mercury (EPA Method 1631e) and methyl mercury (EPA Method 1630) (**Table 2-2**).

### 2.3.3 Polychaete Sample Quantity

A minimum target mass of three grams of tissue was to be collected per polychaete sample. If the sample mass was not achieved locally, the area of sampling was widened concentrically to collect the specimens into a composited sample to achieve minimum mass requirements for chemical analysis (1 gram for mercury and methyl mercury). A total of 60 polychaete samples were collected from 12 locations. Additional polychaete sample locations were sampled in 2017 to provide additional data in areas that were deemed hydrologically important, and where limited biota data were previously collected. See **Table 2-1** for sample locations and quantities.

### 2.3.4 Blue Mussel Collection Procedures

Blue mussels were collected by hand (see Shellfish Sampling Tissue SOP S-14 in the QAPP). Blue mussels were picked from the substrate, taking care not to damage the tissue (e.g., if mussel byssal threads did not pull freely from the substrate, a scraper or knife was used to sever the threads). The removed mussels were rinsed to remove sediment from the outer shell. Depuration was not necessary because mussels are filter feeders and do not burrow into sediment (in contrast to polychaetes). The samples from each location were placed into labeled sealable plastic bags, and then transferred to the field station in a cooler with wet ice and/or dry ice.

### 2.3.5 Blue Mussel Processing Procedures

Coordinates were collected for each sample location using a Trimble R1 paired with an electronic data collector, which provided sub-meter accuracy. Coordinates were recorded and visually verified on base maps in ArcGIS 10.3 (ESRI 2014). Sample weight was measured using a digital scale with 0.1-gram accuracy. Blue mussel sample containers were labeled with sampling date and capture location, and shipped via COC on dry ice to Eurofins. Samples were analyzed for mercury (EPA Method 1631e) (**Table 2-2**). Sample identification numbers and date of collection were recorded on the field data record (**Appendix B-1**).

### 2.3.6 Blue Mussel Sample Quantity

A total of 91 blue mussels were collected from five sample locations. See **Table 2-1** for sample locations and quantities.

### 2.3.7 American Lobster Collection Procedures

American lobsters were captured by lobster trap described in Shellfish Sampling Tissue SOP S-14 in the QAPP, with the aid of a contracted professional lobster fisherman/boat captain. The traps were metal wire and measured 48 inches by 21 inches by 13.5 inches. Both vented and non-vented traps were deployed. The vent allows smaller lobsters to escape. Each trap was on a single buoy. The traps were deployed in the desired sample collection location for two days.

Lobster traps were checked every two days until the target number of samples was collected and then traps were removed from the water. Lobsters were sexed when removed from the trap.

Coordinates were collected for each sample location using a Trimble R1 paired with an electronic data collector, which provided sub-meter accuracy. Coordinates were recorded and visually verified on base maps in ArcGIS 10.3 (ESRI 2014). Sample weight was measured using a digital scale with 0.1-gram accuracy. Sample identification numbers and date of collection were recorded on the field data record (**Appendix B-1**). Photographs of the lobster collection are presented in **Appendix B-2**.

### 2.3.8 American Lobster Processing Procedures

Lobsters of "legal" size (3.25 to 5 inches) were targeted, when available. Measurement and weight of each specimen after collection was conducted to ensure that appropriately sized shellfish were taken and that minimum sample mass requirements were satisfied. Lobsters were placed into labeled sealable plastic bags, and then into a cooler with ice to transport to the field station. Lobster sample containers were labeled with sampling date and capture location, and shipped on dry ice to Eurofins. The analytical laboratory dissected lobsters, removing the tail muscle for analysis. Samples were analyzed for mercury by EPA Method 1631e (**Table 2-2**).

### 2.3.9 American Lobster Sample Quantity

A total of 120 American lobster were collected from six sample locations. See **Table 2-1** for sample locations and quantities.

## 2.4 Fish Species

Four fish species (American eel, Atlantic tomcod, rainbow smelt, and mummichog), which were sampled historically, were sampled again in 2017.

Mummichog were chosen because these fish are typically found in brackish environments and are a prey fish, representing a lower trophic level fish (mid trophic level in a food web). Mummichog feed on an array of food items such as algae, insects and insect larvae, worms, and small shellfish. Mummichog have historically been difficult to locate and collect in sufficient numbers for trend analysis.

Atlantic tomcod were chosen because these fish are representative of benthic feeding fish (i.e., fish that consume organisms associated with the sediment). Tomcod are a mid- to upper trophic level species, tending to feed on small crustaceans, polychaetes, mollusks, and fish. Tomcod provide a comparison to rainbow smelt (a pelagic feeder).

Rainbow smelt were chosen because these fish are representative of pelagic feeding fish (i.e., fish that consume organisms living in the water column, not the sediment). Rainbow smelt feed on a range of prey items such as small invertebrates, benthic crustaceans, and small fish. Rainbow smelt cover the same range as tomcod, so the two can be sampled together to compare benthic and pelagic feeding fish at the same locations.

The American eel was chosen because eel span salt and freshwater environments and are a predatory fish, representing the upper trophic level of fish. "Yellow" eels (resident juveniles), which represent local area conditions unlike the migratory "silver" eels, were targeted. Eel feed on prey items such as shellfish, worms, and small fish.

### 2.4.1 Fish Collection Procedure

Fish were captured by various traps and nets using handling techniques described in Fish Sampling Procedures SOP S-12 in the QAPP. Sample identification numbers and date of collection were recorded on the field data record (**Appendix B-1**). Each section that follows describes capture methods employed. Photographs of fish collection are presented in **Appendix B-2**.

#### *2.4.1.1 Eel Trap*

Eel traps were used to target Atlantic tomcod and American eel. If other target species were captured in this trap during the targeted sampling period, the fish were retained as samples. Standard eel traps were approximately 1-foot-square by 3-foot-long wire traps with a 2.5-inch by 2.5-inch "funnel" that ran into the trap. Bait used for the trap included cat food, crushed green crabs, and horseshoe crabs. The bait was placed in plastic perforated bags to minimize consumption of the bait. Eel traps were placed at sample locations within or adjacent to appropriate aquatic habitats for the target species. Traps were set on one buoy to mark trap locations. Target species were removed from the traps and were placed into labeled sealable plastic bags on dry ice.

#### *2.4.1.2 Hoop Net*

Hoop nets were used to target Atlantic tomcod. If other target species were captured in this net during the targeted sampling period, the fish were retained as samples. Hoop nets are approximately 3 feet in diameter with 0.5-inch mesh and five metal hoops spanning the 20-foot length. The hoop nets were placed within or adjacent to appropriate aquatic habitats for the target species. Nets were set on one buoy to mark trap locations. Target species were removed from the trap nets and were placed into labeled sealable plastic bags on dry ice.

#### *2.4.1.3 Trawling*

Trawling was not included in the permit held by Amec Foster Wheeler due to NOAA National Marine Fisheries Service and United States Fish and Wildlife Service concerns related to the potential for interacting and/or capturing threatened and endangered species during the targeted sampling period. However, National Marine Fisheries Service research scientists conducted permitted trawling and agreed to provide rainbow smelt and Atlantic tomcod captured on trawling transects that corresponded with the biota sampling location for either of these species. Target species of appropriate size were removed from the trawl nets and were placed into labeled sealable plastic bags on dry ice. Data related to fish collection was provided by NOAA.

#### *2.4.1.4 Seine Net*

Seine nets were used to target rainbow smelt and mummichog. If other target species were captured in this net during the targeted sampling period, the fish were retained as samples. Seine nets are approximately 6 feet by 50 feet with 0.125-inch mesh. The nets had lead weights to hold the nets down, and buoys to keep the top edge of the net above water. Seine nets were used along the shore in appropriate aquatic habitats for target species. Two sampling personnel used the seine to collect the target fish species. The seine net was held vertically, with one person on shore and a second person circling around either by wading or with the assistance of a boat to close the loop back on the person on shore. When moving through the water, the bottom of the seine remained in contact with the substrate and the top floats held the net vertical in the water. Target species were removed from the seines and were placed into labeled sealable plastic bags on dry ice.

#### *2.4.1.5 Minnow Traps*

Minnow traps were used to target mummichog. If other target species were captured in this trap during the targeted sampling period, the fish were retained as samples. Minnow traps are two-part mesh traps 9 inches by 17.5 inches long and with a narrow, conical opening on each end. Minnow traps were placed in strings of three to four traps per line with one buoy. The traps were placed within or adjacent to appropriate aquatic habitats for the targeted species. Target species were removed from the minnow traps and placed into labeled sealable plastic bags on dry ice for transport to the field station.

### 2.4.2 Fish Sampling Procedures

Coordinates were collected for each trap or net using a Trimble R1 paired with an electronic data collector, which provided sub-meter accuracy. Coordinates were recorded and visually verified on base maps in ArcGIS 10.3 (ESRI 2014). Sample identification numbers and date of collection were recorded on the field data record (**Appendix B-1**). Fish were measured for total length and mass of the individual or composite sample in the field station. No samples were processed in the field. Sample mass was measured using a digital scale with 0.1-gram accuracy. A target sample mass of 5 grams was required for chemical analysis, but if necessary due to fish size, the minimum sample mass allowable was 3 grams. No specific age or size limits were targeted for fish. Sample mass relates inversely to detection limits so sample mass less than 3 grams elevates the detection limits targeted in the QAPP (Amec Foster Wheeler 2016b). If individual fish were too small to meet the 3-gram mass requirement, fish of similar lengths were composited. The average length of the fish within each composite was reported and used in statistical treatment of the samples. Compositing fish of similar lengths and using the average length of fish in each composite in the statistical evaluation of data increases sample size. Similar length fish from the same location were likely exposed to similar mercury concentrations over a similar duration because most fish species have a strong length-age relationship. Including small fish in the statistical evaluation ensures applicability of the results to the entire population of that fish species. Photographs of collection are presented in **Appendix B-2**). Samples were shipped via COC procedures on dry ice to Eurofins. The analytical laboratory filleted and removed the skin of Atlantic tomcod and American eel samples prior to homogenization and analysis. Mummichog and rainbow smelt samples were homogenized and analyzed as whole body samples. Samples were analyzed for mercury for the four fish species sampled by EPA Method 1631e, and percent lipids for eel only by NOAA Method 1993a (**Table 2-2**).

### 2.4.3 Fish Sample Quantity

See **Table 2-1** for sample locations and quantities.

## 2.5 LABORATORY DATA DELIVERABLES AND DATA VALIDATION

Amec Foster Wheeler identified qualified laboratories based on licensing and credentials for the project-required analyses. Chosen laboratories, analyses, and turnaround times are identified in the QAPP (Amec Foster Wheeler 2016b). Samples collected and shipped to the laboratory were documented on a COC form following procedures specified in the Sample Chain of Custody Procedures SOP S-19 in the QAPP. Sample collection volumes, containers, preservation requirements, and hold times are identified in the QAPP and field sampling analysis plan.

Every 20 samples collected in the field required additional volume for a matrix spike (MS)/ matrix spike duplicate (MSD). Quality control (QC) samples were sent with field samples to the laboratory. QC samples sent to the laboratories from the field included temperature blanks, field blanks where appropriate, and extra sample volumes for MS/MSD analyses.

The laboratories separated the field samples into sample delivery groups (SDGs) based on time of receipt at the laboratory. The SDGs included QC samples. The laboratory provided the sample results (wet weight) in hard copy analytical reports and electronic data deliverables to Amec Foster Wheeler. Additional QC material included the laboratory volume for analysis for method blanks, instrument blanks, laboratory duplicates, and laboratory control samples. Summaries for QC data and associated raw data generated in support of the reported results (including instrument calibration) were included in the laboratory reports and reviewed during data validation.

Amec Foster Wheeler performed EPA Stage IIB validation of each SDG, and a Stage III data validation on ten percent of samples. Stage IIB and Stage III validation are defined in Guidance for Labeling Externally Validated Laboratory Analytical Data for Superfund Use (EPA 2009). Data validation was completed using National Functional Guidelines for Inorganic Superfund Data Review (EPA 2014) and EPA New England Environmental Data Review Supplement for Regional Data Review Elements and Superfund Specific Guidance/Procedures (EPA 2013), where applicable. Data quality evaluations were completed using QC limits specified in the QAPP.

Data qualifications were completed in accordance with the guidelines or the professional judgment of the project chemist. The following qualifiers applied during data validation or reported by the laboratory are included in the final data set:

- J: The reported concentration is considered an estimated value;
- U: The target analyte was not detected above the method detection limit; and
- UJ: The target analyte was not detected and the reporting limit is considered to be estimated.

Data quality interpretations regarding accuracy, precision, and completeness were summarized in data validation reports. Data validation reports were reviewed by the project chemist, or designee, before the data were finalized for use in the following sections of this report and other project reports. J-flagged values are typically used in statistical data evaluations because the data are still considered valid and do not affect the interpretation of the results.

Laboratory results were loaded to Amec Foster Wheeler's Technical Environmental Database for storage, organization and future statistical query. Data summary tables are provided in **Appendix C**.

Laboratory analytical reports and the analytical data validation reports are presented in **Appendices D and E**, respectively.

## 2.6 STATISTICAL METHODS

The statistical evaluation of biota data was conducted using the publicly available statistical software package R, version 3.5.1 (R Core Team 2018). Code and data for each biota species are presented in **Appendix F**. An alpha value of 0.05 was used to determine significance where $p<0.05$ indicates a rejection of the null hypothesis at the 95 percent level of confidence. Regressions where the p-value is between 0.05 and 0.1 are considered to be nearing significance and are highlighted by drawing a dashed line on the figure rather than a solid line; however, a designation of "statistically significant" is not given to these cases. Regression coefficients and statistics are reported on each figure.

Historical data were evaluated by number of samples and years to determine which sampling locations had multiple years of data that would result in a robust data evaluation. The data used in the statistical evaluation included data from the years 2006 to 2012, 2016, and 2017, with the exception of black duck data, which included data from 2011 to 2014, 2017, and 2018. All data at a location were used in statistical analyses; data were not tested for outliers.

Mercury results of fish and shellfish were adjusted for length due to differences in size of individuals collected and to improve model fit compared to a linear regression of unadjusted mercury concentrations. Fish and shellfish generally showed a positive, significant relationship between mercury concentration and length (**Appendix G-1**). Terrestrial insects, spiders, polychaetes, and birds were not length adjusted. Adjustment of mercury concentrations by length was conducted for each sample by dividing the individual mercury concentration by individual length and then multiplying by the median length for the entire data set. By adjusting mercury concentrations by median length for the entire data set, fish concentrations and trends are comparable among sampling locations and readily interpretable (i.e., concentration rather than concentration per length). The central tendency of length (median rather than the average) of the data set was used to scale ("adjust") each data point. Lengths and weights in fish are typically a function of each other. Given that weights were not consistently available for historical data, lengths were used to adjust the data and reduce the variability of the data due to size differences among samples. The length-adjusted mercury concentrations are calculated individually in nanograms per gram (ng/g). An example calculation using only three samples from the data is shown below.

*Example calculation*: (1104 ng/g) / (6.2 centimeters [cm]) * 7.3 cm = 1300 ng/g (wet weight)

| Sample | Mercury (ng/g) | Length (cm) | Length-Adjusted Mercury (ng/g) |
|---|---|---|---|
| 1 | 994 | 7.3 | 994 |
| 2 | 1,104 | 6.2 | 1,300 |
| 3 | 1,247 | 7.3 | 1,247 |

Median length = 7.3 cm

Mercury concentrations were evaluated within the river and by location against year to determine if tissue concentrations change through time (i.e., the hypothesis is that mercury concentrations change through time). Mercury concentrations (raw or length adjusted) were log-transformed (using the natural log) to account for the asymmetrical and right-skew often seen in environmental data (Gilbert 1987). These log-transformed mercury concentrations were used in a loglinear regression with year to evaluate temporal trends. This is similar to treatment of the data by the PRMSP (PRMSP 2013a). Trends were evaluated when sufficient data were available (i.e., three or more years of data with more than one sample collected in a year). Where fewer data were available and recent data (i.e., 2016-2017) from the two years were comparable (same location, similar sample type, and more than one sample in a year), a Kruskal-Wallis rank sum test was conducted to compare the median mercury concentrations of the two years.

The relationship of age and mercury concentrations was investigated for American eels. A relatively strong relationship between length and age (typical for many fish) in eels was demonstrated (**Appendix G-2**). The relationships of mercury and length versus mercury and age were relatively similar. Length was used to adjust mercury concentrations in eel tissue.

Compositing of individual fish was conducted for three species (i.e., mummichog, blue mussel, rainbow smelt) in order to meet required sample mass. Section 2.4.2 discusses compositing procedures for creating consistent and intentional composites. Smaller (and shorter) fish were composited to provide sufficient mass for sample analysis. Given the strong length-mercury relationship (**Appendix G-1**), it is expected that composite samples have lower mercury concentrations than individual samples of larger fish that have sufficient mass for analysis of a single fish. However, the compositing of similarly sized small fish into samples is not expected to change the mercury-length relationship. Figures in **Appendix G-3** represent the concentrations in individual and composite samples for each species where compositing occurred. Composite sample mercury concentrations are representative of the individual fish with similar lengths.

# 3.0 ANALYTICAL RESULTS FOR BIOTA

Mercury and methyl mercury results (wet weight) are discussed for each species in this section. Mercury and methyl mercury (where available) concentration results for the selected species in the Estuary are presented on **Figures 3-1a through 3-12**. Methyl mercury was not analyzed in all species. Mercury and methyl mercury results for biota reference sites are presented on **Figures 3-13a through 3-14b**, with the exception of American eel. The reference site for American eel is upstream of the study area, and reference site mercury results are presented with Estuary mercury results on **Figure 3-11**. **Figures 3-15a through 3-16b** present mercury and methyl mercury results by terrestrial insect taxa for historical and current data.

Mercury and methyl mercury (when analyzed) results by species and location are presented in **Appendix C** (wet weight). Lipid results are also presented in **Appendix C** for American eel at each location, when analyzed, but not discussed in this report.

In this section, mercury and methyl mercury concentrations in biota are compared to toxicity or human consumption benchmarks for the species where benchmarks have been selected. Benchmarks are discussed in the 2017 Risk Assessment Report (Amec Foster Wheeler 2018b). The Maine Center for Disease Control and Prevention (MeCDC) methyl mercury fish tissue action levels for freshwater finfish of 200 ng/g is applied as a human consumption benchmark for fish, blue mussels, lobsters, and black duck based on the Order on Remediation Plan (United States District Court, District of Maine 2015), which states that "…*to the extent the parties require a general benchmark, the Court adopts the state of Maine standards of 200 nanograms per gram*". The application of fish tissue action levels to lobster, black duck, and blue mussels may be inappropriate, as the MeCDC freshwater fish tissue action levels were derived based on a finfish consumption rate of one 8-ounce fish meal per week (52 meals per year, 32.4 grams per day) (MeCDC 2001), which is greater than the local consumer consumption rates for lobster (1.7 grams per day) (Cooper et al. 1991), shellfish (0.51 gram per day) (Cooper et al. 1991), and duck (14.9 grams per day) (MDIFW 2017), and may overestimate risk associated with the actual consumption of lobster, blue mussels, and black duck. Because of convention and not specifically as an assessment of risk, the results are compared to the 200 ng/g methyl mercury threshold level at which the MeCDC would advise people to limit their fish consumption.

## 3.1 TERRESTRIAL INVERTEBRATE MONITORING RESULTS

### 3.1.1 Terrestrial Insects

Historical and recent data show that prey mercury concentrations can vary widely by insect taxa. However, birds consume multiple taxa, generating a daily composite of terrestrial insects. Thus, the range of mercury concentrations represented by the terrestrial insect composite and individual samples is appropriate for understanding and estimating the exposure of birds to mercury from terrestrial insects.

#### *3.1.1.1 2016*

A total of 20 composite terrestrial insect samples were collected in July 2016, and were analyzed for mercury and methyl mercury. Terrestrial insects were collected from three areas of the Penobscot River marsh platform: W-17-N, MM-Southeast (SE), and MM-Southwest (SW) (**Figures 3-1a and 3-1b**) and the Pleasant River reference location (**Figures 3-13a and 3-13b**). Composite samples were composed of insects such as grasshoppers (order: Orthoptera), damselflies (order: Odonata), dragonflies (order: Odonata), greenhead flies (order: Diptera), leafhoppers (order: Hemiptera), flies (order: Diptera), and mosquitoes (order: Diptera). The number of individuals in a sample depended on the species composition of the composite to achieve the target weight for analysis.

Mercury concentrations in insect samples ranged from 7.37 to 63.2 ng/g, with a median of 16.8 ng/g at the Pleasant River reference location (**Table 3-1; Figure 3-13a**). In contrast, from the marsh platform, terrestrial insect sample mercury concentrations ranged from 16.5 ng/g at location MM-SE to 354 ng/g, also at location MM-SE (**Figure 3-1a**), with a median concentration for terrestrial insects collected from the Penobscot River marsh platform in 2016 of 50.0 ng/g.

There is no discernible spatial gradient of mercury concentrations in terrestrial insects from the Penobscot River marsh platform areas, likely due to the influence of Mendall Marsh on the W-17-N area, as median mercury concentrations would generally be hypothesized to decrease downstream (downstream and upstream being defined by being closer to the ocean along the flowpath of the river) (**Figure 3-1a**). From W-17-N (upstream of Mendall Marsh) to MM-SE and MM-SW, median insect mercury concentrations in 2016 samples by location were 30.4, 222, and 47.5 ng/g, respectively (**Table 3-1**). There appear to be two levels of mercury concentrations in the insect samples with one level between 20 and 60 ng/g and a second level between 200 and 360 ng/g. The difference in concentration could be associated with the order of the insects within the composite samples. A number of composite samples collected in 2016 included greenhead flies (*Tabanus nigrovittatus*), a species of biting horse-fly typically found in coastal marshes. Deer flies and horse flies tend to have elevated concentrations of mercury relative to other terrestrial insects collected in 2009, 2016, and 2017 (**Figure 3-15a**).

Methyl mercury concentrations in terrestrial insect samples ranged from 2.50 to 31.2 ng/g, with a median of 18.6 ng/g at the Pleasant River reference location (**Table 3-1; Figure 3-13b**). Methyl mercury concentrations in terrestrial insects collected from the Penobscot River marsh platform ranged from 6.90 ng/g at location MM-SE to 241 ng/g, also at location MM-SE (**Figure 3-1b**), with a median concentration of 33.5 ng/g. The concentration of methyl mercury was 62 percent (mean) of mercury concentrations in terrestrial insect composite samples collected in 2016. Similar to mercury, there is not a discernible spatial gradient of methyl mercury concentrations in terrestrial insects from the Penobscot River marsh platform in the 2016 samples, as the median results among the locations are very similar (**Figure 3-1b**). From W-17-N (upstream of Mendall Marsh) to MM-SE to MM-SW, median terrestrial insect methyl mercury concentrations in 2016 samples by location were 56.7, 91.2, and 26.8 ng/g, respectively (**Table 3-1**). There also appear to be two levels of methyl mercury concentrations in the insect samples, similar to mercury. The difference in concentration could be associated with the order of the insects within the composite samples. A number of composite samples collected in 2016 included greenhead flies, which may have elevated concentrations of methyl mercury relative to other terrestrial insects collected in 2009, 2016, and 2017 (**Figure 3-15b**).

#### *3.1.1.2 2017*

A total of 20 composite terrestrial insect samples were collected in June 2017, and were analyzed for mercury and methyl mercury. Terrestrial insects were collected from three areas (W-17-N, MM-SE, and MM-SW) of the Penobscot River marsh platform (**Figures 3-1a and 3-1b**) and the Pleasant River reference location (**Figures 3-13a and 3-13b**). Composite samples were composed of insects such as grasshoppers (order: Orthoptera), leaf beetles (*Donacia* spp.), dragonflies (order: Odonata), picture-winged flies (family: Ulidiidae), stink bugs (family: Penatomidae), flies (order: Diptera), and beetles (order: Coleoptera). The number of individuals in a sample depended on the species composition of the composite to achieve the target weight for analysis.

Mercury concentrations in terrestrial insect samples ranged from 1.54 to 41.8 ng/g, with a median of 11.5 ng/g at the Pleasant River reference location (**Table 3-1; Figure 3-13a**). In contrast, from the marsh platform, terrestrial insect sample mercury concentrations ranged from 2.95 ng/g at location MM-SE to 93.7 ng/g at location MM-SW (**Figure 3-1a**), with a median concentration for terrestrial insects collected from the Penobscot River marsh platform in 2017 of 22.7 ng/g.

There is no discernible spatial gradient of mercury concentrations in terrestrial insects from the Penobscot River marsh platform, likely due to the influence of the Mendall Marsh area, as median mercury concentrations would generally be hypothesized to decrease downstream (**Figure 3-1a**). From W-17-N (upstream of Mendall Marsh) to MM-SE and MM-SW, median insect mercury concentrations in 2017 samples by location were 6.59, 22.7, and 34.3 ng/g, respectively (**Table 3-1**). There appear to be a wide range of mercury concentrations in terrestrial insect samples even within individual sample areas (i.e., 2.95 ng/g to 71.7 ng/g for MM-SE, 3.75 ng/g to 93.7 ng/g for MM-SW, and 5.19 ng/g to 49.7 ng/g for W-17-N; **Figure 3-1a**). The range of W-17-N samples is similar to the range of mercury concentrations in reference samples collected at Pleasant River. The lower range of mercury concentrations at MM-SE and MM-SW were similar to samples at Pleasant River, but the upper end of the range for these two Mendall Marsh sample locations was approximately twice the concentration of the maximum Pleasant River concentrations. Samples from the Estuary collected in 2017 tended to have higher mercury concentrations in samples composed of dragonflies, picture-winged flies, or a composite of multiple species (**Figure 3-16a**).

Methyl mercury concentrations in terrestrial insect samples ranged from 1.30 to 29.8 ng/g, with a median of 8.20 ng/g at the Pleasant River reference location (**Table 3-1; Figure 3-13b**). The concentration of methyl mercury was 80 percent (mean) of mercury concentrations in terrestrial insect composite samples collected in 2017 (Estuary and reference samples). Methyl mercury concentrations in terrestrial insects collected from the Penobscot River marsh platform ranged from 2.10 ng/g at location MM-SE to 60.2 ng/g, also at location MM-SE (**Figure 3-1b**), with a median concentration of 21.2 ng/g. From W-17-N (upstream of Mendall Marsh) to MM-SE to MM-SW, median terrestrial insect methyl mercury concentrations in 2017 samples by location were 4.90, 21.2, and 27.1 ng/g, respectively (**Table 3-1**). Unlike mercury, there is a discernible spatial gradient of methyl mercury concentrations in terrestrial insects from the Penobscot River marsh platform in the 2017 samples, as there is an increase in median concentrations from upstream to downstream (**Figure 3-1b**). Samples from the Estuary collected in 2017 tended to have higher methyl mercury concentrations in samples composed of dragonflies, picture-winged flies, or a composite of multiple species (**Figure 3-16b**).

### 3.1.2 Spiders

Historical and recent data show that prey mercury concentrations can vary widely by taxa. However, birds consume multiple taxa, as if generating a daily composite of spiders. Thus, the range of mercury concentrations represented by the composite and individual samples is appropriate for understanding and estimating the exposure of birds to mercury from spiders.

#### *3.1.2.1 2016*

A total of 20 composite spider samples were collected in July 2016, and were analyzed for mercury and methyl mercury. Spiders were collected from three areas (W-17-N, MM-SE, and MM-SW) of the Penobscot River marsh platform (**Figures 3-2a and 3-2b**) and the Pleasant River reference location (**Figures 3-13a and 3-13b**). Composite samples were composed of spiders such as wolf spider (family: Lycosidae), jumping spider (family: Salticidae), and crab spider (family: Thomisidae). The number of individuals in a sample depended on the species composition of the composite to achieve the target weight.

Mercury concentrations in spider samples ranged from 25.9 to 44.2 ng/g, with a median of 31.4 ng/g at the Pleasant River reference location (**Table 3-2; Figure 3-13a**). In contrast, from the marsh platform, spider sample mercury concentrations ranged from 166 ng/g at location MM-SW to 771 ng/g at location MM-SE (**Figure 3-2a**), with a median concentration for spiders collected from the Penobscot River marsh platform in 2016 of 213 ng/g.

There is no discernible spatial gradient of mercury concentrations in spiders from the Penobscot River marsh platform in the 2016 samples, as the median results among the locations are very similar. From W-17-N (upstream of Mendall Marsh) to MM-SE to MM-SW, median spider mercury concentrations in 2016 samples by location were 263, 205, and 219 ng/g, respectively (**Table 3-2**). There also appear to be two levels of mercury concentrations in the spider samples, similar to the pattern seen in insect samples. The difference in concentration could be associated with the family of the spiders (e.g., wolf spiders) within the composite samples. Samples from the Estuary collected in 2016 (categorized as "spider") tended to have similar or lower mercury concentrations than samples collected historically (**Figure 3-17**).

Methyl mercury concentrations in spider samples ranged from 14.6 to 60.2 ng/g, with a median of 22.9 ng/g at the Pleasant River reference location (**Table 3-2; Figure 3-13b**). Methyl mercury concentrations in spiders collected from the Penobscot River marsh platform ranged from 136 ng/g at location MM-SE to 642 ng/g at location W-17-N (**Figure 3-2b**), with a median concentration of 217 ng/g. The concentration of methyl mercury was 79 percent (mean) of mercury concentrations in spider composite samples collected in 2016. There is not a discernible spatial gradient of methyl mercury concentrations in spiders from the Penobscot River marsh platform in the 2016 samples, as the median results among the locations are very similar. From W-17-N (upstream of Mendall Marsh) to MM-SE to MM-SW, median spider methyl mercury concentrations in 2016 samples by location were 282, 174, and 217 ng/g, respectively (**Table 3-2**). There also appear to be two levels of methyl mercury concentrations in the spider samples similar to the insect samples. The difference in concentration could be associated with the family of the spiders (e.g., wolf spiders) within the composite samples. Samples from the Estuary collected in 2016 (categorized as "spider") tended to have similar or lower methyl mercury concentrations than samples collected historically (**Figure 3-17**). Birds consume multiple taxa and are exposed to a range of methyl mercury concentrations, as represented by these composite samples.

#### *3.1.2.2 2017*

A total of 20 composite spider samples were collected in June 2017, and were analyzed for mercury and methyl mercury. Spiders were collected from three areas (W-17-N, MM-SE, and MM-SW) of the Penobscot River marsh platform (**Figures 3-2a and 3-2b**) and the Pleasant River reference location (**Figures 3-13a and 3-13b**). Composite samples were composed of insects such as wolf spider (family: Lycosidae), orb-weaver spider (family: Araneidae) and crab spider (family: Thomisidae). The number of individuals in a sample depended on the species composition of the composite to achieve the target weight.

Mercury concentrations in spider samples ranged from 44.2 to 67.5 ng/g, with a median of 55.0 ng/g at the Pleasant River reference location (**Table 3-2; Figure 3-13a**). In contrast, from the marsh platform, spider sample mercury concentrations ranged from 278 ng/g at location MM-SE to 622 ng/g also at location MM-SE (**Figure 3-2a**), with a median concentration for spiders collected from the Penobscot River marsh platform in 2017 of 325 ng/g.

There is no discernible spatial gradient of mercury concentrations in spiders from the Penobscot River marsh platform in the 2017 samples. From W-17-N (upstream of Mendall Marsh) to MM-SE to MM-SW, median spider mercury concentrations in 2017 samples by location were 315, 560, and 315 ng/g, respectively (**Table 3-2**). Differences in concentration could be associated with the family of the spiders (e.g., wolf spiders) within the composite samples. Samples from the Estuary collected in 2017 tended to have similar or lower mercury concentrations than samples collected historically (**Figure 3-17**). Wolf spiders tended to have the highest mercury concentrations of spiders collected in 2017.

Methyl mercury concentrations in spider samples ranged from 50.4 to 73.2 ng/g, with a median of 58.5 ng/g at the Pleasant River reference location (**Table 3-2; Figure 3-13b**). Methyl mercury concentrations in spiders collected from the Penobscot River marsh platform ranged from 50.8 ng/g at location MM-SW to 748 ng/g at location MM-SE (**Figure 3-2b**), with a median concentration of 330 ng/g. The concentration of methyl mercury was 92 percent (mean) of mercury concentrations in spider composite samples collected in 2017.

There is not a discernible spatial gradient of methyl mercury concentrations in spiders from the Penobscot River marsh platform in the 2017 samples. From W-17-N (upstream of Mendall Marsh) to MM-SE to MM-SW, median spider methyl mercury concentrations in 2017 samples by location were 323, 544, and 337 ng/g, respectively (**Table 3-2**). The difference in concentration could be associated with the family of the spiders (e.g., wolf spiders) within the composite samples. Samples from the Estuary collected in 2017 tended to have similar or lower methyl mercury concentrations than samples collected historically (**Figure 3-17**). Wolf spiders tended to have the highest methyl mercury concentrations in spiders collected in 2017. Birds consume multiple taxa and are exposed to a range of methyl mercury concentrations represented by these composite samples.

## 3.2 Bird Monitoring Results

### 3.2.1 Nelson's Sparrow

#### *3.2.1.1 2016*

A total of 52 Nelson's sparrows were captured during 2016 for blood sample mercury analysis. Nelson's sparrows were collected from three areas (W-17-N, MM-SE, and MM-SW) in the Penobscot River marsh platform (**Figure 3-3**) and the Pleasant River reference location (**Figure 3-13a**).

Mercury concentrations in Nelson's sparrow blood ranged from 290 to 740 ng/g (**Figure 3-13a**), with a median of 467 ng/g at the Pleasant River reference location (**Table 3-3a**). In contrast, within the marsh platform, sparrow mercury concentrations ranged from 734 ng/g at location W-17-N to 10,300 ng/g at location W-17-N (**Figure 3-3**), with a median concentration for sparrows collected in the Penobscot River marsh platform in 2016 of 5,730 ng/g. Mercury concentrations in juvenile (hatch year) and adult birds are presented by year and location on **Tables 3-3b and 3-3c**.

There is no discernible spatial gradient of mercury concentrations in sparrow blood in the Penobscot River marsh platform, likely due to the influence of the Mendall Marsh area, as median mercury concentrations would generally be hypothesized to decrease downstream. From W-17-N (upstream of Mendall Marsh) to MM-SE to MM-SW, median sparrow mercury concentrations in 2016 samples by location were 5,000, 6,130, and 5,840 ng/g, respectively (**Table 3-3a**).

The blood effect level recommended in the Penobscot River Risk Assessment and Preliminary Remediation Goal Development (Amec Foster Wheeler 2018b) for methyl mercury concentrations in Nelson's sparrow blood is 2,100 ng/g (Jackson et al. 2011, Fuchsman et al. 2016). From W-17-N (upstream of Mendall Marsh) to MM-SE to MM-SW, the percentage of sparrows with blood mercury concentrations in 2016 above the effect level was 73 percent, 100 percent, and 100 percent, respectively (**Table 3-3a**).

#### *3.2.1.2 2017*

A total of 57 Nelson's sparrows were captured during 2017 for blood sample mercury analysis. Nelson's sparrows were collected from three areas (W-17-N, MM-SE, and MM-SW) in the Penobscot River marsh platform (**Figure 3-3**) and the Pleasant River reference location (**Figure 3-13a**).

Mercury concentrations in Nelson's sparrow ranged from 219 to 618 ng/g (**Figure 3-13a**), with a median of 373 ng/g at the Pleasant River reference location (**Table 3-3a**). In contrast, within the marsh platform, sparrow mercury concentrations ranged from 1,290 ng/g at location MM-SE to

6,010 ng/g at location W-17-N (**Figure 3-3**), with a median concentration for sparrows collected in the Penobscot River marsh platform in 2017 of 2,355 ng/g. Mercury concentrations in juvenile (hatch year) and adult birds are presented by year and location on **Tables 3-3b and 3-3c**.

There is no discernible spatial gradient of mercury concentrations in sparrows in the Penobscot River marsh platform, likely due to the influence of the Mendall Marsh area, as median mercury concentrations would generally be hypothesized to decrease downstream. From W-17-N (upstream of Mendall Marsh) to MM-SE to MM-SW, median sparrow mercury concentrations in 2017 samples by location were 2,465, 2,200, and 2,990 ng/g, respectively (**Table 3-3a**).

The blood effect level recommended in the Penobscot River Risk Assessment and Preliminary Remediation Goal Development (Amec Foster Wheeler 2018b) for mercury concentrations in Nelson's sparrow blood is 2,100 ng/g (Jackson et al. 2011, Fuchsman et al. 2016). From W-17-N (upstream of Mendall Marsh) to MM-SE to MM-SW, the percentage of sparrows with blood mercury concentrations in 2017 above the effect level was 67 percent, 53 percent, and 87 percent, respectively (**Table 3-3a**).

### 3.2.2 Red-winged Blackbird

#### *3.2.2.1 2016*

No red-winged blackbirds were observed at the reference location. Repeated efforts to capture red-winged blackbirds in the Penobscot River marsh platform sites met with minimal success despite targeting perches, nests, appropriate habitat, and other areas observed during the field event to be heavily frequented by individual red-winged blackbirds. A total of three red-winged blackbirds were captured for blood samples during 2016, which were analyzed for mercury. The birds were collected from location W-17-N in the Estuary (**Figure 3-4**).

Mercury concentrations in red-winged blackbirds from location W-17-N were 99.4, 2,500, and 5,850 ng/g (**Figure 3-4**). There is insufficient data to support the spatial gradient analysis of mercury concentrations in red-winged blackbirds in the Estuary in 2016, as only three blood samples were collected from the same sampling location.

The proposed blood effect level recommended in the Penobscot River Risk Assessment and Preliminary Remediation Goal Development (Amec Foster Wheeler 2018b) for mercury concentrations in red-winged blackbird blood is 2,100 ng/g (Jackson et al. 2011, Fuchsman et al. 2016). The percentage of blackbirds with mercury concentrations above the effect level was 67 percent (**Table 3-4a**). Mercury concentrations in juvenile (hatch year) and adult birds are presented by year and location on **Tables 3-4b and 3-4c**.

#### *3.2.2.2 2017*

No red-winged blackbirds were observed at the reference location. Repeated efforts to capture red-winged blackbirds at the marshes on-site met with limited success despite targeting perches, nests, appropriate habitat, and other areas observed to be heavily frequented by individual red-winged blackbirds during the field event. A total of 17 red-winged blackbirds were captured for blood samples during 2017, which were analyzed for mercury. The birds were collected from three areas (W-17-N, MM-SE, and MM-SW) in the Penobscot River marsh platform (**Figure 3-4**).

Within the marsh platform, red-winged blackbird mercury concentrations ranged from 165 ng/g at location W-17-N to 8,460 ng/g at location MM-SW (**Figure 3-4**), with a median concentration for red-winged blackbirds collected in the Penobscot River marsh platform in 2017 of 4,940 ng/g.

There is no discernible spatial gradient of mercury concentrations in red-winged blackbirds in the Penobscot River marsh platform, likely due to the influence of the Mendall Marsh area, as median mercury concentrations would generally be hypothesized to decrease downstream. From W-17-N (upstream of Mendall Marsh) to MM-SE to MM-SW, median red-winged blackbird mercury concentrations in 2017 samples by location were 2,450, 4,425, and 5,880 ng/g, respectively (**Table 3-4a**). Mercury concentrations in juvenile (hatch year) and adult birds are presented by year and location on **Tables 3-4b and 3-4c**.

The proposed blood effect level recommended in the Penobscot River Risk Assessment and Preliminary Remediation Goal Development (Amec Foster Wheeler 2018b) for mercury concentrations in red-winged blackbird blood is 2,100 ng/g (Jackson et al. 2011, Fuchsman et al. 2016). From W-17-N (upstream of Mendall Marsh) to MM-SE to MM-SW, the percentage of red-winged blackbirds with blood mercury concentrations in 2017 above the effect level was 60 percent, 67 percent, and 83 percent, respectively (**Table 3-4a**).

### 3.2.3 American Black Duck

#### *3.2.3.1 2016*

A total of 45 American black ducks were captured for blood and tissue samples during winter 2017, which were analyzed for mercury. All 45 ducks were sampled for blood, and 15 were euthanized for tissue analysis. Black ducks were collected from two areas (Mendall Marsh and South Verona) in the Estuary for blood (**Figure 3-5a**) and breast muscle tissue (**Figure 3-5b**), and from the Frenchman Bay reference location (**Figure 3-14a**).

### *3.2.3.2 American Black Duck Blood*

Mercury concentrations in black duck blood ranged from 11.3 to 109 ng/g at the Frenchman Bay reference location, with a median of 43.5 ng/g (**Table 3-5a; Figure 3-14a**). In contrast, within the Estuary, black duck blood mercury concentrations ranged from 126 ng/g at South Verona to 1,400 ng/g at Mendall Marsh (**Figure 3-5a**), with a median concentration for black duck blood collected in the Estuary in 2017 of 400 ng/g.

### *3.2.3.3 American Black Duck Tissue*

Mercury concentrations in black duck muscle tissue ranged from 10.1 to 47.6 ng/g at the Frenchman Bay reference location, with a median of 44.8 ng/g (**Table 3-5b; Figure 3-14a**). In contrast, black duck muscle tissue mercury concentrations within the Estuary ranged from 121 ng/g at Mendall Marsh to 854 ng/g also at Mendall Marsh (**Figure 3-5b**), with a median concentration for black duck tissue collected in the Estuary in 2017 of 348 ng/g.

### *3.2.3.4 American Black Duck Summary*

There is no discernible spatial gradient of mercury concentrations in black ducks in the Estuary, as the blood and tissue results conflict with the hypothesis that mercury levels would decrease downstream (**Figures 3-5a and 3-5b**). Median duck muscle tissue mercury concentrations in Mendall Marsh (177 ng/g) were lower than at South Verona (441 ng/g) in 2017 (**Table 3-5b**) while median black duck blood concentrations were higher in Mendall Marsh (504 ng/g) than at South Verona (377 ng/g) in 2017 (**Table 3-5a**). It should be noted that the two locations from which ducks were collected, the South Verona and Mendall Marsh areas, have elevated sediment mercury concentrations in comparison to upstream or adjacent areas in the Estuary. These two locations have also shown variable spatial distributions for other biota in relation to other portions of the Estuary.

The MeCDC action level of 200 ng/g for finfish is used here as a benchmark for comparison of human consumption of duck tissue. The percentage of black ducks with breast muscle tissue mercury concentrations in excess of the MeCDC fish tissue action level was 40 percent at Mendall Marsh and 100 percent at South Verona (**Table 3-5b**).

The effect level in blood for American black duck of 2,100 ng/g was established in the ecological risk assessment (Amec Foster Wheeler 2018b). The highest black duck blood sample concentration was 1,400 ng/g in Mendall Marsh (**Figure 3-5a**). The second highest black duck blood samples concentration was 961 ng/g, also from a duck collected in Mendall Marsh. The other sample mercury concentrations were approximately 700 ng/g and lower. The Frenchman

Bay reference location black duck blood sample mercury concentrations were less than 110 ng/g (**Figure 3-14a**). No ducks exceeded the blood effect level.

#### *3.2.3.5 2017*

A total of 45 American black ducks were captured during winter 2017 and were sampled for blood mercury analysis. Black ducks were collected from two areas (Mendall Marsh and South Verona) in the Estuary for blood (**Figure 3-5a**), as well as from the Frenchman Bay reference location (**Figure 3-14a**).

#### *3.2.3.6 American Black Duck Blood*

Mercury concentrations in black duck blood ranged from 21.3 to 86.1 ng/g at the Frenchman Bay reference location, with a median of 55.8 ng/g (**Table 3-5a; Figure 3-14a**). In contrast, within the Estuary, black duck blood mercury concentrations ranged from 50.6 ng/g at South Verona to 459 ng/g at Mendall Marsh (**Figure 3-5a**), with a median concentration for black duck blood collected in the Estuary in 2017 of 228 ng/g.

#### *3.2.3.7 American Black Duck Summary*

Median black duck blood concentrations continue to be higher in Mendall Marsh (275 ng/g) than at South Verona (165 ng/g) in winter of 2018 (**Table 3-5a**), indicating a spatial pattern of mercury concentrations decreasing downstream.

The MeCDC action level of 200 ng/g for finfish is used here as a benchmark for comparison of human consumption of duck tissue. While duck breast muscle tissue was not collected in 2018, the correlation between blood and muscle developed in the 2016 Biota Monitoring Report can be used to estimate breast muscle mercury concentrations (muscle tissue concentrations (ng/g) can be approximated as 0.7956 x blood mercury concentration (ng/g) +25.0515). The percentage of black ducks with estimated breast muscle tissue mercury concentrations in 2018 in excess of the MeCDC fish tissue action level was 80 percent at Mendall Marsh and 27 percent at South Verona.

The effect level in blood for American black duck of 2,100 ng/g was established in the ecological risk assessment (Amec Foster Wheeler 2018b). The highest black duck blood sample concentration was 1,400 ng/g in Mendall Marsh in winter of 2016-2017 (**Figure 3-5a**). In winter of 2018, the highest duck blood sample was 459 ng/g, in samples collected at approximately the same time of year as samples collected in 2017. No ducks exceeded the blood effect level.

## 3.3 Aquatic Invertebrate Monitoring Results

### 3.3.1 Polychaetes

#### *3.3.1.1 2016*

A total of 30 composite polychaete samples were collected and analyzed (whole body) for mercury and methyl mercury during 2016. The polychaetes were collected from five areas in the Penobscot River Estuary (BO-04, OB-05, Mendall Marsh [MMPOLY in 2016], ES-13, and ES-FP) (**Figures 3-6a and 3-6b**) and the Frenchman Bay reference location (**Figure 3-14a and 3-14b**).

Mercury concentrations in four of the five polychaete samples collected at the Frenchman Bay reference location were non-detect, while one sample had a mercury concentration of 3.18 ng/g (**Figure 3-14a**). Within the Estuary, polychaete mercury concentrations ranged from 12.8 ng/g at location ES-13 to 321 ng/g at location MMPOLY (**Figure 3-6a**), with a median concentration for polychaetes collected in the Estuary in 2016 of 142 ng/g.

There is a general north-south spatial gradient of mercury concentrations in polychaetes in the Estuary, as median mercury concentrations in polychaetes are substantially lower at the two most downstream locations, South Verona and Fort Point, compared to the three upstream locations, BO-04, OB-05, and Mendall Marsh. The three upstream locations are similar in concentration magnitude, which drops sharply to the two downstream locations that are of similar magnitude (**Figure 3-6a**). From upstream to downstream, median polychaete mercury concentrations in 2016 samples by location were 185, 215, 190, 24.7, and 24.5 ng/g, respectively (**Table 3-6**).

Methyl mercury was not detected in polychaetes collected at the Frenchman Bay reference location (**Figure 3-14b**). Methyl mercury concentrations in polychaetes collected from the Estuary ranged from non-detect at locations ES-FP and ES-13 to 15.7 ng/g, also at location ES-FP (**Figure 3-6b**), with a median concentration of 8.2 ng/g. The three upstream locations are similar in methyl mercury concentration magnitude and generally higher than the two downstream locations, which are also of similar magnitude (**Figure 3-6b**), which matches the concentration trend for mercury. From upstream to downstream, median polychaete methyl mercury concentrations in 2016 samples by location were 8.3, 12.7, 9.9, 1.5, and 5.3 ng/g, respectively (**Table 3-6**). The concentration of methyl mercury was 8.6 percent (mean) of mercury concentrations in polychaete composite samples collected in 2016.

#### *3.3.1.2 2017*

A total of 60 composite polychaete samples were collected and analyzed (whole body) for mercury during 2017. The polychaetes were collected from eleven areas in the Penobscot River Estuary (OB-01, Mendall Marsh [MM-MR in 2017], Bucksport/Fort Knox [BFK], Porcupine Island in the channel east of Verona Island [PI], ES-02E, ES-15, VI-W, ES-13, SVE-02INT, ES-03, and ES-FP) (**Figures 3-6a and 3-6b**) and the Frenchman Bay reference location (**Figure 3-14a**).

Mercury concentrations in polychaete samples collected at the Frenchman Bay reference location ranged from 7.17 to 8.82 ng/g, with a median concentration of 7.66 ng/g (**Table 3-6; Figure 3-14a**). Within the Estuary, polychaete mercury concentrations ranged from 8.94 ng/g at location ES-FP to 59.2 ng/g at location MM-MR (**Figure 3-6a**), with a median concentration for polychaetes collected in the Estuary in 2017 of 25.0 ng/g.

Polychaetes were identified to the family level in 2017. A comparison of mercury and methyl mercury historical samples, 2016 composite samples, and 2017 samples identified to species across all locations is provided on **Figure 3-18**. Samples collected in 2017 were typically in the same concentration range as historical samples.

Concentrations are generally consistent for all sampling locations with some of the variability potentially explained by whether an area was depositional (having higher concentrations relative to nearby samples not in a depositional area) or not (**Figure 3-6a**). From upstream to downstream, median polychaete mercury concentrations in 2017 samples by location were 30.6, 53.8, 17.6, 37.1, 29.8, 30.5, 20.1, 19.5, 24.7, 29.7, and 12.0 ng/g, respectively (**Table 3-6**).

Methyl mercury was not analyzed in polychaetes collected at the Frenchman Bay reference location. Methyl mercury concentrations in polychaetes collected from the Estuary ranged from 3.4 ng/g at location BFK to 17.7 ng/g at location ES-02E (**Figure 3-6b**), with a median concentration of 9.50 ng/g. Concentrations are generally consistent for all sampling locations (**Figure 3-6b**). From upstream to downstream, median polychaete methyl mercury concentrations in 2017 samples by location were 10.4, 6.10, 8.70, 11.6, 11.4, and 9.7 ng/g, respectively (**Table 3-6**). The concentration of methyl mercury was 35 percent (mean) of mercury concentrations in polychaete composite samples collected in 2017.

### 3.3.2 Blue Mussel

#### *3.3.2.1 2016*

A total of 80 blue mussel samples were collected and analyzed (whole body) for mercury during 2016. The mussels were collected from four areas (ES-15, ES-13, ES-03, and ES-FP) in the Estuary (**Figure 3-7**).

Mercury concentrations in mussels within the Estuary ranged from 40.0 ng/g at location ES-FP to 138 ng/g at location ES-03 (**Figure 3-7**), with a median concentration for blue mussels collected in the Estuary in 2016 of 63.3 ng/g.

There is no discernible spatial gradient of mercury concentrations in mussels in the Estuary, as the median mercury concentrations are of a similar magnitude among locations (**Figure 3-7**). A lack of spatial gradient may be attributable to the filter-feeding nature of the mussel, as opposed to the sediment-associated lifestyles of other biota or the prey of other biota. From upstream to downstream, median blue mussel mercury concentrations in 2016 samples by location were 56.9, 60.9, 77.5, and 58.9 ng/g, respectively (**Table 3-7**). The MeCDC action level of 200 ng/g for finfish is used here as a benchmark for comparison of human consumption of blue mussels. The percentage of blue mussels mercury concentrations in excess of the MeCDC fish tissue action level from upstream to downstream was 0 percent, 0 percent, 0 percent, and 0 percent (**Table 3-7**).

#### *3.3.2.2 2017*

A total of 91 blue mussel samples were collected and analyzed (whole body) for mercury during 2017. The mussels were collected from four areas (ES-15, ES-13, ES-03, ES-FP) in the Estuary (**Figure 3-7**) and the Frenchman Bay reference location (**Figure 3-14a**). If individual blue mussels did not meet the necessary sample weight, individual shellfish were composited to compose a sample. Seventy-three of the samples were individual blue mussels, and 18 were composite samples. The number of blue mussels in each composite ranged from two to three. For the Frenchman Bay reference samples, 12 were composite samples and eight were individual samples. Fourteen individual and six composite samples were collected from ES-13. The remaining samples of blue mussels were individual samples. The use of composite and individual samples increases the sample size for statistical analyses.

Mercury concentrations in blue mussel samples collected at the Frenchman Bay reference location ranged from 5.46 to 13.0 ng/g, with a median concentration of 7.56 ng/g (**Table 3-7; Figure 3-14a**). Mercury concentrations in mussels within the Estuary ranged from 39.1 ng/g at location ES-FP to 207 ng/g at location ES-03 (**Figure 3-7**), with a median concentration for blue mussels collected in the Estuary in 2017 of 86.1 ng/g.

There is no discernible spatial gradient of mercury concentrations in mussels in the Estuary, as the median mercury concentrations are of a similar magnitude among locations (**Figure 3-7**). A lack of spatial gradient may be attributable to the filter-feeding nature of the mussel, as opposed to the sediment-associated lifestyles of other biota or the prey of other biota. Additionally, mussel sampling locations are within Penobscot Bay, so a spatial gradient may not be discernible due to mixing. From upstream to downstream, median blue mussel mercury concentrations in 2017 samples by location were 71.4, 86.5, 92.3, and 89.3 ng/g, respectively (**Table 3-7**).

The MeCDC action level of 200 ng/g for finfish is used here as a benchmark for comparison of human consumption of blue mussels. The percentage of blue mussels mercury concentrations in excess of the MeCDC fish tissue action level from upstream to downstream was 0 percent, 0 percent, 5 percent, and 0 percent (**Table 3-7**).

### 3.3.3 Lobster

Maine DMR designated a lobster fishing closure area in Penobscot Bay to as far south as a line from Squaw Point to Perkins Point (**Figure 3-8**) in response to elevated mercury concentrations in lobster tissue collected prior to 2015. Lobsters typically forage readily on the bait in lobster traps and represent mercury concentrations in dietary items whether bait or natural prey items. In the absence of baited traps (e.g., 2016 and 2017 in the lobster closure area), the diet of lobsters while in the closure area is composed of natural prey items and lobsters are not subject to harvesting pressure. Four of the five sampling locations for lobsters are within the lobster closure area; Harborside is not in the lobster closure area. Lobster movements/migration and interannual variability also affect lobster tail concentrations.

#### *3.3.3.1 2016*

A total of 100 American lobsters were collected for mercury analysis of the tails in 2016. Lobsters were collected from five areas in the Estuary (**Figure 3-8**).

Mercury concentrations in lobsters ranged from 44.4 ng/g at location HB-01 (Harborside) to 1,320 ng/g at South Verona (**Figure 3-8**), with a median concentration for lobsters collected in the Estuary in 2016 of 176 ng/g.

There is a general north-south spatial gradient of mercury concentrations in lobster in the Estuary, as median mercury concentrations generally decrease downstream (**Figure 3-8**). From upstream to downstream, median lobster mercury concentrations in 2016 samples by location were 207, 366, 180, 164, and 102 ng/g, respectively (**Table 3-8**). The median lobster mercury concentration of 366 ng/g for the South Verona area follows the pattern of elevated mercury concentrations in other biota in this area relative to other areas in which those biota are sampled.

As with mercury concentrations, the percentage of lobster with mercury concentrations in excess of the MeCDC fish tissue action level of 200 ng/g generally decreases downstream. From upstream to downstream, the percentage of lobster with mercury concentrations at or above the action level were 55 percent, 90 percent, 35 percent, 20 percent, and 0 percent in 2016 (**Table 3-8**). Again, it should be noted that the percentage of lobster mercury concentrations above the action level at South Verona (90 percent) does not follow the general decreasing pattern downstream.

#### *3.3.3.2 2017*

A total of 120 American lobsters were collected for mercury analysis of the tails in 2017. Lobsters were collected from five areas in the Estuary (**Figure 3-8**) and the Frenchman Bay reference location (**Figure 3-14a**). Lobster traps were also set in the Union River, just west of Frenchman Bay, which would have been designated a reference location for lobsters. No lobster trap buoys of local lobstermen were seen in the vicinity. Traps deployed captured no lobsters and many green crabs.

Mercury concentrations in lobster samples collected at the Frenchman Bay reference location ranged from 26.8 to 64.8 ng/g, with a median concentration of 38.7 ng/g (**Table 3-8; Figure 3-14a**). Mercury concentrations in lobsters ranged from 50.3 ng/g at location HB-01 (Harborside) to 1,730 ng/g at Odom Ledge (**Figure 3-8**), with a median concentration for lobsters collected in the Estuary in 2017 of 218 ng/g.

There is not a strong north-south spatial gradient of mercury concentrations in lobster in the Estuary, as median mercury concentrations generally decrease downstream (**Figure 3-8**). From upstream to downstream, median lobster mercury concentrations in 2017 samples by location were 239, 291, 223, 244, and 92.7 ng/g, respectively (**Table 3-8**). The median lobster mercury concentration of 291 ng/g for the South Verona area follows the pattern of elevated mercury concentrations in other biota in this area relative to other areas in which those biota are sampled.

The percentage of lobster with mercury concentrations in excess of the MeCDC fish tissue action level of 200 ng/g generally decreases downstream. From upstream to downstream, the percentage of lobster with mercury concentrations at or above the action level were 60 percent, 75 percent, 60 percent, 65 percent, and 5 percent in 2017 (**Table 3-8**). Again, it should be noted that the percentage of lobster mercury concentrations above the action level at South Verona (75 percent) does not follow the general decreasing pattern downstream.

## 3.4 FISH MONITORING RESULTS

### 3.4.1 Mummichog

#### *3.4.1.1 2016*

A total of 65 mummichog samples were collected and analyzed (whole body) for mercury during 2016. Mummichog were collected from four areas (BO-04, OB-05, OB-01, and Mendall Marsh) in the Estuary (**Figure 3-9**) and the Frenchman Bay reference location (**Figure 3-14a**). If individual mummichogs did not meet the necessary sample weight, individual fish were composited to compose a sample. Twenty-six of the samples were individual mummichog, and 39 were composite samples. The number of fish in each composite ranged from two to six. Sixteen individual and four composite samples were collected from BO-04. Six individual and 14 composite samples were collected from OB-05. Three individual and one composite samples were collected from Mendall Marsh. One composite sample was collected from OB-01. One individual and 19 composite samples were collected from the Frenchman Bay reference location. The use of composite and individual samples increases the sample size for statistical analyses. Fish consume many sizes of fish and are exposed to the range of concentrations represented by these composite samples.

Mercury concentrations in mummichog ranged from 4.94 to 13.5 ng/g at the Frenchman Bay reference location, with a median of 7.96 ng/g (**Table 3-9; Figure 3-14a**). In contrast, within the Estuary, mummichog mercury concentrations ranged from 48.9 ng/g at location OB-05 to 249 ng/g in Mendall Marsh (**Figure 3-9**), with a median concentration for mummichogs collected in the Estuary in 2016 of 87.6 ng/g.

There is a general north-south spatial gradient of mercury concentrations in mummichog in the Estuary, as median mercury concentrations generally increase downstream (**Figure 3-9**). However, it should be noted that the upstream and downstream locations are of a similar magnitude, and the downstream locations are associated with Mendall Marsh, where sediment mercury concentrations are elevated in comparison to adjacent areas. From upstream to downstream, median mummichog mercury concentrations in 2016 samples by location were 71.2, 89.1, 134 (OB-01 – one sample), and 159 ng/g (Mendall Marsh – four samples), respectively (**Table 3-9**).

The tissue toxicity level of 440 ng/g for mummichog based on mortality was established in the ecological risk assessment (Amec Foster Wheeler 2018b). The percentage of mummichog mercury concentrations in excess of the effect level was 0 percent at BO-04, OB-05, OB-01, and Mendall Marsh (**Table 3-9**).

#### *3.4.1.2 2017*

A total of 75 mummichog samples were collected and analyzed (whole body) for mercury during 2017. Mummichog were collected from four areas (BO-04, OB-05, OB-01, and Mendall Marsh) in the Estuary (**Figure 3-9**) and the Frenchman Bay reference location (**Figure 3-14a**). If individual mummichogs did not meet the necessary sample weight, individual fish were composited to compose a sample. Thirty-eight of the samples were individual mummichog, and 37 were composite samples. The number of fish in each composite ranged from two to four. A single sample was collected at BO-04. Four individual and 16 composite samples were collected from OB-05. Nineteen individual samples were collected from Mendall Marsh. Fourteen individual and one composite sample were collected from OB-01. Twenty composite samples were collected from the Frenchman Bay reference location. The use of composite and individual samples increases the sample size of statistical analyses. Fish consume many sizes of fish and are exposed to the range of concentrations represented by these composite samples.

Mercury concentrations in mummichog ranged from 4.44 to 8.36 ng/g at the Frenchman Bay reference location, with a median of 6.50 ng/g (**Table 3-9; Figure 3-14a**). In contrast, within the Estuary, mummichog mercury concentrations ranged from 37.4 ng/g at location OB-01 to 256 ng/g in Mendall Marsh (**Figure 3-9**), with a median concentration for mummichogs collected in the Estuary in 2017 of 94.4 ng/g.

There is a general north-south spatial gradient of mercury concentrations in mummichog in the Estuary, as median mercury concentrations generally increase downstream (**Figure 3-9**). However, it should be noted that the upstream and downstream locations are of a similar magnitude, and the downstream locations are associated with Mendall Marsh, where sediment mercury concentrations are elevated in comparison to adjacent areas. From upstream to downstream, median mummichog mercury concentrations in 2017 samples by location were 63.4 (one sample at BO-04), 76.7, 109, and 109 ng/g, respectively (**Table 3-9**). A single sample was collected at location BO-04.

The tissue toxicity level of 440 ng/g for mummichog based on mortality was established in the ecological risk assessment (Amec Foster Wheeler 2018b). The percentage of mummichog mercury concentrations in excess of the effect level was 0 percent at BO-04, OB-05, OB-01, and Mendall Marsh (**Table 3-9**).

### 3.4.2 Rainbow Smelt

#### *3.4.2.1 2016*

A total of 62 rainbow smelt samples were collected and analyzed (whole body) for mercury during 2016. Smelt were collected from five areas (OB-05, OB-04, OB-01, ES-15, and ES-FP) in the Estuary (**Figure 3-10**) and the Frenchman Bay reference location (**Figure 3-14a**). If individual smelt did not meet the necessary sample weight, individual fish were composited to form a sample. The majority of samples were individual smelt (41 samples) and 21 were composite samples. The number of fish in each composite ranged from two to three. Individual samples were collected from OB-05 (one sample), OB-04 (five samples), OB-01 (15 samples), and ES-15 (one sample). Samples for smelt were obtained from NOAA trawls that spanned a stretch of river and were matched as closely as possible to target locations identified in the 2016 Biota Monitoring Plan (Amec Foster Wheeler 2017b). Sampling locations OB-04 and ES-15 are closest to the stretches covered by the NOAA trawls, but were not original target locations. Eighteen individual and two composite samples were collected from ES-FP. One individual and 19 composite samples were collected from the Frenchman Bay reference location. The use of composite and individual samples increases the sample size of statistical analyses. Fish consume many sizes of fish and are exposed to the range of concentrations represented by these composite samples.

Mercury concentrations in smelt ranged from 5.07 to 8.37 ng/g at the Frenchman Bay reference location, with a median of 6.64 ng/g (**Table 3-10; Figure 3-14a**). In contrast, within the Estuary, smelt mercury concentrations ranged from 27.1 ng/g at location ES-FP to 201 ng/g at location OB-05 (only one smelt sample was collected at this location) (**Figure 3-10**), with a median concentration for smelt collected in the Estuary in 2016 of 60.6 ng/g.

There is no discernible spatial gradient of mercury concentrations in smelt in the Estuary. Although the median mercury concentrations are of a similar magnitude among locations, median mercury concentrations are lower at the two downstream locations than at two of the three upstream locations (**Figure 3-10**). The lack of an observed spatial gradient may be attributable to the large home range of the species, approximately 16.6 miles, which encompasses a substantial portion of the project site. From upstream to downstream, median smelt mercury concentrations in 2016 samples by location were 201 (OB-05 – one sample), 54.9 (OB-04), 90.8 (OB-01 just outside of Mendall Marsh), 38.4 (ES-15 – one sample), and 55.4 ng/g (ES-FP), respectively (**Table 3-10**).

The MeCDC action level of 200 ng/g for finfish is used here as a benchmark for comparison of human consumption of rainbow smelt. The percentage of rainbow smelt mercury concentrations in excess of the effect level from upstream to downstream was 100 percent (one sample), 0 percent, 0 percent, 0 percent, and 0 percent, respectively (**Table 3-10**).

#### *3.4.2.2 2017*

A total of 85 rainbow smelt samples were collected and analyzed (whole body) for mercury during 2017. Smelt were collected from four areas (OB-05, OB-01, ES-13, and ES-FP) in the Estuary (**Figure 3-10**) and the Frenchman Bay reference location (**Figure 3-14a)**. Six samples for smelt at OB-01 were obtained from NOAA trawls that spanned a stretch of river and matched as closely as possible to this target location. While the smelt captured by NOAA at OB-01 tended to be larger than the smelt captured by seining in 2016, the lengths and mercury concentrations were within the range of historical data and of fish captured at other locations in the Estuary an thus these NOAA smelt samples were deemed usable for inclusion in the evaluation. If individual smelt did not meet the necessary sample weight, individual fish were composited to form a sample. The majority of samples were composite samples (51 samples) and 34 were individual smelt. The number of fish in each composite ranged from two to four. Individual samples were collected from OB-01 (six samples) and ES-13 (one sample). Two composite samples (one with two fish and one with three fish) were collected at OB-05. These two composite samples were split into five individual fish samples because sample mass was sufficient for each individual fish (**Appendix E**). Twelve individual and eight composite samples were collected from ES-FP. Ten individual and 10 composite samples were collected from the Frenchman Bay reference location. The use of composite and individual samples increases the sample size of statistical analyses. Fish consume many sizes of fish and are exposed to the range of concentrations represented by these composite samples.

Mercury concentrations in smelt ranged from 6.57 to 26.2 ng/g at the Frenchman Bay reference location, with a median of 11.4 ng/g (**Table 3-10; Figure 3-14a**). In contrast, within the Estuary, smelt mercury concentrations ranged from 26.4 ng/g at location ES-13 to 207 ng/g at location ES-FP (**Figure 3-10**), with a median concentration for smelt collected in the Estuary in 2017 of 46.5 ng/g.

There is no discernible spatial gradient of mercury concentrations in smelt in the Estuary. In addition, median mercury concentrations are of a similar magnitude among locations (**Figure 3-10**). The lack of an observed spatial gradient may be attributable to the large home range of the species, approximately 16.6 miles, which encompasses a substantial portion of the project site. From upstream to downstream, median smelt mercury concentrations in 2017 samples by location were 83.5, 46.7, 37.8, and 72.0 ng/g, respectively (**Table 3-10**).

The MeCDC action level of 200 ng/g for finfish is used here as a benchmark for comparison of human consumption of rainbow smelt. The percentage of rainbow smelt mercury concentrations in excess of the effect level from upstream to downstream was 0 percent, 0 percent, 0 percent, 0 percent, and 5 percent, respectively (**Table 3-10**).

### 3.4.3 American Eel

#### *3.4.3.1 2016*

A total of seven American eel were collected and analyzed (whole body) for mercury during 2016. Eels were collected from three areas (BO-04, OB-05, and OB-01) in the Estuary (**Figure 3-11**). All eel met the target sample weight and were analyzed as individual samples.

Mercury concentrations in American eels ranged from 391 ng/g at location OB-05 to 1,370 ng/g at location BO-04 (**Figure 3-11**), with a median concentration for eels collected in the Estuary in 2016 of 461 ng/g. No attempt was made to collect eels at the historically established reference location, OV-04, in 2016; collection efforts were instead increased in the Estuary locations in order to attempt to collect additional site data due to a low number of samples.

Insufficient 2016 data are available to discern a spatial gradient of mercury concentrations in eel in the Estuary. From upstream to downstream, median American eel mercury concentrations in 2016 samples by location were 1,370, 461, and 394 ng/g, respectively (**Table 3-11**).

A background threshold value was calculated for American eels collected historically (2007 to 2012) and in 2017 in the OV reach. The resulting calculated background threshold value was higher than the maximum detected mercury concentration of eels and thus the calculation defaulted to the use of the maximum detected concentration as the background threshold value. The maximum detected concentration collected in the OV reach in American eel of 320 ng/g (2017) is used for comparison with mercury concentrations in eel collected downstream of the OV reach. The MeCDC fish tissue action level of 200 ng/g for finfish is not applied to eel because the background reference tissue value for eel of 320 ng/g is higher than the fish tissue action level because screening to a tissue level below background is not reasonable and the decision was made to screen against the higher of the two values. American eels in the OV reach tend to be longer (and older) than eels captured at downstream locations. All seven of the American eels collected and analyzed in 2016 were above the maximum background tissue mercury concentration for OV reach data (**Figure 3-11**).

#### *3.4.3.2 2017*

A total of 46 American eel were collected and analyzed (whole body) for mercury during 2017. Eels were collected from two areas in the Estuary (BO-04 and OB-05 on **Figure 3-11**) and the reference location OV-04 (**Figure 3-11).** Eel collection in 2017 was limited by availability of eels at Estuary locations (postulated by local fishermen as being related to green crab abundance) and water depths at OV-04 (eel traps set in deeper water than found at OV-04 typically were more successful than traps in shallower water environments). All eel met the target sample weight and were analyzed as individual samples.

Mercury concentrations in eel ranged from 142 to 320 ng/g at the reference location, with a median of 169 ng/g (**Table 3-11; Figure 3-11**). Within the Estuary, mercury concentrations in American eels ranged from 80 ng/g at location OB-05 to 1,320 ng/g at location BO-04 (**Figure 3-11**), with a median concentration for eels collected in the Estuary in 2017 of 404 ng/g.

Insufficient data, from 2017, are available to discern a spatial gradient of mercury concentrations in eel in the Estuary. From upstream to downstream, median American eel mercury concentrations in 2017 samples by location were 491 and 263 ng/g, respectively (**Table 3-11**).

Thirty-three percent of the eel samples collected in 2017 in the OV reach are above the MeCDC fish tissue action level of 200 ng/g. A background threshold value was calculated for American eels collected historically (2007 to 2012) and in 2017 in the OV reach resulting in a value higher than the action level of 200 ng/g, and so the maximum mercury concentration of eels collected in 2017 in the OV reach in American eel of 320 ng/g is used for comparison with mercury concentrations in eel collected downstream of the OV reach. The MeCDC action level of 200 ng/g for finfish is not applied to eel because reference tissue value of 320 ng/g is higher than the freshwater finfish action level. From upstream to downstream, the percentage of American eel with mercury concentrations at or above the maximum background tissue mercury concentration for OV reach data were 95 percent and 30 percent in 2017 (**Table 3-11**).

### 3.4.4 Tomcod

#### *3.4.4.1 2016*

A total of 55 Atlantic tomcod were collected and analyzed (whole body) for mercury during 2016. Tomcod were collected from five areas (BO-04, OB-05, OB-01, ES-13, and ES-FP) in the Estuary (**Figure 3-12**) and the Frenchman Bay reference location (**Figure 3-14a**). All tomcod met the target sample weight and were analyzed as individual samples.

The tomcod mercury concentration (one sample) at the Frenchman Bay reference location was 36.5 ng/g (**Table 3-12; Figure 3-14a**). In contrast, within the Estuary, tomcod mercury concentrations ranged from 55.5 ng/g at location ES-FP near Fort Point to 315 ng/g at location BO-04 (**Figure 3-12**), with a median concentration for tomcod collected in the Estuary in 2016 of 154.5 ng/g.

There is a general north-south spatial gradient of mercury concentrations in tomcod in the Estuary, as median mercury concentrations generally decrease downstream (**Figure 3-12**). From upstream to downstream, median tomcod mercury concentrations in 2016 samples by location were 308, 152, 174, 103, and 64.9 ng/g, respectively (**Table 3-12**).

The percent of tomcod with mercury concentrations in excess of the MeCDC 200 ng/g fish tissue action level generally decreases downstream. From upstream to downstream, the percent of tomcod with mercury concentrations exceeding the action level was 75 percent, 28 percent, 32 percent, 9 percent, and 0 percent (**Table 3-12**).

#### *3.4.4.2 2017*

A total of 60 Atlantic tomcod were collected and analyzed (whole body) for mercury during 2017. Tomcod were collected from five areas (BO-04, OB-05, OB-01, ES-13, and ES-FP) in the Estuary (**Figure 3-12**). No tomcod were collected in the Frenchman Bay reference location despite efforts to capture this species. All tomcod met the target sample weight and were analyzed as individual samples.

Tomcod mercury concentrations ranged from 32.7 ng/g at location ES-13 to 413 ng/g at location OB-01 (**Figure 3-12**), with a median concentration for tomcod collected in the Estuary in 2017 of 138 ng/g.

There is a general north-south spatial gradient of mercury concentrations in tomcod in the Estuary, as median mercury concentrations generally decrease downstream (**Figure 3-12**). From upstream to downstream, median tomcod mercury concentrations in 2017 samples by location were 157, 125, 171, 60.2, and 37.2 ng/g (ES-FP – one sample), respectively (**Table 3-12**).

The percent of tomcod with mercury concentrations in excess of the MeCDC 200 ng/g fish tissue action level generally decreases downstream. From upstream to downstream, the percent of tomcod with mercury concentrations above the action level was 13 percent, 25 percent, 40 percent, 27 percent, and 0 percent in 2017 (**Table 3-12**).

# 4.0 TEMPORAL TRENDS OF MERCURY IN BIOTA

Throughout this section, figures with data and regression statistics are referenced. **Figure 4-0** presents a figure legend to aid in the interpretation of **Figure 4-1 through Figure 4-76**.

Biota such as reference and site terrestrial insects, reference and site spiders, reference Nelson's sparrows, reference red-winged blackbirds, and reference and site polychaetes were not statistically evaluated for one of the following reasons: 1) insufficient data (less than three years of data with more than one sample); 2) data collected from different locations in different years; and/or 3) data were collected differently (i.e., composite of multiple families vs. composite of individual genera/families). Data with a mix of composite and individual samples are included in the statistical evaluations because composites consist of similar sized individuals, and are appropriately representative of samples composed of single individuals (**Appendix G-3**). The data are presented on figures with natural log (Ln) transformed concentrations so that concentrations can be compared across species in addition to interpreting the temporal trends. Figure titles indicate whether a statistical temporal trend evaluation was performed (e.g., loglinear regression) or not (e.g., Ln mercury concentrations).

For the statistical evaluation figures in this section, the coefficient of determination ($R^2$) values indicate how much the independent variable, in this case year, can predict the variability of the dependent variable (mercury concentration). While $R^2$ (i.e., $R^2$ or adjusted $R^2$) values are indicative of fit (and usefulness for predictive purposes), an adjusted $R^2$ value approaching zero does not mean the regression is invalid or not useful. Interpretation of the validity of regression output is based on the p-value which is a test of the hypothesis that the slope is not significantly different than zero. If the p-value is less than 0.05, the slope of the regression is significantly different than zero (with 95 percent confidence) and indicates whether concentrations are increasing or decreasing through time. Regressions where the p-value is between 0.05 and 0.10 are considered to be nearing significance and are highlighted by drawing a dashed line on the figure rather than a solid line (**Figure 4-0**); however, a designation of "statistically significant" is not given to these cases. Regression coefficients and statistics are reported on each figure.

$R^2$ values describe the variability of the data relative to the best fit line, as described by the regression equation provided on the figures. Much variability amongst data points is expected given that biota mercury concentrations are influenced by many factors such as prey concentrations, individual home range, habitat, and a variety of life history traits. There are numerous influencing factors that result in interannual variability. Considering these potential influences, if a statistically significant trend of mercury and year is shown ($p<0.05$ or $p<0.10$), then mercury concentrations are likely changing from year to year (i.e., with the passage of time), even if the $R^2$ for the regression is low. This interpretation means that the slope of the concentration line is significantly downward over time but the samples have a high degree of variability and do not appear on or close to the line. The trend in concentration is still significantly downward.

For additional information on the statistical evaluation, see Section 2.6.

## 4.1 TERRESTRIAL INVERTEBRATES

### 4.1.1 Terrestrial Insects

Tissue composited from terrestrial insects was collected from the reference location on the Pleasant River in 2017, co-located with the songbird samples. Samples collected in 2017 were typically composited by taxa; however, one sample per location was a composite of multiple taxa. Terrestrial insects were historically sampled in 2009 along the Spurwink River near Cape Elizabeth, Maine. Terrestrial insects at the Pleasant River and Spurwink River locations typically had historical average mercury tissue concentrations of approximately 29 ng/g, but terrestrial insects had an average mercury tissue concentration of 16.5 ng/g in 2017 (**Table 3-1; Figure 4-1**). No further statistical analysis was conducted to compare these data because samples were collected from multiple locations and in a limited number of years.

Terrestrial insects at the Pleasant River and Spurwink River locations typically had average methyl mercury tissue concentrations of approximately 14 to 19 ng/g (**Table 3-1**; **Figure 4-2**). Six samples at Spurwink River had methyl mercury tissue concentrations that were non-detect (below the detection limit). The five terrestrial insect samples collected at Pleasant River in 2017 had detected methyl mercury concentrations. No further statistical analysis was conducted to compare these data because samples were collected from multiple locations and in a limited number of years.

Tissue composited from terrestrial insects was collected from two Mendall Marsh locations (MM-SE and MM-SW) and from W-17-N in 2009, 2016, and 2017 (**Figure 2-1**; figure presents 2016 and 2017 locations only). Terrestrial insect tissue from the Estuary typically exceeded mercury concentrations in insects sampled at the Pleasant River and Spurwink River reference locations. Terrestrial insects show much intra- and interannual variability in tissue mercury concentrations (**Table 3-1; Figure 4-3 through Figure 4-6**). Flies, particularly biting flies like horse and deer flies, tended to have higher mercury concentrations than other terrestrial insects (**Figure 3-15a and 3-16a**). No further statistical analysis was conducted to compare these data because limited data were available.

Terrestrial insect tissue methyl mercury concentrations from the Estuary typically were similar to insects sampled at the Pleasant River and Spurwink River reference locations. Terrestrial insects show much intra- and interannual variability in tissue methyl mercury concentrations (**Table 3-1; Figure 4-7 through Figure 4-10**). Flies, particularly biting flies like horse and deer flies, tended to have higher methyl mercury concentrations than other terrestrial insects (**Figure 3-15b and 3-16b**). No further statistical analysis was conducted to compare these data because limited data were available.

### 4.1.2 Spiders

Tissue composited from spiders was collected from the reference location on the Pleasant River in 2017, so that samples were co-located with songbird samples. Spiders were historically sampled in 2009 along the Spurwink River near Cape Elizabeth, Maine. Spiders at the Pleasant River and Spurwink River locations typically had average mercury tissue concentrations of approximately 35 to 55 ng/g (**Table 3-2**; **Figure 4-11**). All reference spider samples had detected mercury concentrations. No further statistical analysis was conducted to compare these data because samples were collected from multiple locations and in a limited number of years.

Spiders at the Spurwink River location typically had average methyl mercury tissue concentrations of approximately 25 ng/g (**Table 3-2**). Spiders at the Pleasant River location show much interannual variability, with spiders averaging 29 ng/g in 2016 and 60 ng/g in 2017 (**Figure 4-12**). All reference spider samples had detected methyl mercury concentrations. No further statistical analysis was conducted to compare these data because samples were collected from multiple locations and in a limited number of years.

Tissue composited from spiders was collected from two Mendall Marsh locations (MM-SE and MM-SW) in 2009, 2010, 2016, and 2017, and from W-17-N in 2009, 2016, and 2017 (**Figure 2-1**; figure presents 2016 and 2017 locations only). Spider tissue from the Estuary typically exceeded mercury concentrations in spiders sampled at the Pleasant River and Spurwink River reference locations (**Figure 4-13 through Figure 4-16**). Spiders showed little intra- and interannual variability between samples collected in 2009, 2016, and 2017, but 2010 shows a difference in tissue mercury concentrations from the other years (**Table 3-2**). No further statistical analysis was conducted to compare these data because limited years of data were available and sample composites were collected differently.

Spider tissue from the Estuary typically exceeded methyl mercury concentrations in spiders sampled at the Pleasant River and Spurwink River reference locations. Spiders showed little intra- and interannual variability in tissue methyl mercury concentrations (**Table 3-2; Figure 4-17**

**through Figure 4-20**). No further statistical analysis was conducted to compare these data because limited years of data were available and sample composites were collected differently.

## 4.2 BIRDS

### 4.2.1 Nelson's Sparrow

The reference location on the Pleasant River was established in 2012 by the PRMS and sampled again in 2016 and 2017. No statistical analysis was conducted for this site. Other Nelson's sparrow samples were collected by the PRMS from 2007 to 2010 and in 2012 on Mount Desert Island and at Tunk Lake (Downeast Maine), along the coast in southern Maine (Spurwink River, Scarborough River, and Moody Beach areas), and New Hampshire (Great Bay area). Nelson's sparrows at the Pleasant River reference location typically had blood mercury concentrations less than 1,000 ng/g (**Figure 4-21a**). Other historical Nelson's sparrow samples collected by the PRMS outside of the Estuary typically showed concentrations ranging from 124 ng/g to 1,413 ng/g. Three reference birds (one bird was sampled twice within two weeks) had blood mercury concentrations above this range (i.e., 2,268 ng/g, 3,590 ng/g, 6,040 ng/g, and 6,337 ng/g).

Blood from Nelson's sparrows was collected from two Mendall Marsh locations (MM-SE and MM-SW) from 2006 to 2010, 2012, 2016, and 2017 and from W-17-N from 2008 to 2010, 2012, 2016, and 2017 (**Figure 2-1**; figure presents 2016 and 2017 locations only). Nelson's sparrow blood from the site exceeded mercury concentrations in birds sampled at reference locations. Nelson's sparrows show much interannual variability in blood mercury concentrations (**Table 3-3a**), and a decline in blood mercury concentrations when sampling locations W-17-N, MM-SE, and MM-SW are considered as a combined data set (**Figure 4-22a**). Mercury concentrations have not changed significantly in MM-SE (**Figure 4-23a**), but show significant decreases in MM-SW (**Figure 4-24a**) and at W-17-N (**Figure 4-25a**). Mercury concentrations in blood of Nelson's sparrows increase from June to July (duration on the marsh), but blood mercury concentrations in June show a significant decline since 2006 (**Figure 4-26a**).

Blood mercury concentrations typically differ between juvenile (i.e., hatch year) and adult birds due to exposure duration. An insufficient number of juvenile birds was collected to perform statistical analysis of blood mercury concentrations in juvenile Nelson's sparrows at any given location. Blood mercury concentrations in hatch year birds are presented on **Figure 4-22b** when sampling locations are considered as a combined data set and **Figures 4-21b and 4-23b through 4-25b and Table 3-3b** by individual sampling location. Blood mercury concentrations by month are presented on **Figure 4-26b**. No statistical evaluation was done on these limited data.

Blood mercury concentrations in adult birds and regression results are presented on **Figures 4-22c** with sampling locations considered as a combined data set and on **Figures 4-21c and 4-23c through 4-25c and Table 3-3c** by individual sampling location. Blood mercury concentrations by month are presented on **Figure 4-26c**. Mercury concentrations in blood of adult Nelson's sparrows increase from June to July (duration on the marsh and peak breeding season) based on data between 2006 and 2016, but blood mercury concentrations in June show a significant decline since 2006. The overall trend at each location typically did not differ for Nelson's sparrows whether juvenile birds were included in the regression dataset (**Figures 4-23a through 4-25a**) or were excluded (**Figures 4-23c through 4-25c**).

### 4.2.2 Red-winged Blackbird

The reference location on the Pleasant River was established in 2012 by the PRMS and sampled again in 2016 and 2017. No red-winged blackbirds were sampled at the Pleasant River site in 2016 or 2017. No statistical analysis was conducted for this site. Red-winged blackbirds at the Pleasant River reference location had blood mercury concentrations lower than 800 ng/g in 2012 (**Figure 4-27a**). Other red-winged blackbird samples were collected by the PRMS in 2008 and 2010 along the coast in southern Maine (Spurwink River and Scarborough River areas). These samples had concentrations ranging from 23.7 ng/g to 356 ng/g.

Blood from red-winged blackbirds was collected from two Mendall Marsh locations (MM-SE and MM-SW) from 2006 to 2010, 2012, and 2017. Blood was collected from red-winged blackbirds from W-17-N in 2009, 2010, 2012, 2016, and 2017 (**Figure 2-1**; figure presents 2016 and 2017 locations only). Red-winged blackbird blood from the Estuary exceeded mercury concentrations in birds sampled at reference locations. Red-winged blackbirds show much intra- and interannual variability in blood mercury concentrations (**Table 3-4a**), and an increase in blood mercury concentrations when sampling locations W-17-N, MM-SE, and MM-SW are considered as a combined data set (**Figure 4-28a**). Blood mercury concentrations show a significant increase in MM-SE (**Figure 4-29a**) and the loglinear regression suggests ($p = 0.061$) an increase in blood mercury concentrations in MM-SW (**Figure 4-30a**). Blood mercury concentrations in red-winged blackbirds have not changed, neither increasing nor decreasing, in W-17-N (**Figure 4-31a**). Mercury concentrations in blood of red-winged blackbirds increase with time on the marsh, but blood mercury concentrations in June do not show a significant trend while blood sampled in July shows a significantly increasing trend in mercury concentrations driven by samples collected in 2012 (**Figure 4-32a**).

Blood mercury concentrations typically differ between juvenile (i.e., hatch year) and adult birds due to exposure duration. An insufficient number of juvenile birds was collected to perform statistical analysis of blood mercury concentrations in juvenile red-winged blackbirds at MM-SE and W-17. Blood mercury concentrations in hatch year birds and regression results are presented on **Figures 4-28b** or sampling locations are considered as a combined data set and **Figures 4-27b and 4-29b through 4-31b and Table 3-4b** for individual sampling locations. Blood mercury concentrations by month are presented on **Figure 4-32b**. Juvenile red-winged blackbirds show a statistically significant decrease in mercury concentrations through time at MM-SW and when the data from the locations are considered as a combined data set. However, the trend based on the combined data set is influenced by a single data point (2016 sample in the combined data set).

Blood mercury concentrations in adult birds and regression results are presented on **Figures 4-28c** with sampling locations considered as a combined data set and on **Figures 4-27c and 4-29c through 4-31c and Table 3-4c** by individual sampling location. Blood mercury concentrations by month are presented on **Figure 4-32c**. The 2012 data appear to drive an increasing trend in July blood concentrations, however, blood results collected during the same timeframe in other years do not show the elevated concentrations seen in 2012.

Regressions where adult and hatch year red-winged blackbirds are combined indicate increasing mercury concentrations. However, regressions including only adult red-winged blackbirds show no statistical trends except for MM-SW, which is suggestive of a potential increasing trend. Red-winged blackbirds were present in limited numbers on the marsh during the collection event which potentially limits statistical evaluations due to a limited number of samples.

### 4.2.3 American Black Duck

A significant, positive correlation between blood and muscle tissue mercury concentrations was developed for black duck in the 2016 Biota Monitoring Report (Amec Foster Wheeler 2017b). Muscle tissue will not be collected from American black ducks in the winter of 2018. Blood will be collected in the winter of 2018 from American black ducks to continue the trending efforts. Additional muscle tissue samples should be collected in the future when blood concentrations entered into the correlation equation suggest that muscle tissue mercury concentrations are below tissue threshold concentrations. The below section discussing blood concentrations will be updated with 2018 data prior to finalizing the document.

Blood mercury concentrations are an indication of recent exposure to mercury whereas tissue muscle mercury concentrations show bioaccumulation of mercury. As indicated by the regression equation, it is possible that ducks have detectable concentrations of mercury in muscle tissue and not in blood. Tissue mercury concentrations (more indicative of a longer time period of exposure than blood likely includes exposure from where the ducks migrated and exposure in the

Penobscot) may be elevated relative to blood concentrations (more indicative of a shorter time period of exposure) due to prior exposure in the area from which the individual ducks migrated.

#### *4.2.3.1 American Black Duck Blood*

The reference location at Frenchman Bay was established in the winter of 2010–2011 by the PRMS and sampled again in the winters of 2011–2012, 2013–2014, and 2016–2017. Black duck blood concentrations have significantly decreased since the winter of 2010–2011 (**Figure 4-33**). The timing of duck migration to the Maine coast and decreases in atmospheric mercury deposition may contribute to this trend. This sample collection effort is designed to provide reference mercury concentrations in black duck blood in the same years as site data, not to understand changes in reference tissue mercury concentrations over time. Black duck blood mercury concentrations in ducks collected from Frenchman Bay were lower than in ducks collected from sites in the Estuary (**Table 3-5a**).

Blood from American black ducks was collected at Mendall Marsh and at South Verona (ES-13) in the winters of 2010–2011, 2011–2012, 2013–2014, and 2016–2017 (**Figure 2-1**; figure presents 2017 and 2018 locations only). American black duck blood from the site exceeded mercury concentrations in birds sampled at the reference location. American black ducks show some intra- and interannual variability in blood mercury concentrations (**Table 3-5a**), but no overall change in blood mercury concentrations when sampling locations Mendall Marsh and South Verona are considered as a combined data set (**Figure 4-34**). Mercury concentrations did not change in Mendall Marsh (**Figure 4-35**). Mercury concentrations significantly increased over time at South Verona, primarily due to the sample concentrations collected in 2017 compared to previous years (**Figure 4-36**). Most duck blood samples were collected in January, with a limited number of samples collected in October and February. Blood mercury concentrations in January and February were similar. Duck blood samples collected in month of January between the years of 2011 to 2018 showed a decrease in concentration through time (**Appendix G-4**).

## 4.3 AQUATIC INVERTEBRATES

### 4.3.1 Polychaetes

Tissue composited from polychaetes was collected from the reference location in Frenchman Bay in 2017 so that samples were co-located with fish and black duck samples. Polychaetes were historically sampled in 2006 at a location on the East Branch of the Penobscot River in the area of Millinocket and at OV-04 in 2009. Polychaetes in reference locations show a wide range of mercury tissue concentrations. Polychaetes on the East Branch of the Penobscot River had mercury tissue concentrations between 15 and 30 ng/g, with a mean of approximately 20 ng/g while OV-04 samples showed concentrations approximately two to four times higher than the East

Branch Penobscot River reference location (**Table 3-6; Figure 4-37**). The average Frenchman Bay polychaete mercury concentration was 7.8 ng/g, approximately three to seven times lower than concentrations in the other reference locations. No further statistical analysis was conducted to compare these data because samples were collected from different locations, and the number of samples per location and year were limited. Polychaete samples collected at Frenchman Bay were not analyzed for methyl mercury in 2017.

Tissue composited from polychaetes was collected from three locations (BO-04, ES-13, and ES-FP) in 2009 and 2016 and two locations (OB-05 and Mendall Marsh) in 2016 (**Figure 2-1**; figure presents 2016 and 2017 locations only). Polychaetes were collected in 2017 at OB-01, Mendall Marsh, BFK, PI, Orland River (ES-02E), near Odom Ledge (VI-W), ES-15, at the tip of South Verona Island (SVE-02INT), ES-13, ES-FP, and ES-03. No polychaetes could be found for collection at BO-04 and OB-05. Polychaete tissue from the Estuary exceeded mercury concentrations in polychaetes sampled at the reference locations. Polychaetes show some intra-annual variability in tissue mercury concentrations (**Table 3-6**). No further statistical analysis was conducted to compare these sites because limited years of data were collected.

Polychaetes in 2017 from a limited number of locations were analyzed for methyl mercury. These locations include at OB-01, Mendall Marsh, BFK, PI, Orland River (ES-02E), and SVE-02INT. Polychaete tissue from the site in 2017 exceeded methyl mercury concentrations in polychaetes sampled at the Frenchman Bay reference location in 2016. Polychaetes show some intra-annual variability in tissue methyl mercury concentrations (**Table 3-6; Figure 4-38**). No further statistical analysis was conducted to compare these sites because limited years of data were collected.

### 4.3.2 Blue Mussel

Blue mussels were collected at Frenchman Bay in 2017. Historically, blue mussels were collected in 2009 in the Narragaugus River and in the St. George River outside the influence of the Estuary (**Figure 4-39**). Additional data collected since 2006 for the NOAA Mussel Watch program was evaluated. Two 2007 samples and two 2011 samples from the Maine coast were included as reference samples. One sample was collected each year near Stover Point in Merriconeag Sound and near Kennebunkport in Cape Arundel. Mussel data from near Searsport are not presented, as this location has the potential to be influenced by the Estuary, and these data are limited because only a single data point is available per year. Mercury concentrations in blue mussels in Frenchman Bay collected in 2017 were approximately three times lower than samples collected in 2009 at the Narragaugus River and the St. George River (**Table 3-7; Figure 4-39**). No further statistical analysis to compare these reference data was conducted because samples were collected from multiple locations and years for different purposes.

Blue mussels were collected from four locations (ES-15, ES-13, ES-03, and ES-FP) in 2006, 2008 to 2010, 2012, 2016, and 2017 (**Figure 2-1**; figure presents 2016 and 2017 locations only). In some years, mussels were not collected from one of these four locations (**Table 3-7**). Blue mussels from the Estuary exceeded mercury concentrations in mussels sampled at the reference locations. Overall, blue mussel tissue mercury concentrations showed a significant decrease in the river since 2006, when sampling locations ES-13, ES-15, ES-03, and ES-FP are considered as a combined data set (**Figure 4-40**). Mercury concentrations decreased significantly at ES-15 (**Figure 4-41**) and at ES-13 (**Figure 4-42**). Mercury concentrations at ES-03 (**Figure 4-43**) and at ES-FP (**Figure 4-44**) showed a significant increase.

### 4.3.3 Lobster

#### *4.3.3.1 Lobster Tail*

Frenchman Bay was sampled as a reference location in 2017. No statistical analysis was conducted for this site (**Figure 4-45**). Lobster at the Frenchman Bay reference location had mercury concentrations lower than lobsters collected in the Estuary.

Lobster were collected from four locations (Odom Ledge, South Verona, Turner Point, and Harborside) in 2006, 2008 to 2010, 2012, and 2014 to 2017 and from Cape Jellison from 2014 to 2017 (**Figure 2-1**; figure presents 2016 and 2017 locations only). In some years, lobsters were not collected from one of these five locations (**Table 3-8**). Lobster show some intra-annual variability in tissue mercury concentrations (**Table 3-8**). Lobster tissue mercury concentrations showed a significant decrease in the river since 2006, when sampling locations Odom Ledge, South Verona, Turner Point, and Harborside are considered as a combined data set (**Figure 4-46**). Samples from Cape Jellison were not included because fewer years of data were collected than at the other sampling locations. Length-adjusted mercury concentrations did not change at Odom Ledge (**Figure 4-47**). Length-adjusted mercury concentrations decreased significantly at South Verona (**Figure 4-48**), Cape Jellison (**Figure 4-49**), Turner Point (**Figure 4-50**), and Harborside (**Figure 4-51**).

#### *4.3.3.2 Lobster Tail and Claw Tissue Correlation*

During historical sampling events, tail and claw tissue were collected for analysis from the same lobster. A significant, positive correlation between these two tissues was developed and is presented in the 2016 Biota Monitoring Report (Amec Foster Wheeler 2017b).

## 4.4 FISH

### 4.4.1 Mummichog

Frenchman Bay was sampled as a reference location in 2016 and 2017 (**Figure 4-52**). No statistical analysis was conducted for this site. Mummichog at the Frenchman Bay reference location had mercury concentrations lower than fish collected in the Estuary.

Mummichog were collected from four locations (OB-05, OB-01, and Mendall Marsh) in 2006, 2008 to 2010, 2012, 2016, and 2017 and at BO-04 in 2006, 2016, and 2017 (**Figure 2-1**; figure presents 2016 and 2017 locations only). Mummichog from the site exceeded mercury concentrations in mummichog sampled at the reference location. Mummichog show some intra- and interannual variability in tissue mercury concentrations (**Table 3-9**). Length-adjusted mummichog tissue mercury concentrations declined significantly when sampling locations OB-05, OB-01, and Mendall Marsh are considered as a combined data set (**Figure 4-53**). Length-adjusted mercury concentrations do not appear to have changed at OB-05 (**Figure 4-54**); however, three of the six years of data only had one sample, limiting interpretability. Mercury concentrations in mummichog have significantly decreased in Mendall Marsh (**Figure 4-55**). Mummichog tissue mercury concentrations at OB-01 were not statistically evaluated due to the small sample size in 2006 and 2016 (**Figure 4-56**). Mummichog samples collected at BO-04 were not included in statistical analyses because of insufficient data.

### 4.4.2 Rainbow Smelt

Frenchman Bay was sampled as a reference location in 2016 and 2017. No statistical analysis was conducted for this site because only two years of data have been collected at this location (**Figure 4-57**). The smelt collected at the Frenchman Bay reference location had mercury concentrations lower than fish collected in the Estuary (**Table 3-10**).

Rainbow smelt were collected from four locations (OB-05, OB-01, ES-13, ES-15, and ES-FP) in 2006, 2008 to 2010, 2012, 2016, and 2017 (**Figure 2-1**; figure presents 2016 and 2017 locations only) with some exceptions (**Table 3-10**). Rainbow smelt from the Estuary exceeded mercury concentrations in the smelt sampled at the reference location. Rainbow smelt showed much intra- and interannual variability in tissue mercury concentrations (**Table 3-10**). Length-adjusted smelt tissue mercury concentrations showed a significant decrease in the river since 2006, when sampling locations OB-05, OB-04, OB-01, ES-13, ES-15, and ES-FP are considered as a combined data set (**Figure 4-58**). Length-adjusted mercury concentrations at OB-05 (**Figure 4-59**), ES-FP (**Figure 4-60**), and at ES-13 (**Figure 4-61**) did not change significantly. Length-adjusted smelt mercury concentrations have significantly decreased at OB-04 (**Figure 4-62**) and

OB-01 (**Figure 4-63**). Statistical analysis was not conducted for rainbow smelt samples collected at ES-15 (**Figure 4-64**).

### 4.4.3 American Eel

Reference location OV-04 was sampled in 2007 to 2010, 2012, and 2017. The length-adjusted mercury concentrations for American eel at the OV-04 reference location did not change among years (**Figure 4-65**), and were generally lower than downstream locations.

American eel were collected from three locations (OB-01, BO-04, and OB-05) from 2006 to 2010, 2012, and 2016. Eel were collected from three locations (OV-04, BO-04, and OB-05) in 2017 (**Figure 2-1**; figure presents 2016 and 2017 locations only). American eel from the Estuary generally exceeded mercury concentrations in eel sampled in 2017 at the reference location (**Table 3-11**). Length-adjusted eel tissue mercury concentrations significantly decreased in the river when sampling locations BO-04, OB-05, and OB-01 are considered as a combined data set (**Figure 4-66**). Mercury concentrations in American eel have significantly decreased at BO-04 (**Figure 4-67**) and at OB-05 (**Figure 4-68**), while length-adjusted mercury concentrations have not changed at OB-01 (**Figure 4-69**).

### 4.4.4 Atlantic Tomcod

Frenchman Bay was sampled as a reference location in 2016 and 2017. No statistical analysis was conducted for this location because only two years of data have been collected there. The one tomcod sample collected in 2016 at the Frenchman Bay reference location had a mercury concentration lower than fish collected in the Estuary (**Table 3-12**). No tomcod were collected in 2017.

Atlantic tomcod were collected from five locations (BO-04, OB-05, OB-01, and ES-13) in 2006, 2008 to 2010, 2012, 2016, and 2017 with some exceptions (**Figure 2-1**; figure presents 2016 and 2017 locations only). ES-FP was sampled in 2012, 2016, and 2017. Atlantic tomcod from the site exceeded mercury concentrations in the single Atlantic tomcod sampled in 2017 at the reference location. Atlantic tomcod show much interannual variability in tissue mercury concentrations (**Table 3-12**). Length-adjusted tomcod tissue mercury concentrations showed a significant decrease in the river since 2006, when sampling locations BO-04, OB-05, OB-01, and ES-13 are considered as a combined data set (ES-FP excluded due to limited year of data and number of samples per year) (**Figure 4-70**). Length-adjusted mercury concentrations at BO-04 (**Figure 4-71**) have not decreased significantly. Length-adjusted tomcod mercury concentrations have significantly decreased at OB-05 (**Figure 4-72**), OB-01 (**Figure 4-73**), and ES-13 (**Figure 4-74**).

Statistical analysis was not conducted for Atlantic tomcod samples collected at ES-FP because limited years of data and a limited number of samples were collected (**Figure 4-75**).

## 4.5 TRENDING INTERPRETATION

Regressions in this report only fit mercury concentration to year and do not consider other factors that likely influence mercury concentrations. Many factors (biological, physical, and chemical) influence mercury concentrations in biota more than a change of a year. These factors include (but are not limited to): changes in sediment geochemistry, climatic conditions, sediment and surface water mercury concentrations and exposure duration, home range, behavior, dietary item mercury concentrations, parental mercury concentrations, reproductive status, and reproductive patterns in dietary items. Overall, the biota trends indicate that natural recovery is occurring in the aquatic (subtidal) environment, with all fish and shellfish species showing downward trends in mercury concentrations. In the wetlands and marsh areas, there is less evidence of natural recovery with increasing mercury concentrations in red-winged black birds, decreasing mercury concentrations in Nelson's Sparrows, but no apparent increasing or decreasing trend for black ducks (without the 2018 black duck data).

# 5.0 CONCLUSIONS AND RECOMMENDATIONS

Blood and tissue concentrations for most biota collected in the Estuary were higher than samples collected in reference areas. Overall, mercury concentrations in biota in the Estuary are generally decreasing (0.2 to 6.5 percent annual decline) or not changing, indicating the potential for some natural attenuation.

## Temporal Trends

Tissue concentrations in Nelson's sparrows typically showed a small decrease in concentrations (green highlighting on **Table 5-1**) whether for individual locations or when locations were considered as a combined data set. Note than an insufficient number of juvenile birds was collected to perform statistical analysis of blood mercury concentrations in juvenile Nelson's sparrows at any given location. As such, overall trend in Nelson's sparrows at each location (generally data available from 2006 to present) typically did not differ for Nelson's sparrows whether juvenile birds were included in the regression dataset or were excluded. Tissue concentrations in red-winged blackbirds tended to show increasing concentrations (orange highlighting on **Table 5-1**) of approximately 1 to 2 percent, whether for individual locations or when locations were considered as a combined data set. However, juvenile red-winged blackbirds show a statistically significant decrease in mercury concentrations through time at MM-SW (based on data between 2006 and 2010) and when the data from the locations are considered as a combined data set (based on data between 2007 and 2016). However, regressions including only adult red-winged blackbirds show no statistical trends except for MM-SW, which is suggestive of a potential increasing trend. Nelson's sparrow trends showed either no change or decreasing mercury concentrations rather than the mix of increasing and decreasing trends shown in the 2012 monitoring report (PRMSP 2013a). No trends were reported for red-winged blackbirds in the 2012 monitoring report. Blue mussels had decreasing mercury concentration overall, but had increasing mercury concentrations (0.4 and 1.2 percent annual increase) at two locations (**Table 5-2**). Tissue concentrations in aquatic biota (i.e., fish and shellfish) typically had decreasing temporal regression trends (green highlighting on **Table 5-2**) for individual locations and when locations were considered as a combined data set. Compared to the 2012 monitoring report (PRMSP 2013a), more fish species showed significant declines with the addition of 2017 data at individual locations and when the locations are combined to represent the Estuary.

## Trophic Levels

Concentrations of mercury in biota tend to increase as the trophic level of the biota increases. Species such as terrestrial insects and spiders that are low trophic level species have low concentrations, while songbirds, which are higher trophic level species, have higher mercury concentrations. In general, mercury concentrations in spiders were approximately an order of magnitude greater than mercury in terrestrial insects. Spiders likely prey on many of the insects included in the terrestrial insect composite samples. Lower trophic level species like spiders, blue mussels, and polychaetes also tend to have smaller home ranges during most of their life histories and shorter life spans than upper trophic level species, which tend to be longer lived and have larger home ranges. Similarly, mercury concentrations in the blood of Nelson's sparrows were approximately an order of magnitude or more greater than spider and terrestrial insect mercury concentrations, which are prey items for this avian species. Aquatic species tended to show a similar pattern of mercury concentrations where polychaetes, blue mussel, mummichog, and rainbow smelt tended to have similar concentrations, while American eel and lobster had similar concentrations that were substantially higher than the forage fish and other aquatic invertebrates. Tomcod appear to fall somewhere between these two groups.

### Effects Levels

Five effects levels were established for biota to be protective of fish and wildlife and human consumers of the fish and wildlife: 2,100 ng/g was used as a blood effects level for avian species; 200 ng/g was used as a benchmark comparison level for aquatic species that are consumed by humans (blue mussels, lobster, tomcod, and smelt); 440 ng/g tissue toxicity level for mummichog; and 320 ng/g was used as a background comparison level for American eel.

Approximately over 80 percent of Nelson's sparrows and 70 percent of the red-winged blackbirds had blood mercury concentrations greater than the blood effects level of 2,100 ng/g for avian species. The effects level of 2,100 ng/g is at the low end of the recommended range of effects levels for small birds such as Nelson's sparrows and red-winged blackbirds (Jackson et al. 2011, Fuchsman et al. 2016) as described in the Final Penobscot River Risk Assessment and Preliminary Remediation Goal Development report (Amec Foster Wheeler 2018b). Multiple nests with red-winged blackbird nestlings, and at least one fledgling, were found in MM-SW. Also, two Nelson's sparrows were recaptured that had been banded in previous years in the same marsh, showing strong philopatry (desire to return to a particular area).

Black duck blood concentrations were below the effects level of 2,100 ng/g for avian species, indicating that mercury was not accumulated to a level of concern for this species. Diet, habitat use, and migration patterns are some of the differences that may result in duck blood levels being well below literature based effects levels.

The MeCDC methyl mercury fish tissue action level was used as a benchmark for comparison to blue mussels, lobsters, and black duck mercury levels based on the Order on Remediation Plan (United States District Court, District of Maine 2015) which states that "…*to the extent the parties require a general benchmark, the Court adopts the state of Maine standards of 200 nanograms* *per gram*". The application of fish tissue action levels to lobster, black duck, and blue mussels may be inappropriate, as the MeCDC fish tissue action levels were derived based on a finfish consumption rate of one 8-ounce fish meal per week (52 meals per year, 32.4 grams per day) (MeCDC 2001), which is greater than the local consumer consumption rates for lobster (1.7 grams per day) (Cooper et al. 1991), shellfish (0.51 gram per day) (Cooper et al. 1991), and duck (14.9 grams per day) (MDIFW 2017), and may overestimate actual consumption of lobster, blue mussels, and black duck. Because of convention and not specifically as an assessment of risk, American black duck, blue mussel, and lobster results are compared to the 200 ng/g methyl mercury threshold level at which the MeCDC would advise people to limit their fish consumption.

Lobster is a tissue that is commonly consumed, and tomcod, smelt and eel are also potentially consumed by humans. The human health risk assessment has a detailed evaluation of the potential for risk from consumption of these biota from the Penobscot (Amec Foster Wheeler 2018b). A substantial portion of the samples of lobster, tomcod, and eel analyzed were above the MeCDC fish tissue action level of 200 ng/g for freshwater finfish. Only one smelt sample in each year had a concentration that exceeded the MeCDC fish tissue action level of 200 ng/g. For tomcod and eel, more of the samples collected close to the former HoltraChem Manufacturing Company, LLC facility exceed the action level than samples that were collected farther from the former facility. Tomcod from locations near Penobscot Bay (i.e., South Verona and ES-FP) typically had concentrations below the action level. Lobster tissues were highest around Odom Ledge and South Verona. Odom Ledge, South Verona, Cape Jellison, and Turner Point had a similar number of lobster exceedances although the concentrations were lower at Cape Jellison and Turner Point than South Verona and Odom Ledge. Outside the lobster closure area (Harborside), only one lobster exceeded the MeCDC fish tissue action level for freshwater finfish. No mummichog exceeded the toxicity value for mummichog.

### Spatial Distribution

It was hypothesized that mercury concentrations in biota would decrease downstream, as this is farther from the site of release. However, the strong tide moves material upstream, functionally mixing mercury concentrations. Biota show varying spatial patterns of mercury concentration in the Estuary. Polychaetes, blue mussel and mummichog showed no strong spatial patterns of mercury concentrations within the Estuary where sampled. In contrast, mercury concentrations in tomcod, smelt, and lobster tended to decrease farther downstream. Tomcod and lobsters have large home ranges and likely integrate concentrations of prey and/or sediment over the home range of each individual so this decrease may be representative of how much area of the home range has lower mercury concentrations.

Terrestrial insects and Nelson's sparrow tended to have higher concentrations at MM-SW, in contrast to higher concentrations in samples collected in 2016 in MM-SE. This is likely due to differences in terrestrial insects available between years. Nelson's sparrow tissue mercury concentrations tends to track terrestrial insect tissue mercury concentrations, in that a sampling location with the highest median concentration of mercury in terrestrial insects tended to also have the highest median mercury concentration in Nelson's sparrows. Biota from the area around South Verona also tended to have higher concentrations than downstream locations. Lobster tissue concentrations were greater in this area than in other sampling locations.

### Uncertainties

The collection and statistical evaluation of biota data from the Estuary encountered a number of uncertainties. The number of samples collected during each sampling event has fluctuated due to presence of the species and effort given to collecting samples. Timing of sample collection has also varied and affects mercury concentrations in species. Samples have been collected from many locations throughout the Estuary. The regression models cannot account for all factors that affect mercury concentrations in biota, but do provide lines of evidence for the trends in biota mercury concentrations in the Estuary. While there is variability inherent in biotic data and the variability in the sample design, a small reduction in mercury concentrations is observable for multiple species. The Biota Monitoring Plan has addressed a number of factors contributing uncertainty to the regression models, including:

- Standardized sample locations: selected location based on historical quantity of data, annual consistency of data, and/or importance of the location in the system (e.g., accretional environment, hydrologically influenced area).
- Standardized time of year: collection of samples at the same time of year as historical samples, collect at time of year when mercury concentrations are likely most representative of exposure.
- Maximize number of samples: extra effort has been made to maximize the number of samples collected.
- Increase effort: multiple types of nets and traps are deployed at a location to collect samples for each species rather than only using one method.
- Co-location of predator and prey tissue samples, rather than just one type of sample.

Future sampling efforts should continue with standard sample locations and time of year for sampling events to reduce the environmental stochasticity introduced by life history traits, distribution of environmental mercury concentrations (e.g., sediment, prey concentrations), and habitat.

## Conclusions

Overall, mercury concentrations in biota in the Estuary are generally decreasing or not changing, indicating the potential for some natural attenuation. For many species, mercury concentrations decreased with distance downstream. Mercury concentrations increased with trophic level, as mercury is a bioaccumulative metal. Low trophic and terrestrial mid-trophic level species tended to show limited or no change in concentrations through time. Upper trophic level species showed more reduction in mercury concentrations than low trophic level or terrestrial mid-trophic level species. Biota collected in the areas of Mendall Marsh and South Verona tended to have higher mercury concentrations than in other parts of the Estuary. This tendency depended on the species and the location of capture (i.e., lobster in South Verona area had the highest concentrations along a point bar near the southern tip of Verona Island, while polychaetes had some of the lowest concentrations collected in a small cove near this area). Future sampling for long-term monitoring, with additional emphasis on specific species, will be recommended in the Penobscot River Phase III Engineering Study Alternatives Evaluation Report to evaluate the effectiveness of remedial alternatives that are implemented. The long-term monitoring recommended would also increase the robustness of the statistical analyses, and be used to better understand the distribution and trend of mercury concentrations, and to describe spatial differences in mercury bioaccumulation within the Estuary.

## 6.0 REFERENCES

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# TABLES

**TABLE 2-1**

**2017 BIOTA SAMPLE COLLECTION COUNTS BY LOCATION[1]**
**Penobscot River Phase III Engineering Study**
**Penobscot River Estuary, Maine**

| | Terrestrial Invertebrates | | Birds | | | Aquatic Invertebrates | | | Fish | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Terrestrial Insects[2] | Spiders[3] | Nelson Sparrow | Red-Winged Blackbird | American Black Duck (Blood) | Polychaetes | Blue Mussel | Lobster | Atlantic Tomcod | Rainbow Smelt | Mummichog | American Eel |
| Location ID (North to South) | June | June/ July | June | June | January/ February | July/ September | September | September | September | September | September | June/ July |
| BO-04 | -- | -- | -- | -- | -- | 0 | 0 | -- | 8 | 0 | 1 | 20 |
| OB-05 | -- | -- | -- | -- | -- | 0 | 0 | -- | 20 | 5 | 20 | 20 |
| OB-01 | -- | -- | -- | -- | -- | 5 | 0 | -- | 20 | 20 | 15 | 0 |
| W-17-N | 5 | 5 | 12 | 5 | -- | -- | -- | -- | -- | -- | -- | -- |
| MMMC-01 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | 19 | -- |
| MM-MR | -- | -- | -- | -- | -- | 5 | -- | -- | -- | -- | -- | -- |
| MMBKD-01 | -- | -- | -- | -- | 15 | -- | -- | -- | -- | -- | -- | -- |
| MMSE-01 | 5 | 5 | 15 | 6 | -- | -- | -- | -- | -- | -- | -- | -- |
| MMSW-C | 5 | 5 | 15 | 6 | -- | -- | -- | -- | -- | -- | -- | -- |
| BFK-1 | -- | -- | -- | -- | -- | 5 | -- | -- | -- | -- | -- | -- |
| PI-01 | -- | -- | -- | -- | -- | 5 | -- | -- | -- | -- | -- | -- |
| ES-02E | -- | -- | -- | -- | -- | 5 | -- | -- | -- | -- | -- | -- |
| Odom Ledge (L10-52) | -- | -- | -- | -- | -- | -- | -- | 20 | -- | -- | -- | 0 |
| VI-W | -- | -- | -- | -- | -- | 5 | -- | -- | -- | -- | -- | -- |
| ES-15 | -- | -- | -- | -- | -- | 5 | 12 | -- | -- | -- | -- | -- |
| ES-13 | -- | -- | -- | -- | 15 | 5 | 20 | -- | 11 | 20 | -- | -- |
| SVE-01 | -- | -- | -- | -- | -- | -- | -- | 20 | -- | -- | -- | -- |
| SVE-02INT | -- | -- | -- | -- | -- | 5 | -- | -- | -- | -- | -- | -- |
| ES-03 | -- | -- | -- | -- | -- | 5 | 19 | -- | -- | -- | -- | -- |
| ES-FP | -- | -- | -- | -- | -- | 5 | 20 | -- | 1 | 20 | -- | -- |
| CPJL | -- | -- | -- | -- | -- | -- | -- | 20 | -- | -- | -- | -- |
| Turner Point (L9-45) | -- | -- | -- | -- | -- | -- | -- | 20 | -- | -- | -- | -- |
| HB-01 | -- | -- | -- | -- | -- | -- | -- | 20 | -- | -- | -- | -- |
| | | | | | | | | | | | | |
| OV-04 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | 6 |
| ADD-01 | 5 | 5 | 15 | 0 | -- | -- | -- | -- | -- | -- | -- | -- |
| FRB-01 | -- | -- | -- | -- | 15 | 5 | 20 | 20 | 0 | 20 | 20 | -- |

*Notes:*
1. Biota samples were collected between June 2017 and September 2017. Black duck samples were collected in January 2018.
2. Terrestrial insects include grasshoppers (order: Orthoptera), leaf beetles (*Donacia* spp.), dragonflies (order: Odonata), stink bugs (family: Pentatomidae), flies (order: Diptera), picture-winged flies (family: Ulidiidae), and beetles (order: Coleoptera).
3. Spiders include wolf spider (family: Lycosidae), orb-weaver spider (family: Araneidae), and crab spider (family: Thomisidae).

*Abbreviations:*
-- Sampling location not appropriate for this biota.
NA = not applicable; samples not yet collected for this year of biota collection

Prepared by/Date: LSV 08/02/18
Checked by/Date: LO 08/03/18

**TABLE 2-2**

**2017 BIOTA SAMPLE ANALYSIS BY SPECIES**
**Penobscot River Phase III Engineering Study**
**Penobscot River Estuary, Maine**

| Species | Media | Mercury | Methyl Mercury | Lipid |
|---|---|---|---|---|
| | | EPA Method 1631e | EPA Method 1630 | NOAA Method 1993a |
| Polychaetes | Whole Body | X | X | -- |
| Terrestrial Insects | Whole Body | X | X | -- |
| Spiders | Whole Body | X | X | -- |
| Blue Mussel | Whole Body | X | -- | -- |
| Lobster | Tail Tissue | X | -- | -- |
| American Eel | Fillet | X | -- | X |
| Rainbow Smelt | Whole Body | X | -- | -- |
| Atlantic Tomcod | Fillet | X | -- | -- |
| Mummichog | Whole Body | X | -- | -- |
| American Black Duck | Blood | X | -- | -- |
| Red-Winged Blackbird | Blood | X | -- | -- |
| Nelson's Sparrow | Blood | X | -- | -- |

*Abbreviations:*
-- = no analysis for this biota
EPA = Environmental Protection Agency
NOAA = National Ocean and Atmospheric Administration

Prepared by: LSV 10/30/17
Checked by: LO 01/08/17

**TABLE 3-1**

**SUMMARY OF MERCURY AND METHYL MERCURY CONCENTRATIONS FOR TERRESTRIAL INSECTS ALONG THE PENOBSCOT RIVER BY YEAR[1, 2]**
**Penobscot River Phase III Engineering Study**
**Penobscot River Estuary, Maine**

| Sample Statistics | Mercury | | | Methyl Mercury | | |
|---|---|---|---|---|---|---|
| | 2009 | 2016 | 2017 | 2009 | 2016 | 2017 |
| **Pleasant River (near Addison, ME)[3]** | | | | | | |
| Number of Samples | NA | 5 | 5 | NA | 5 | 5 |
| Mean | NA | 29.1 ± 11.4 | 16.5 ± 7.60 | NA | 18.0 ± 4.95 | 13.5 ± 6.04 |
| Median | NA | 16.8 | 11.5 | NA | 18.6 | 8.20 |
| **Spurwink River[3]** | | | | | | |
| Number of Samples | 20 | NA | NA | 20 | NA | NA |
| Mean | 29.3 ± 6.85 | NA | NA | 19.3 ± 5.91 | NA | NA |
| Median | 8.86 | NA | NA | 5.79 | NA | NA |
| **W-17-N** | | | | | | |
| Number of Samples | 41 | 5 | 5 | 41 | 5 | 5 |
| Mean | 179 ± 51.1 | 77.8 ± 44.3 | 20.7 ± 9.37 | 153 ± 49.0 | 57.7 ± 17.1 | 18.3 ± 9.06 |
| Median | 41.9 | 30.4 | 6.59 | 37.2 | 56.7 | 4.90 |
| **MM-SE** | | | | | | |
| Number of Samples | 40 | 5 | 5 | 40 | 5 | 5 |
| Mean | 90.9 ± 23.4 | 195 ± 68.8 | 25.9 ± 12.2 | 59.4 ± 13.2 | 101 ± 38.5 | 22.4 ± 10.2 |
| Median | 21.9 | 222 | 22.7 | 14.4 | 91.2 | 21.2 |
| **MM-SW** | | | | | | |
| Number of Samples | 20 | 5 | 5 | 20 | 5 | 5 |
| Mean | 209 ± 89.7 | 47.5 ± 4.31 | 35.8 ± 15.8 | 150 ± 74.7 | 22.7 ± 4.58 | 24.5 ± 7.78 |
| Median | 15.1 | 47.5 | 34.3 | 8.87 | 26.8 | 27.1 |

*Notes:*
1. All concentrations in nanograms/gram wet weight.
2. Mean concentrations are followed by the standard error of the mean.
3. Reference location.

*Abbreviations:*
NA = not available

Prepared by: JPM 10/30/17
Checked by: LO 11/16/17

## TABLE 3-2

**SUMMARY OF MERCURY AND METHYL MERCURY CONCENTRATIONS FOR SPIDERS ALONG THE PENOBSCOT RIVER BY YEAR[1, 2]**
**Penobscot River Phase III Engineering Study**
**Penobscot River Estuary, Maine**

| Sample Statistics | Mercury | | | | Methyl Mercury | | | |
|---|---|---|---|---|---|---|---|---|
| | 2009 | 2010 | 2016 | 2017 | 2009 | 2010 | 2016 | 2017 |
| **.** | | | | | | | | |
| **Number of Samples** | NA | NA | 5 | 5 | NA | NA | 5 | 5 |
| **Mean** | NA | NA | 35.1 ± 3.67 | 55.0 ± 3.82 | NA | NA | 28.9 ± 8.00 | 59.7 ± 3.74 |
| **Median** | NA | NA | 31.4 | 55.0 | NA | NA | 22.90 | 58.5 |
| **Spurwink River[3]** | | | | | | | | |
| **Number of Samples** | 15 | NA | NA | NA | 15 | NA | NA | NA |
| **Mean** | 43.8 ± 7.63 | NA | NA | NA | 25.2 ± 3.01 | NA | NA | NA |
| **Median** | 28.1 | NA | NA | NA | 24 | NA | NA | NA |
| **W-17-N** | | | | | | | | |
| **Number of Samples** | 12 | NA | 5 | 5 | 12 | NA | 5 | 5 |
| **Mean** | 328 ± 73.2 | NA | 305 ± 50.5 | 332 ± 19.9 | 302 ± 62.5 | NA | 378 ± 79.9 | 306 ± 12.5 |
| **Median** | 263 | NA | 263 | 315 | 258 | NA | 282 | 323 |
| **MM-SE** | | | | | | | | |
| **Number of Samples** | 21 | 3 | 5 | 5 | 21 | 3 | 5 | 5 |
| **Mean** | 221 ± 20.6 | 2133 ± 145 | 316 ± 114 | 513 ± 60.9 | 152 ± 17.5 | 2130 ± 147 | 180 ± 17.7 | 533 ± 72.1 |
| **Median** | 214 | 2070 | 205 | 560 | 143 | 2,070 | 174 | 544 |
| **MM-SW** | | | | | | | | |
| **Number of Samples** | 14 | 39 | 5 | 5 | 14 | 39 | 5 | 5 |
| **Mean** | 152 ± 32.3 | 1552 ± 138 | 222 ± 18.9 | 325 ± 20.9 | 134 ± 33.7 | 1423 ±140 | 235 ± 30.9 | 317 ± 72.8 |
| **Median** | 149 | 1320 | 219 | 315 | 101 | 1,180 | 217 | 337 |

*Notes:*
1. All concentrations in nanograms/gram wet weight.
2. Mean concentrations are followed by the standard error of the mean.
3. Reference location.

*Abbreviations:*
NA = not available

Prepared by: JPM 01/03/18
Checked by: LO 01/03/18

**TABLE 3-3a**

**SUMMARY OF NELSON'S SPARROW MERCURY CONCENTRATIONS IN WETLANDS ALONG THE PENOBSCOT RIVER BY YEAR[1, 2]**
**Penobscot River Phase III Engineering Study**
**Penobscot River Estuary, Maine**

| Sample Statistics | 2006 | 2007 | 2008 | 2009 | 2010 | 2012 | 2016 | 2017 |
|---|---|---|---|---|---|---|---|---|
| **Pleasant River (near Addison, ME)[3]** | | | | | | | | |
| **Number of Samples** | NA | NA | NA | NA | NA | 10 | 11 | 15 |
| **Mean** | NA | NA | NA | NA | NA | 399 ± 36.5 | 469 ± 44.0 | 388 ± 27.6 |
| **Median** | NA | NA | NA | NA | NA | 365 | 467 | 373 |
| **Percent of Samples Above 2,100 ng/g** | NA | NA | NA | NA | NA | 0 | 0 | 0 |
| **Maine[3, 4]** | | | | | | | | |
| **Number of Samples** | NA | 2 | NA | 8 | NA | 1 | NA | NA |
| **Mean** | NA | 6188 ± 149 | NA | 666 ± 73.7 | NA | 3,590 | NA | NA |
| **Median** | NA | 6,188 | NA | 701 | NA | 3,590 | NA | NA |
| **Percent of Samples Above 2,100 ng/g** | NA | 100 | NA | 0 | NA | 100 | NA | NA |
| **New Hampshire[3]** | | | | | | | | |
| **Number of Samples** | NA | 9 | 8 | 16 | 10 | NA | NA | NA |
| **Mean** | NA | 345 ± 39.2 | 806 ± 172 | 689 ± 114 | 511 ± 56.5 | NA | NA | NA |
| **Median** | NA | 340 | 914 | 537 | 459 | NA | NA | NA |
| **Percent of Samples Above 2,100 ng/g** | NA | 0 | 0 | 0 | 0 | NA | NA | NA |
| **W-17-N** | | | | | | | | |
| **Number of Samples** | NA | NA | 9 | 7 | 4 | 9 | 15 | 12 |
| **Mean** | NA | NA | 4263 ± 106 | 4949 ± 913 | 5281 ± 1447 | 5009 ± 226 | 4712 ± 764 | 2738 ± 353 |
| **Median** | NA | NA | 4,221 | 5,109 | 5,924 | 4,990 | 5,000 | 2,465 |
| **Percent of Samples Above 2,100 ng/g** | NA | NA | 100 | 100 | 83 | 100 | 73 | 67 |
| **MM-SE** | | | | | | | | |
| **Number of Samples** | 3 | 40 | 82 | 30 | 18 | 5 | 15 | 15 |
| **Mean** | 4276 ± 726 | 6451 ± 380 | 3525 ± 176 | 3859 ± 204 | 5474 ± 349 | 10290 ± 485 | 6191 ± 428 | 2232 ± 146 |
| **Median** | 4,200 | 6,946 | 3,445 | 3,715 | 5,490 | 10,470 | 6,130 | 2,200 |
| **Percent of Samples Above 2,100 ng/g** | 100 | 98 | 87 | 97 | 94 | 100 | 100 | 53 |
| **MM-SW** | | | | | | | | |
| **Number of Samples** | 12 | 39 | 30 | 17 | 19 | 5 | 11 | 15 |
| **Mean** | 5329 ± 518 | 7404 ± 348 | 5321 ± 286 | 3325 ± 350 | 6964 ± 480 | 7516 ± 816 | 5845 ± 408 | 3051 ± 280 |
| **Median** | 5,664 | 7,290 | 5,506 | 3,291 | 6,620 | 7,630 | 5,840 | 2,990 |
| **Percent of Samples Above 2,100 ng/g** | 92 | 97 | 100 | 76 | 100 | 100 | 100 | 87 |

*Notes:*
1. All concentrations in nanograms/gram wet weight.
2. Mean concentrations are followed by the standard error of the mean.
3. Reference location.
4. Maine reference samples do not include the data for Addison.

*Abbreviations:*
NA = not available
ng/g = nanograms per gram

PREPARED BY/DATE: LO 8/6/18
CHECKED BY/DATE: IMR 8/6/18

**TABLE 3-3b**

**SUMMARY OF NELSON'S SPARROW (HATCH YEAR) MERCURY CONCENTRATIONS IN WETLANDS ALONG THE PENOBSCOT RIVER BY YEAR[1, 2]**
**Penobscot River Phase III Engineering Study**
**Penobscot River Estuary, Maine**

| Sample Statistics | 2007 | 2008 | 2016 |
|---|---|---|---|
| **Pleasant River (near Addison, ME)[3]** | | | |
| **Number of Samples** | NA | NA | 1 |
| **Mean** | NA | NA | 296 |
| **Median** | NA | NA | 296 |
| **Percent of Samples Above 2,100 ng/g** | NA | NA | 0 |
| **W-17-N** | | | |
| **Number of Samples** | NA | NA | 6 |
| **Mean** | NA | NA | 2954 ± 875 |
| **Median** | NA | NA | 2,050 |
| **Percent of Samples Above 2,100 ng/g** | NA | NA | 33 |
| **MM-SE** | | | |
| **Number of Samples** | 2 | 10 | 1 |
| **Mean** | 2618 ± 214 | 1817 ± 357 | 6220 |
| **Median** | 2,618 | 2,065 | 6,220 |
| **Percent of Samples Above 2,100 ng/g** | 0 | 20 | 100 |
| **MM-SW** | | | |
| **Number of Samples** | 1 | NA | NA |
| **Mean** | 1968 | NA | NA |
| **Median** | 1,968 | NA | NA |
| **Percent of Samples Above 2,100 ng/g** | 0 | NA | NA |

*Notes:*
1. All concentrations in nanograms/gram wet weight.
2. Mean concentrations are followed by the standard error of the mean.
3. Reference location.
4. Maine reference samples do not include the data for Addison.

*Abbreviations:*
NA = not available
ng/g = nanograms per gram

PREPARED BY/DATE: JPM 08/02/18
CHECKED BY/DATE: LO 08/02/18

**TABLE 3-3c**

**SUMMARY OF NELSON'S SPARROW (ADULT) MERCURY CONCENTRATIONS IN WETLANDS ALONG THE PENOBSCOT RIVER BY YEAR[1, 2]**
**Penobscot River Phase III Engineering Study**
**Penobscot River Estuary, Maine**

| Sample Statistics | 2007 | 2008 | 2009 | 2010 | 2012 | 2016 | 2017 |
|---|---|---|---|---|---|---|---|
| **Pleasant River (near Addison, ME)[3]** | | | | | | | |
| Number of Samples | NA | NA | NA | NA | 10 | 8 | 15 |
| Mean | NA | NA | NA | NA | 399 ± 36.5 | 492 ± 46.0 | 388 ± 27.6 |
| Median | NA | NA | NA | NA | 365 | 468 | 373 |
| Percent of Samples Above 2,100 ng/g | NA | NA | NA | NA | 0 | 0 | 0 |
| **Maine[3, 4]** | | | | | | | |
| Number of Samples | 2 | NA | 8 | NA | 1 | NA | NA |
| Mean | 6188 ± 149 | NA | 666 ± 73.7 | NA | 3,590 | NA | NA |
| Median | 6,188 | NA | 701 | NA | 3,590 | NA | NA |
| Percent of Samples Above 2,100 ng/g | 100 | NA | 0 | NA | 100 | NA | NA |
| **New Hampshire[3]** | | | | | | | |
| Number of Samples | 9 | 2 | 12 | 10 | NA | NA | NA |
| Mean | 345 ± 39.2 | 347 ± 153 | 750 ± 149 | 511 ± 56.5 | NA | NA | NA |
| Median | 340 | 347 | 541 | 459 | NA | NA | NA |
| Percent of Samples Above 2,100 ng/g | 0 | 0 | 0 | 0 | NA | NA | NA |
| **W-17-N** | | | | | | | |
| Number of Samples | NA | 9 | 8 | 6 | 9 | 8 | 12 |
| Mean | NA | 4263 ± 106 | 4847 ± 797 | 5622 ± 956 | 5009 ± 226 | 6425 ± 924 | 2738 ± 353 |
| Median | NA | 4,221 | 4,622 | 6,304 | 4,990 | 6,015 | 2,465 |
| Percent of Samples Above 2,100 ng/g | NA | 100 | 100 | 83 | 100 | 100 | 67 |
| **MM-SE** | | | | | | | |
| Number of Samples | 37 | 72 | 30 | 18 | 5 | 14 | 15 |
| Mean | 6657 ± 382 | 3762 ± 177 | 3859 ± 204 | 5474 ± 349 | 10290 ± 485 | 6189 ± 460 | 2232 ± 146 |
| Median | 7,046 | 3,671 | 3,715 | 5,490 | 10,470 | 5,930 | 2,200 |
| Percent of Samples Above 2,100 ng/g | 97 | 92 | 97 | 94 | 100 | 100 | 53 |
| **MM-SW** | | | | | | | |
| Number of Samples | 37 | 30 | 16 | 19 | 5 | 7 | 15 |
| Mean | 7567 ± 334 | 5321 ± 286 | 3403 ± 364 | 6964 ± 480 | 7516 ± 816 | 6313 ± 485 | 3051 ± 280 |
| Median | 7,361 | 5,506 | 3,437 | 6,620 | 7,630 | 6,620 | 2,990 |
| Percent of Samples Above 2,100 ng/g | 100 | 100 | 81 | 100 | 100 | 100 | 87 |

*Notes:*
1. All concentrations in nanograms/gram wet weight.
2. Mean concentrations are followed by the standard error of the mean.
3. Reference location.
4. Maine reference samples do not include the data for Addison.

*Abbreviations:*
NA = not available
ng/g = nanograms per gram

PREPARED BY/DATE: LO 8/6/18
CHECKED BY/DATE: IMR 8/6/18

**TABLE 3-4a**

**SUMMARY OF RED-WINGED BLACKBIRD MERCURY CONCENTRATIONS IN WETLANDS ALONG THE PENOBSCOT RIVER BY YEAR[1, 2]**
**Penobscot River Phase III Engineering Study**
**Penobscot River Estuary, Maine**

| Sample Statistics | 2007 | 2008 | 2009 | 2010 | 2012 | 2016 | 2017 |
|---|---|---|---|---|---|---|---|
| **Pleasant River (near Addison, ME)[3]** | | | | | | | |
| Number of Samples | NA | NA | NA | NA | 3 | NA | NA |
| Mean | NA | NA | NA | NA | 453 ± 181 | NA | NA |
| Median | NA | NA | NA | NA | 399 | NA | NA |
| Percent of Samples Above 2,100 ng/g | NA | NA | NA | NA | 0 | NA | NA |
| **Coastal Maine[3, 4]** | | | | | | | |
| Number of Samples | NA | 1 | NA | 5 | NA | NA | NA |
| Mean | NA | 109 | NA | 173 ± 59.0 | NA | NA | NA |
| Median | NA | 109 | NA | 143 | NA | NA | NA |
| Percent of Samples Above 2,100 ng/g | NA | 0 | NA | 0 | NA | NA | NA |
| **W-17-N** | | | | | | | |
| Number of Samples | NA | NA | 6 | 4 | 6 | 3 | 5 |
| Mean | NA | NA | 2555 ± 713 | 2828 ± 398 | 7518 ± 1951 | 2816 ± 1668 | 2759 ± 875 |
| Median | NA | NA | 2,597 | 2,815 | 8,755 | 2,500 | 2,450 |
| Percent of Samples Above 2,100 ng/g | NA | NA | 50 | 75 | 83 | 67 | 60 |
| **MM-SE** | | | | | | | |
| Number of Samples | 3 | 12 | 32 | 2 | 2 | NA | 6 |
| Mean | 7885 ± 2789 | 919 ± 244 | 1983 ± 464 | 9650 ± 950 | 11040 ± 710 | NA | 4093 ± 1131 |
| Median | 5,506 | 732 | 666 | 9,650 | 11,040 | NA | 4,425 |
| Percent of Samples Above 2,100 ng/g | 100 | 8 | 25 | 100 | 100 | NA | 67 |
| **MM-SW** | | | | | | | |
| Number of Samples | 17 | 33 | 29 | 10 | 4 | NA | 6 |
| Mean | 4545 ± 842 | 3279 ± 575 | 3154 ± 577 | 5232 ± 1476 | 14810 ± 836 | NA | 5498 ± 1013 |
| Median | 3,377 | 1,874 | 1,970 | 4,348 | 14,350 | NA | 5,880 |
| Percent of Samples Above 2,100 ng/g | 71 | 45 | 45 | 50 | 100 | NA | 83 |

*Notes:*
1. All concentrations in nanograms/gram wet weight.
2. Mean concentrations are followed by the standard error of the mean.
3. Reference location.
4. Maine reference samples include data for Scarborough River in 2008 and Spurwink River in 2010.

*Abbreviations:*
NA = not available
ng/g = nanograms per gram

Prepared by: JPM 10/30/17
Checked by: LO 11/16/17

**TABLE 3-4b**

**SUMMARY OF RED-WINGED BLACKBIRD (HATCH YEAR) MERCURY CONCENTRATIONS IN WETLANDS**
**Penobscot River Phase III Engineering Study**
**Penobscot River Estuary, Maine**

| Sample Statistics | 2007 | 2008 | 2009 | 2010 | 2016 |
|---|---|---|---|---|---|
| **Coastal Maine[3, 4]** | | | | | |
| Number of Samples | NA | NA | NA | 3 | NA |
| Mean | NA | NA | NA | 157 ± 101 | NA |
| Median | NA | NA | NA | 91.4 | NA |
| Percent of Samples Above 2,100 ng/g | NA | NA | NA | 0 | NA |
| **W-17-N** | | | | | |
| Number of Samples | NA | NA | 5 | 1 | 1 |
| Mean | NA | NA | 2,215 ± 767 | 2,290 | 99.4 |
| Median | NA | NA | 1,235 | 2,290 | 99.4 |
| Percent of Samples Above 2,100 ng/g | NA | NA | 40 | 100 | 0 |
| **MM-SE** | | | | | |
| Number of Samples | NA | 10 | 25 | NA | NA |
| Mean | NA | 902 ± 275 | 1,112 ± 357 | NA | NA |
| Median | NA | 732 | 537 | NA | NA |
| Percent of Samples Above 2,100 ng/g | NA | 10 | 12 | NA | NA |
| **MM-SW** | | | | | |
| Number of Samples | 7 | 12 | 11 | 4 | NA |
| Mean | 2,849 ± 751 | 732 ± 164 | 890 ± 202 | 1,132 ± 443 | NA |
| Median | 2,422 | 593 | 680 | 1,107 | NA |
| Percent of Samples Above 2,100 ng/g | 57 | 83 | 0 | 0 | NA |

*Notes:*
1. All concentrations in nanograms/gram wet weight.
2. Mean concentrations are followed by the standard error of the mean.
3. Reference location.
4. Maine reference samples include data for Scarborough River in 2008 and Spurwink River in 2010.

*Abbreviations:*
NA = not available
ng/g = nanograms per gram

Prepared by: JPM 08/02/18
Checked by: LO 08/03/18

**TABLE 3-4c**

**SUMMARY OF RED-WINGED BLACKBIRD (ADULT) MERCURY CONCENTRATIONS IN WETLANDS ALONG THE PENOBSCOT RIVER BY YEAR[1, 2]**
**Penobscot River Phase III Engineering Study**
**Penobscot River Estuary, Maine**

| Sample Statistics | 2007 | 2008 | 2009 | 2010 | 2012 | 2016 | 2017 |
|---|---|---|---|---|---|---|---|
| **Pleasant River (near Addison, ME)[3]** | | | | | | | |
| **Number of Samples** | NA | NA | NA | NA | 3 | NA | NA |
| **Mean** | NA | NA | NA | NA | 453 ± 181 | NA | NA |
| **Median** | NA | NA | NA | NA | 399 | NA | NA |
| **Percent of Samples Above 2,100 ng/g** | NA | NA | NA | NA | 0 | NA | NA |
| **Coastal Maine[3, 4]** | | | | | | | |
| **Number of Samples** | NA | 1 | NA | 2 | NA | NA | NA |
| **Mean** | NA | 109 | NA | 198 ± 54.6 | NA | NA | NA |
| **Median** | NA | 109 | NA | 198 | NA | NA | NA |
| **Percent of Samples Above 2,100 ng/g** | NA | 0 | NA | 0 | NA | NA | NA |
| **W-17-N** | | | | | | | |
| **Number of Samples** | NA | NA | 1 | 3 | 6 | 2 | 5 |
| **Mean** | NA | NA | 4,254 | 3,007 ± 502 | 7,518 ± 1,951 | 4,175 ± 1,675 | 2,759 ± 875 |
| **Median** | NA | NA | 4,254 | 3,340 | 8,755 | 4,175 | 2,450 |
| **Percent of Samples Above 2,100 ng/g** | NA | NA | 100 | 67 | 83 | 100 | 60 |
| **MM-SE** | | | | | | | |
| **Number of Samples** | 3 | 2 | 7 | 2 | 2 | NA | 6 |
| **Mean** | 7,885 ± 2,789 | 1,003 ± 714 | 5,094 ± 1,095 | 9,650 ± 950 | 11,040 ± 710 | NA | 4,093 ± 1,131 |
| **Median** | 5,506 | 1,003 | 5,296 | 9,650 | 11,040 | NA | 4,425 |
| **Percent of Samples Above 2,100 ng/g** | 100 | 0 | 71 | 100 | 100 | NA | 67 |
| **MM-SW** | | | | | | | |
| **Number of Samples** | 10 | 21 | 18 | 6 | 4 | NA | 5 |
| **Mean** | 5,732 ± 1225 | 4,735 ± 729 | 4,357 ± 756 | 7,965 ± 1651 | 14,810 ± 836 | NA | 6,392 ± 584 |
| **Median** | 5,385 | 4,695 | 3,457 | 9,979 | 14,350 | NA | 6,020 |
| **Percent of Samples Above 2,100 ng/g** | 80 | 67 | 72 | 83 | 100 | NA | 100 |

*Notes:*
1. All concentrations in nanograms/gram wet weight.
2. Mean concentrations are followed by the standard error of the mean.
3. Reference location.
4. Maine reference samples include data for Scarborough River in 2008 and Spurwink River in 2010.

*Abbreviations:*
NA = not available
ng/g = nanograms per gram

Prepared by: JPM 08/02/18
Checked by: LO 08/03/18

**TABLE 3-5a**

**SUMMARY OF AMERICAN BLACK DUCK BLOOD MERCURY CONCENTRATIONS IN WETLANDS ALONG THE PENOBSCOT RIVER BY YEAR**
**Penobscot River Phase III Engineering Study**
**Penobscot River Estuary, Maine**

| | | 2011 | 2012 | 2014 | 2017 | 2018 |
|---|---|---|---|---|---|---|
| **Frenchman Bay*** | **Number of Samples** | 8 | 6 | 22 | 15 | 15 |
| | **Mean** | 82.6 ± 8.00 | 106 ± 12.9 | 84.2 ± 16.0 | 53.3 ± 6.79 | 54.9 ± 4.73 |
| | **Median** | 81.2 | 101 | 64.9 | 43.5 | 55.8 |
| **Mendall Marsh** | | **2011** | **2012** | **2014** | **2017** | **2018** |
| | **Number of Samples** | 8 | 11 | 8 | 15 | 15 |
| | **Mean** | 811 ± 182 | 582 ± 173 | 314 ± 76.2 | 529 ± 82.2 | 292 ± 21.7 |
| | **Median** | 936 | 434 | 242 | 504 | 275 |
| **South Verona** | | **2011** | **2012** | **2014** | **2017** | **2018** |
| | **Number of Samples** | 3 | 8 | 21 | 15 | 15 |
| | **Mean** | 488 ± 248 | 139 ± 11.1 | 103 ± 6.44 | 380 ± 38.3 | 180 ± 26.4 |
| | **Median** | 299 | 138 | 97.3 | 377 | 165 |

Notes:
Concentrations in nanograms/gram (ng/g) wet weight
* Reference location
Mean concentrations are followed by the standard error of the mean.
Abbreviations:
NA = Not available

PREPARED BY/DATE: JPM 07/09/18
CHECKED BY/DATE: LO 07/30/18

**TABLE 3-5b**

**SUMMARY OF AMERICAN BLACK DUCK BREAST MUSCLE TISSUE MERCURY CONCENTRATIONS IN THE PENOBSCOT RIVER BY YEAR[1, 2]**
**Penobscot River Phase III Engineering Study**
**Penobscot River Estuary, Maine**

| Sample Statistics | 2011 | 2012 | 2014 | 2017 |
|---|---|---|---|---|
| **Frenchman Bay[3]** | | | | |
| **Number of Samples** | NA | NA | 1 | 5 |
| **Mean** | NA | NA | 85.3 | 38.1 ± 7.08 |
| **Median** | NA | NA | 85.3 | 44.8 |
| **Percent of Samples Above 200 ng/g** | NA | NA | 0 | 0 |
| **Mendall Marsh** | | | | |
| **Number of Samples** | 11 | 14 | 3 | 5 |
| **Mean** | 765 ± 118 | 487 ± 92.5 | 432 ± 25.3 | 329 ± 136 |
| **Median** | 747 | 444 | 430 | 177 |
| **Percent of Samples Above 200 ng/g** | 91 | 71 | 100 | 40 |
| **South Verona** | | | | |
| **Number of Samples** | NA | NA | NA | 5 |
| **Mean** | NA | NA | NA | 456 ± 78.6 |
| **Median** | NA | NA | NA | 441 |
| **Percent of Samples Above 200 ng/g** | NA | NA | NA | 100 |

*Notes:*
1. All concentrations in nanograms/gram wet weight.
2. Mean concentrations are followed by the standard error of the mean.
3. Reference location.

*Abbreviations:*
NA = not available
ng/g = nanograms per gram

PREPARED BY/DATE: LSV 04/07/17
CHECKED BY/DATE: NTG 04/25/17

**TABLE 3-6**

**SUMMARY OF MERCURY AND METHYL MERCURY CONCENTRATIONS FOR POLYCHAETES IN THE PENOBSCOT RIVER BY YEAR**
**Penobscot River Phase III Engineering Study**
**Penobscot River Estuary, Maine**

| Sample Statistics | Mercury | | | | Methyl Mercury | | | |
|---|---|---|---|---|---|---|---|---|
| | 2006 | 2009 | 2016 | 2017 | 2006 | 2009 | 2016 | 2017 |
| **East Branch Penobscot River[3]** | | | | | | | | |
| **Number of Samples** | 3 | NA | NA | NA | 1 | NA | NA | NA |
| **Mean** | 20.3 ± 3.76 | NA | NA | NA | 1.7 | NA | NA | NA |
| **Median** | 20.0 | NA | NA | NA | 1.7 | NA | NA | NA |
| **OV-04[3]** | | | | | | | | |
| **Number of Samples** | NA | 2 | NA | NA | NA | 2 | NA | NA |
| **Mean** | NA | 55.3 ± 7.20 | NA | NA | NA | 2.71 ± 0.50 | NA | NA |
| **Median** | NA | 55.3 | NA | NA | NA | 2.71 | NA | NA |
| **Frenchman Bay[3]** | | | | | | | | |
| **Number of Samples** | NA | NA | 5 | 5 | NA | NA | 5 | NA |
| **Mean** | NA | NA | 3.18 | 7.83 ± 0.292 | NA | NA | ND | NA |
| **Median** | NA | NA | ND | 7.66 | NA | NA | ND | NA |
| **BO-04** | | | | | | | | |
| **Number of Samples** | NA | 2 | 5 | NA | NA | 4 | 5 | NA |
| **Mean** | NA | 139 ± 25.0 | 214 ± 30.5 | NA | NA | 30.3 ± 3.99 | 8.06 ± 0.423 | NA |
| **Median** | NA | 139 | 185 | NA | NA | 31.3 | 8.30 | NA |
| **OB-05** | | | | | | | | |
| **Number of Samples** | NA | NA | 5 | NA | NA | NA | 5 | NA |
| **Mean** | NA | NA | 213 ± 7.26 | NA | NA | NA | 12.2 ± 0.365 | NA |
| **Median** | NA | NA | 215 | NA | NA | NA | 12.7 | NA |
| **OB-01** | | | | | | | | |
| **Number of Samples** | NA | NA | NA | 5 | NA | NA | NA | 5 |
| **Mean** | NA | NA | NA | 31.7 ± 1.10 | NA | NA | NA | 10.6 ± 0.934 |
| **Median** | NA | NA | NA | 30.6 | NA | NA | NA | 10.4 |
| **Mendall Marsh** | | | | | | | | |
| **Number of Samples** | NA | NA | 5 | 5 | NA | NA | 5 | 5 |
| **Mean** | NA | NA | 192 ± 42.6 | 49.0 ± 4.33 | NA | NA | 8.38 ± 1.83 | 6.22 ± 0.656 |
| **Median** | NA | NA | 190 | 53.8 | NA | NA | 9.90 | 6.10 |
| **Bucksport/Fort Knox** | | | | | | | | |
| **Number of Samples** | NA | NA | NA | 5 | NA | NA | NA | 5 |
| **Mean** | NA | NA | NA | 16.8 ± 1.52 | NA | NA | NA | 7.82 ± 1.14 |
| **Median** | NA | NA | NA | 17.6 | NA | NA | NA | 8.70 |
| **Porcupine Island** | | | | | | | | |
| **Number of Samples** | NA | NA | NA | 5 | NA | NA | NA | 5 |
| **Mean** | NA | NA | NA | 35.9 ± 4.10 | NA | NA | NA | 11.0 ± 2.52 |
| **Median** | NA | NA | NA | 37.1 | NA | NA | NA | 11.6 |
| **ES-02E** | | | | | | | | |
| **Number of Samples** | NA | NA | NA | 5 | NA | NA | NA | 5 |
| **Mean** | NA | NA | NA | 27.0 ± 4.75 | NA | NA | NA | 11.6 ± 1.83 |
| **Median** | NA | NA | NA | 29.8 | NA | NA | NA | 11.4 |
| **ES-15** | | | | | | | | |
| **Number of Samples** | 1 | 5 | NA | 5 | 1 | 5 | NA | NA |
| **Mean** | 23.8 | 21.0 ± 1.50 | NA | 29.5 ± 3.83 | 8.90 | 8.14 ± 0.574 | NA | NA |
| **Median** | 23.8 | 21.9 | NA | 30.5 | 8.90 | 7.76 | NA | NA |
| **VI-W** | | | | | | | | |
| **Number of Samples** | NA | NA | NA | 5 | NA | NA | NA | NA |
| **Mean** | NA | NA | NA | 20.8 ± 1.31 | NA | NA | NA | NA |
| **Median** | NA | NA | NA | 20.1 | NA | NA | NA | NA |
| **ES-13** | | | | | | | | |
| **Number of Samples** | NA | 5 | 5 | 5 | NA | 5 | 5 | NA |
| **Mean** | NA | 35.4 ± 3.19 | 35.0 ± 10.5 | 24.0 ± 6.14 | NA | 13.4 ± 3.99 | 2.50 ± 0.716 | NA |
| **Median** | NA | 36.9 | 24.7 | 19.5 | NA | 8.82 | 1.50 | NA |
| **SVE-02INT** | | | | | | | | |
| **Number of Samples** | NA | NA | NA | 5 | NA | NA | NA | 5 |
| **Mean** | NA | NA | NA | 24.9 ± 1.12 | NA | NA | NA | 10.3 ± 0.702 |
| **Median** | NA | NA | NA | 24.7 | NA | NA | NA | 9.70 |
| **ES-03** | | | | | | | | |
| **Number of Samples** | NA | NA | NA | 5 | NA | NA | NA | NA |
| **Mean** | NA | NA | NA | 32.8 ± 4.38 | NA | NA | NA | NA |
| **Median** | NA | NA | NA | 29.7 | NA | NA | NA | NA |
| **ES-FP** | | | | | | | | |
| **Number of Samples** | NA | 4 | 5 | 5 | NA | 5 | 5 | NA |
| **Mean** | NA | 32.8 ± 3.89 | 29.7 ± 4.79 | 11.3 ± 0.828 | NA | 7.64 ± 1.52 | 7.90 ± 2.63 | NA |
| **Median** | NA | 33.4 | 24.5 | 12.0 | NA | 8.39 | 5.30 | NA |

*Notes:*
1. All concentrations in nanograms/gram wet weight.
2. Mean concentrations are followed by the standard error of the mean.
3. Reference location.

*Abbreviations:*
NA = not available
ND = non-detect; indicates a set of values where the median of the list (sorted by lab qualifier, then value) is a non-detect result

PREPARED BY/DATE: JPM 12/21/17
CHECKED BY/DATE: LO 1/04/18

**TABLE 3-7**

**SUMMARY OF BLUE MUSSEL MERCURY CONCENTRATIONS IN THE PENOBSCOT RIVER BY YEAR[1, 2]**
**Penobscot River Phase III Engineering Study**
**Penobscot River Estuary, Maine**

| Sample Statistics | 2006 | 2008 | 2009 | 2010 | 2012 | 2016 | 2017 |
|---|---|---|---|---|---|---|---|
| **Narraguagus River[3]** | | | | | | | |
| **Number of Samples** | NA | NA | 60 | NA | NA | NA | NA |
| **Mean** | NA | NA | 26.7 ± 0.779 | NA | NA | NA | NA |
| **Median** | NA | NA | 26.5 | NA | NA | NA | NA |
| **Percent of Samples Above 200 ng/g** | NA | NA | 0 | NA | NA | NA | NA |
| **St. George River[3]** | | | | | | | |
| **Number of Samples** | NA | NA | 60 | NA | NA | NA | NA |
| **Mean** | NA | NA | 26.0 ± 0.883 | NA | NA | NA | NA |
| **Median** | NA | NA | 24.7 | NA | NA | NA | NA |
| **Percent of Samples Above 200 ng/g** | NA | NA | 0 | NA | NA | NA | NA |
| **Frenchman Bay[3]** | | | | | | | |
| **Number of Samples** | NA | NA | NA | NA | NA | NA | 20 |
| **Mean** | NA | NA | NA | NA | NA | NA | 8.26 ± 0.484 |
| **Median** | NA | NA | NA | NA | NA | NA | 7.56 |
| **Percent of Samples Above 200 ng/g** | NA | NA | NA | NA | NA | NA | 0 |
| **Southern Cove** | | | | | | | |
| **Number of Samples** | NA | NA | 40 | NA | NA | NA | NA |
| **Mean** | NA | NA | 77.0 ± 3.22 | NA | NA | NA | NA |
| **Median** | NA | NA | 74.6 | NA | NA | NA | NA |
| **Percent of Samples Above 200 ng/g** | NA | NA | 0 | NA | NA | NA | NA |
| **ES-15** | | | | | | | |
| **Number of Samples** | 20 | 30 | 40 | 35 | 15 | 20 | 12 |
| **Mean** | 97.8 ± 10.2 | 74.0 ± 3.12 | 71.3 ± 2.21 | 65.4 ± 2.03 | 65.8 ± 3.87 | 59.6 ± 2.77 | 73.7 ± 3.04 |
| **Median** | 91.1 | 70.9 | 72.8 | 63.4 | 61.5 | 56.9 | 71.4 |
| **Percent of Samples Above 200 ng/g** | 6.7 | 0 | 0 | 0 | 0 | 0 | 0 |
| **ES-13** | | | | | | | |
| **Number of Samples** | 20 | 30 | 40 | 34 | 30 | 20 | 20 |
| **Mean** | 158 ±13.9 | 91.1 ± 3.31 | 80.7 ± 2.47 | 76.6 ± 2.69 | 86.1 ± 3.78 | 63.6 ± 2.94 | 90.2 ± 5.49 |
| **Median** | 142 | 88.4 | 81.0 | 73.8 | 83.5 | 60.9 | 86.5 |
| **Percent of Samples Above 200 ng/g** | 25 | 0 | 0 | 0 | 0 | 0 | 0 |
| **ES-03** | | | | | | | |
| **Number of Samples** | 20 | 30 | 40 | 35 | NA | 20 | 19 |
| **Mean** | 103 ± 10.5 | 76.4 ± 2.56 | 63.3 ± 2.21 | 64.3 ± 2.28 | NA | 82.0 ± 4.97 | 100 ± 7.87 |
| **Median** | 88.4 | 75.7 | 61.9 | 62.5 | NA | 77.5 | 92.3 |
| **Percent of Samples Above 200 ng/g** | 0 | 0 | 0 | 0 | NA | 0 | 5.3 |
| **ES-FP** | | | | | | | |
| **Number of Samples** | NA | NA | 20 | 15 | 15 | 20 | 20 |
| **Mean** | NA | NA | 53.9 ± 1.31 | 57.4 ± 1.79 | 52.2 ± 1.53 | 62.6 ± 3.90 | 94.4 ± 8.56 |
| **Median** | NA | NA | 52.1 | 55.4 | 52.3 | 58.9 | 89.3 |
| **Percent of Samples Above 200 ng/g** | NA | NA | 0 | 0 | 0 | 0 | 0 |

*Notes:*
1. All concentrations in nanograms/gram wet weight.
2. Mean concentrations are followed by the standard error of the mean.
3. Reference location.

*Abbreviations:*
NA = not available
ng/g = nanograms per gram

PREPARED BY/DATE: JPM 12/19/17
CHECKED BY/DATE: LO 02/16/18

**TABLE 3-8**

**SUMMARY OF LOBSTER MERCURY CONCENTRATIONS IN THE PENOBSCOT RIVER BY YEAR[1, 2]**
**Penobscot River Phase III Engineering Study**
**Penobscot River Estuary, Maine**

| Sample Statistics | 2006 | 2008 | 2009 | 2010 | 2012 | 2014 | 2015 | 2016 | 2017 |
|---|---|---|---|---|---|---|---|---|---|
| **Frenchman Bay[3]** | | | | | | | | | |
| **Number of Samples** | NA | NA | NA | NA | NA | NA | NA | NA | 20 |
| **Mean** | NA | NA | NA | NA | NA | NA | NA | NA | 40.6 ± 1.98 |
| **Median** | NA | NA | NA | NA | NA | NA | NA | NA | 38.7 |
| **Percent of Samples Above 200 ng/g** | NA | NA | NA | NA | NA | NA | NA | NA | 0 |
| **Odom Ledge** | | | | | | | | | |
| **Number of Samples** | NA | 21 | 16 | 19 | 15 | 40 | 20 | 20 | 20 |
| **Mean** | NA | 350 ± 42.4 | 206 ± 31.3 | 267 ± 22.6 | 208 ± 32.4 | 525 ± 73.4 | 415 ± 71.4 | 304 ± 44.2 | 345 ± 79.5 |
| **Median** | NA | 306 | 182 | 257 | 214 | 371 | 324 | 207 | 239 |
| **Percent of Samples Above 200 ng/g** | NA | 90 | 44 | 79 | 53 | 88 | 80 | 55 | 60 |
| **South Verona** | | | | | | | | | |
| **Number of Samples** | NA | 10 | 5 | 12 | 15 | 12 | 20 | 20 | 20 |
| **Mean** | NA | 543 ± 72.3 | 466 ± 48.3 | 443 ± 54.7 | 448 ± 75.8 | 432 ± 75.6 | 435 ± 55.9 | 426 ± 58.8 | 325 ± 29.0 |
| **Median** | NA | 504 | 445 | 466 | 335 | 336 | 395 | 366 | 291 |
| **Percent of Samples Above 200 ng/g** | NA | 100 | 100 | 92 | 80 | 92 | 85 | 90 | 75 |
| **Fort Point** | | | | | | | | | |
| **Number of Samples** | NA | 11 | 12 | 21 | 15 | 43 | 28 | NA | NA |
| **Mean** | NA | 240 ± 31.8 | 273 ± 51.1 | 197 ± 21.6 | 232 ± 29.6 | 364 ± 49.3 | 310 ± 48.8 | NA | NA |
| **Median** | NA | 211 | 217 | 190 | 214 | 295 | 209 | NA | NA |
| **Percent of Samples Above 200 ng/g** | NA | 55 | 67 | 43 | 53 | 70 | 57 | NA | NA |
| **Cape Jellison** | | | | | | | | | |
| **Number of Samples** | NA | NA | NA | NA | NA | 39 | 24 | 20 | 20 |
| **Mean** | NA | NA | NA | NA | NA | 252 ± 29.6 | 171 ± 16.7 | 199 ± 16.5 | 288 ± 43.4 |
| **Median** | NA | NA | NA | NA | NA | 196 | 151 | 180 | 223 |
| **Percent of Samples Above 200 ng/g** | NA | NA | NA | NA | NA | 49 | 29 | 35 | 60 |
| **Turner Point** | | | | | | | | | |
| **Number of Samples** | 5 | 34 | 21 | 20 | 15 | 29 | 22 | 20 | 20 |
| **Mean** | 338 ± 46.2 | 198 ± 14.1 | 190 ± 26.1 | 179 ± 18.6 | 187 ± 21.1 | 250 ± 32.1 | 198 ± 53.2 | 168 ± 10.2 | 256 ± 30.5 |
| **Median** | 398 | 174 | 171 | 156 | 146 | 230 | 135 | 164 | 244 |
| **Percent of Samples Above 200 ng/g** | 80 | 41 | 33 | 30 | 33 | 55 | 23 | 20 | 65 |
| **Sears Island/ Marshall Point** | | | | | | | | | |
| **Number of Samples** | 2 | 88 | 22 | 20 | 16 | 59 | 31 | NA | NA |
| **Mean** | 133 ± 11.5 | 112 ± 4.67 | 120 ± 10.8 | 114 ± 11.6 | 128 ± 20.4 | 162 ± 12.9 | 124 ± 9.46 | NA | NA |
| **Median** | 133 | 106 | 99.1 | 94.0 | 104 | 128 | 114 | NA | NA |
| **Percent of Samples Above 200 ng/g** | 0 | 3 | 14 | 10 | 25 | 29 | 6 | NA | NA |
| **Kelly's Cove** | | | | | | | | | |
| **Number of Samples** | NA | 2 | 20 | 20 | NA | NA | NA | NA | NA |
| **Mean** | NA | 87.9 ± 3.85 | 109 ± 10.6 | 134 ± 20.1 | NA | NA | NA | NA | NA |
| **Median** | NA | 87.9 | 96.6 | 106 | NA | NA | NA | NA | NA |
| **Percent of Samples Above 200 ng/g** | NA | 0 | 5 | 15 | NA | NA | NA | NA | NA |
| **Harborside** | | | | | | | | | |
| **Number of Samples** | 1 | 40 | 40 | 40 | 30 | 10 | NA | 20 | 20 |
| **Mean** | 319 | 185 ± 14.3 | 123 ± 6.51 | 158 ± 13.7 | 131 ± 18.2 | 137 ± 36.4 | NA | 98.0 ± 6.27 | 106 ± 11.2 |
| **Median** | 319 | 169 | 116 | 137 | 113 | 103 | NA | 102 | 92.7 |
| **Percent of Samples Above 200 ng/g** | 100 | 40 | 5 | 28 | 10 | 20 | NA | 0 | 5 |

*Notes:*
1. All concentrations in nanograms/gram wet weight.
2. Mean concentrations are followed by the standard error of the mean.
3. Reference location.

*Abbreviations:*
NA = not available
ng/g = nanograms per gram

PREPARED BY/DATE: JPM 12/19/17
CHECKED BY/DATE: LO 01/03/18

**TABLE 3-9**

**SUMMARY OF MUMMICHOG MERCURY CONCENTRATIONS IN WETLANDS ALONG THE PENOBSCOT RIVER BY YEAR[1, 2]**
**Penobscot River Phase III Engineering Study**
**Penobscot River Estuary, Maine**

| Sample Statistics | 2006 | 2008 | 2009 | 2010 | 2012 | 2016 | 2017 |
|---|---|---|---|---|---|---|---|
| **Frenchman Bay[3]** | | | | | | | |
| **Number of Samples** | NA | NA | NA | NA | NA | 20 | 20 |
| **Mean** | NA | NA | NA | NA | NA | 8.06 ± 0.447 | 6.38 ± 0.249 |
| **Median** | NA | NA | NA | NA | NA | 7.96 | 6.50 |
| **Percent of Samples Above 440 ng/g** | NA | NA | NA | NA | NA | 0 | 0 |
| **BO-04** | | | | | | | |
| **Number of Samples** | 5 | NA | NA | NA | NA | 20 | 1 |
| **Mean** | 138 ± 22.4 | NA | NA | NA | NA | 95.6 ± 12.6 | 63.4 |
| **Median** | 120 | NA | NA | NA | NA | 71.2 | 63.4 |
| **Percent of Samples Above 440 ng/g** | 0 | NA | NA | NA | NA | 0 | 0 |
| **OB-05** | | | | | | | |
| **Number of Samples** | 1 | 1 | 24 | 1 | NA | 20 | 20 |
| **Mean** | 251 | 234 | 189 ± 13.8 | 328 | NA | 89.7 ± 4.20 | 83.8 ± 5.14 |
| **Median** | 251 | 234 | 196 | 328 | NA | 89.1 | 76.7 |
| **Percent of Samples Above 440 ng/g** | 0 | 0 | 0 | 0 | NA | 0 | 0 |
| **OB-01** | | | | | | | |
| **Number of Samples** | 2 | NA | 12 | NA | NA | 1 | 15 |
| **Mean** | 421 ± 134 | NA | 224 ± 11.0 | NA | NA | 134 | 119 ± 14.4 |
| **Median** | 421 | NA | 222 | NA | NA | 134 | 109 |
| **Percent of Samples Above 440 ng/g** | 50 | NA | 0 | NA | NA | 0 | 0 |
| **Mendall Marsh Locations[4]** | | | | | | | |
| **Number of Samples** | NA | NA | NA | 14 | 15 | 4 | 19 |
| **Mean** | NA | NA | NA | 352 ± 20.6 | 181 ± 18.1 | 172 ± 28.3 | 124 ± 11.2 |
| **Median** | NA | NA | NA | 343 | 158 | 159 | 109 |
| **Percent of Samples Above 440 ng/g** | NA | NA | NA | 7.1 | 0 | 0 | 0 |

*Notes:*
1. All concentrations in nanograms/gram wet weight.
2. Mean concentrations are followed by the standard error of the mean.
3. Reference location.
4. Mendall Marsh locations include both W-21 and Mendall Marsh sampling locations.

*Abbreviations:*
NA = not available
ng/g = nanograms per gram

PREPARED BY/DATE: JPM 01/05/18
CHECKED BY/DATE: LO 02/16/08

**TABLE 3-10**

**SUMMARY OF RAINBOW SMELT MERCURY CONCENTRATIONS IN THE PENOBSCOT RIVER BY YEAR[1, 2]**
**Penobscot River Phase III Engineering Study**
**Penobscot River Estuary, Maine**

| Sample Statistics | 2006 | 2008 | 2009 | 2010 | 2012 | 2016 | 2017 |
|---|---|---|---|---|---|---|---|
| **Frenchman Bay[3]** | | | | | | | |
| **Number of Samples** | NA | NA | NA | NA | NA | 20 | 20 |
| **Mean** | NA | NA | NA | NA | NA | 6.76 ± 0.197 | 13.2 ± 1.35 |
| **Median** | NA | NA | NA | NA | NA | 6.64 | 11.4 |
| **Percent of Samples Above 200 ng/g** | NA | NA | NA | NA | NA | 0 | 0 |
| **OB-05** | | | | | | | |
| **Number of Samples** | 1 | 8 | NA | 5 | 3 | 1 | 5 |
| **Mean** | 96.5 | 142 ± 30.4 | NA | 65.4 ± 7.64 | 151 ± 42.7 | 201 | 80.1 ± 5.50 |
| **Median** | 96.5 | 102 | NA | 67.5 | 110 | 201 | 83.5 |
| **Percent of Samples Above 200 ng/g** | 0 | 25 | NA | 0 | 33 | 100 | 0 |
| **OB-04** | | | | | | | |
| **Number of Samples** | 1 | 1 | 3 | 6 | NA | 5 | NA |
| **Mean** | 186 | 91.0 | 181 ± 112 | 95.4 ± 10.4 | NA | 56.9 ± 6.61 | NA |
| **Median** | 186 | 91.0 | 90.4 | 88.4 | NA | 54.9 | NA |
| **Percent of Samples Above 200 ng/g** | 0 | 0 | 33 | 0 | NA | 0 | NA |
| **OB-01** | | | | | | | |
| **Number of Samples** | 9 | NA | 30 | 5 | 15 | 15 | 20 |
| **Mean** | 92.1 ± 8.46 | NA | 100 ± 4.52 | 155 ± 46.4 | 108 ± 18.8 | 86.2 ± 8.87 | 49.0 ± 2.31 |
| **Median** | 90.1 | NA | 91.2 | 125 | 92.1 | 90.8 | 46.7 |
| **Percent of Samples Above 200 ng/g** | 0 | NA | 0 | 20 | 6.7 | 0 | 0 |
| **ES-15** | | | | | | | |
| **Number of Samples** | NA | 16 | 7 | NA | NA | 1 | NA |
| **Mean** | NA | 52.4 ± 5.07 | 75.4 ± 9.89 | NA | NA | 38.4 | NA |
| **Median** | NA | 48.0 | 76.4 | NA | NA | 38.4 | NA |
| **Percent of Samples Above 200 ng/g** | NA | 0 | 0 | NA | NA | 0 | NA |
| **ES-13** | | | | | | | |
| **Number of Samples** | 10 | 15 | 33 | 6 | 9 | NA | 20 |
| **Mean** | 75.3 ± 7.34 | 46.2 ± 2.78 | 83.0 ± 3.61 | 40.7 ± 5.3 | 78.2 ± 13.7 | NA | 44.5 ± 4.05 |
| **Median** | 75.2 | 47.1 | 78.6 | 37.15 | 58.3 | NA | 37.8 |
| **Percent of Samples Above 200 ng/g** | 0 | 0 | 0 | 0 | 0 | NA | 0 |
| **ES-FP** | | | | | | | |
| **Number of Samples** | NA | NA | 20 | 15 | 15 | 20 | 20 |
| **Mean** | NA | NA | 56.0 ± 3.19 | 36.9 ± 1.96 | 59.1 ± 9.14 | 59.7 ± 5.65 | 84.9 ± 12.5 |
| **Median** | NA | NA | 54.6 | 36.3 | 47.3 | 55.4 | 72.0 |
| **Percent of Samples Above 200 ng/g** | NA | NA | 0 | 0 | 0 | 0 | 5.0 |

*Notes:*
1. All concentrations in nanograms/gram wet weight.
2. Mean concentrations are followed by the standard error of the mean.
3. Reference location.

*Abbreviations:*
NA = not available
ng/g = nanograms per gram

PREPARED BY/DATE: JPM 12/21/17
CHECKED BY/DATE: LO 02/16/18

**TABLE 3-11**

**SUMMARY OF AMERICAN EEL MERCURY CONCENTRATIONS IN THE PENOBSCOT RIVER BY YEAR[1, 2]**
**Penobscot River Phase III Engineering Study**
**Penobscot River Estuary, Maine**

| Sample Statistics | 2007 | 2008 | 2009 | 2010 | 2012 | 2016 | 2017 |
|---|---|---|---|---|---|---|---|
| **OV-04*** | | | | | | | |
| **Number of Samples** | 24 | 18 | 7 | 26 | 41 | NA | 6 |
| **Mean** | 348 ± 39.4 | 355 ± 39.2 | 282 ± 58.9 | 353 ± 35.3 | 247 ± 24.4 | NA | 210 ± 33.0 |
| **Median** | 268 | 360 | 221 | 333 | 186 | NA | 169 |
| **Percent of Samples Above 320 ng/g** | 46 | 56 | 29 | 54 | 22 | NA | 0 |
| **BO-04** | | | | | | | |
| **Number of Samples** | 18 | 19 | 5 | 14 | 20 | 1 | 20 |
| **Mean** | 625 ± 37.5 | 586 ± 74.8 | 704 ± 90.8 | 682 ± 82.7 | 495 ± 41.8 | 1,370 | 551 ± 47.6 |
| **Median** | 590 | 652 | 717 | 649 | 458 | 1,370 | 491 |
| **Percent of Samples Above 320 ng/g** | 100 | 68 | 100 | 86 | 85 | 100 | 95 |
| **OB-05** | | | | | | | |
| **Number of Samples** | 22 | 16 | 13 | 20 | 20 | 5 | 20 |
| **Mean** | 500 ± 51.0 | 395 ± 27.3 | 549 ± 61.9 | 520 ± 51.5 | 609 ± 65.0 | 469 ± 31.8 | 283 ± 35.6 |
| **Median** | 449 | 395 | 569 | 472 | 613 | 461 | 263 |
| **Percent of Samples Above 320 ng/g** | 73 | 81 | 85 | 85 | 90 | 100 | 30 |
| **OB-01** | | | | | | | |
| **Number of Samples** | 10 | 5 | 20 | 4 | 18 | 1 | NA |
| **Mean** | 561 ± 21.7 | 413 ± 52.5 | 409 ± 40.8 | 506 ± 40.3 | 497 ± 31.0 | 394 | NA |
| **Median** | 552 | 413 | 390 | 494 | 465 | 394 | NA |
| **Percent of Samples Above 320 ng/g** | 100 | 80 | 65 | 100 | 94 | 100 | NA |

*Notes:*
1. All concentrations in nanograms/gram wet weight.
2. Mean concentrations are followed by the standard error of the mean
3. Reference location.

*Abbreviations:*
NA = not available
ng/g = nanograms per gram

Prepared by: JPM 11/10/17
Checked by: LO 1/03/18

**TABLE 3-12**

**SUMMARY OF ATLANTIC TOMCOD MERCURY CONCENTRATIONS IN THE PENOBSCOT RIVER BY YEAR[1, 2]**
**Penobscot River Phase III Engineering Study**
**Penobscot River Estuary, Maine**

| Sample Statistics | 2006 | 2008 | 2009 | 2010 | 2012 | 2016 | 2017 |
|---|---|---|---|---|---|---|---|
| **Frenchman Bay[3]** | | | | | | | |
| Number of Samples | NA | NA | NA | NA | NA | 1 | NA |
| Mean | NA | NA | NA | NA | NA | 36.5 | NA |
| Median | NA | NA | NA | NA | NA | 36.5 | NA |
| Percent of Samples Above 200 ng/g | NA | NA | NA | NA | NA | 0 | NA |
| **BO-04** | | | | | | | |
| Number of Samples | 7 | NA | NA | 1 | NA | 4 | 8 |
| Mean | 289 ± 16.9 | NA | NA | 325 | NA | 282 ± 28.9 | 161 ± 13.7 |
| Median | 302 | NA | NA | 325 | NA | 308 | 157 |
| Percent of Samples Above 200 ng/g | 86 | NA | NA | 100 | NA | 75 | 13 |
| **OB-05** | | | | | | | |
| Number of Samples | 10 | 1 | 22 | 15 | 15 | 18 | 20 |
| Mean | 198 ± 26.7 | 254 | 160 ± 7.35 | 172 ± 19.6 | 193 ± 12.3 | 164 ± 13.1 | 156 ± 19.2 |
| Median | 175 | 254 | 152 | 162 | 203 | 152 | 125 |
| Percent of Samples Above 200 ng/g | 40 | 100 | 14 | 27 | 53 | 28 | 25 |
| **OB-01** | | | | | | | |
| Number of Samples | 10 | 37 | 38 | 30 | 15 | 19 | 20 |
| Mean | 162 ± 20.3 | 160 ± 12.4 | 134 ± 9.43 | 191 ± 17.4 | 166 ± 24.7 | 169 ± 15.4 | 182 ± 26.9 |
| Median | 144 | 139 | 119 | 187 | 155 | 174 | 171 |
| Percent of Samples Above 200 ng/g | 10 | 27 | 11 | 40 | 27 | 32 | 40 |
| **ES-13** | | | | | | | |
| Number of Samples | 7 | NA | 14 | NA | 15 | 11 | 11 |
| Mean | 115 ± 7.49 | NA | 92.3 ± 7.07 | NA | 113 ± 10.4 | 109 ± 14.8 | 113 ± 24.9 |
| Median | 115 | NA | 90.1 | NA | 98.8 | 103 | 60.2 |
| Percent of Samples Above 200 ng/g | 0 | NA | 0 | NA | 0 | 9 | 27 |
| **ES-FP** | | | | | | | |
| Number of Samples | NA | NA | NA | NA | 15 | 2 | 1 |
| Mean | NA | NA | NA | NA | 88.6 ± 9.33 | 64.9 ± 9.40 | 37.2 |
| Median | NA | NA | NA | NA | 71.7 | 64.9 | 37.2 |
| Percent of Samples Above 200 ng/g | NA | NA | NA | NA | 0 | 0 | 0 |

*Notes:*
1. All concentrations in nanograms/gram wet weight.
2. Mean concentrations are followed by the standard error of the mean.
3. Reference location.

*Abbreviations:*
NA = not available
ng/g = nanograms per gram

PREPARED BY/DATE: JPM 12/19/17
CHECKED BY/DATE: LO 01/03/18

**TABLE 5-1**

**AVIAN SPECIES REGRESSION SUMMARY[1]**
**Penobscot River Phase III Engineering Study**
**Penobscot River Estuary, Maine**

| Species | Location | Overall Regression Direction[2] | Site-Specific Regression Direction[2, 3] | Percent Annual Change[5] | Blood Concentration Regression Direction[2,3] | Hatch-Year Percent Annual Change[5] | Hatch-Year Regression Direction[2,3] | Adult Percent Annual Change[5] | Adult Regression Direction[2,3] |
|---|---|---|---|---|---|---|---|---|---|
| Nelson's Sparrow | Overall | Declining | | -0.35% | Declining | NA | No Trend | -0.40% | Declining |
| | W-17 | | Declining | -0.59% | Declining | NA | NA | -0.41% | Declining |
| | Mendall Marsh SE | | No Trend | NA | No Trend | NA | NA | -0.25% | Declining[4] |
| | Mendall Marsh SW | | Declining | -0.48% | Declining | NA | NA | -0.62% | Declining |
| | Reference | | NA | NA | NA | NA | NA | NA | NA |
| Red-winged Blackbird | Overall | Increasing | | 1.0% | Increasing | -3.6% | Declining | NA | No Trend |
| | W-17 | | No Trend | NA | No Trend | NA | NA | NA | No Trend |
| | Mendall Marsh SE | | Increasing | 2.2% | Increasing | NA | NA | NA | No Trend |
| | Mendall Marsh SW | | Increasing[4] | 1.3% | Increasing[4] | -4.8% | Declining | 1.2% | Increasing[4] |
| | Reference | | NA | NA | NA | NA | NA | NA | NA |
| American Black Duck Blood | Overall | No Trend | | NA | No Trend | NA | NA | NA | NA |
| | Mendall Marsh | | No Trend | NA | No Trend | NA | NA | NA | NA |
| | South Verona | | Increasing | 1.6% | Increasing | NA | NA | NA | NA |
| | Reference | | Declining | -2.0% | Declining | NA | NA | NA | NA |

*Notes:*
1. The meaning of color coded cells is as follows:
   - (green) Declining
   - (yellow) No Trend
   - (orange) Increasing
2. Declining or Increasing means p-value < 0.05
3. No Trend means p-value ≥ 0.10 and the slope is not statistically different than zero
4. indicates p-value ≥ 0.05 and < 0.10
5. Regression equations (provided on the Section 4 figures) were used to calculate percent annual change as: (y0 - y1)/number of years between y0 and y1, where y0 is the mercury concentration calculated with the regression equation for a given year and y1 is the mercury concentration calculated for another given year.

*Abbreviations:*
NA = not applicable

Prepared by/Date: LO 08/03/18
Checked by/Date: IMR 08/07/18

**TABLE 5-2**

**AQUATIC BIOTA REGRESSION SUMMARY[1]**
**Penobscot River Phase III Engineering Study**
**Penobscot River Estuary, Maine**

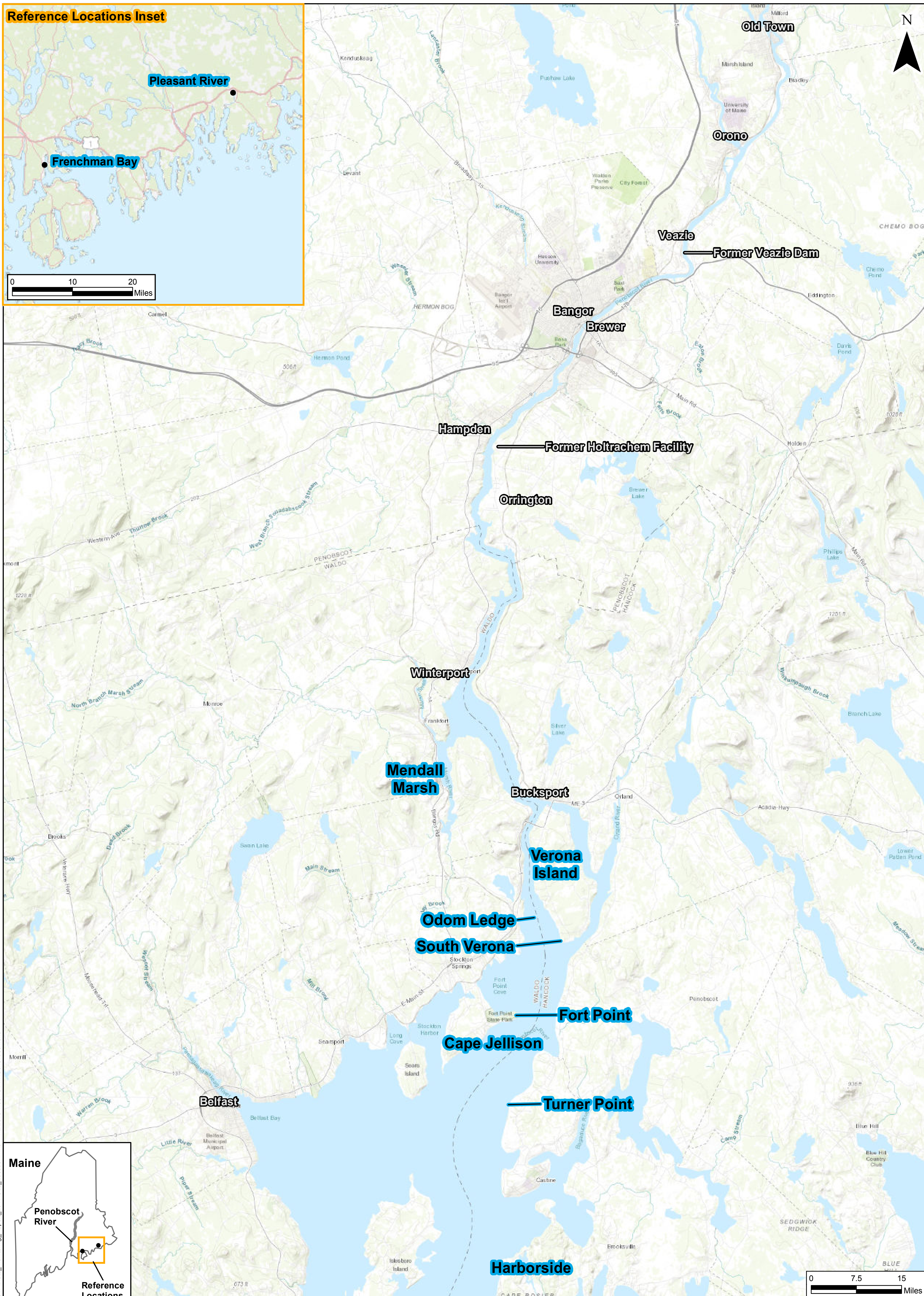
| Species | Location | Overall Regression Direction[2] | Site-Specific Regression Direction[2, 3] | Percent Annual Change[4] |
|---|---|---|---|---|
| Blue Mussel | Overall | Declining | | -0.2% |
| | ES-15 | | Declining | -0.5% |
| | ES-13 | | Declining | -0.8% |
| | ES-03 | | Increasing | 0.4% |
| | ES-FP | | Increasing | 1.2% |
| | Reference | | NA | NA |
| Lobsters | Overall | Declining | | -0.8% |
| | Odom Ledge | | No Trend | NA |
| | South Verona | | Declining | -2.5% |
| | Cape Jellison | | Declining | -3.8% |
| | Turner Point | | Declining | -1.1% |
| | Harborside | | Declining | -1.1% |
| Mummichog | Overall | Declining | | -1.5% |
| | BO-04 | | NA | NA |
| | OB-05 | | No Trend | NA |
| | OB-01 | | NA | NA |
| | Mendall Marsh | | Declining | -4.9% |
| | Reference | | NA | NA |
| Rainbow Smelt | Overall | Declining | | -3.2% |
| | OB-05 | | No Trend | NA |
| | OB-04 | | Declining | -6.5% |
| | OB-01 | | Declining | -5.9% |
| | ES-13 | | No Trend | NA |
| | ES-15 | | NA | NA |
| | ES-FP | | No Trend | NA |
| | Reference | | NA | NA |
| American Eel | Overall | Declining | | -2.1% |
| | BO-04 | | Declining | -2.4% |
| | OB-05 | | Declining | -2.1% |
| | OB-01 | | No Trend | NA |
| | Reference | | No Trend | NA |
| Atlantic Tomcod | Overall | Declining | | -1.4% |
| | BO-04 | | No Trend | NA |
| | OB-05 | | Declining | -1.6% |
| | OB-01 | | Declining | -1.7% |
| | ES-13 | | Declining | -3.1% |
| | ES-FP | | NA | NA |
| | Reference | | NA | NA |

*Notes:*
1. The meaning of color coded cells is as follows:
   - (green) Declining
   - (yellow) No Trend
   - (orange) Increasing
2. Declining or Increasing means p-value < 0.05
3. No Trend means p-value ≥ 0.10 and the slope is not statistically different than zero
4. Regression equations (provided on the Section 4 figures) were used to calculate percent annual change as: (y0 - y1)/number of years between y0 and y1, where y0 is the mercury concentration calculated with the regression equation for a given year and y1 is the mercury concentration calculated for another given year.

*Abbreviations:*
NA = not applicable

Prepared by/Date: JAW 01/18/18
Checked by/Date: ADB 01/22/18

# FIGURES




Legend

**Mendall Marsh** Geographic Area Label

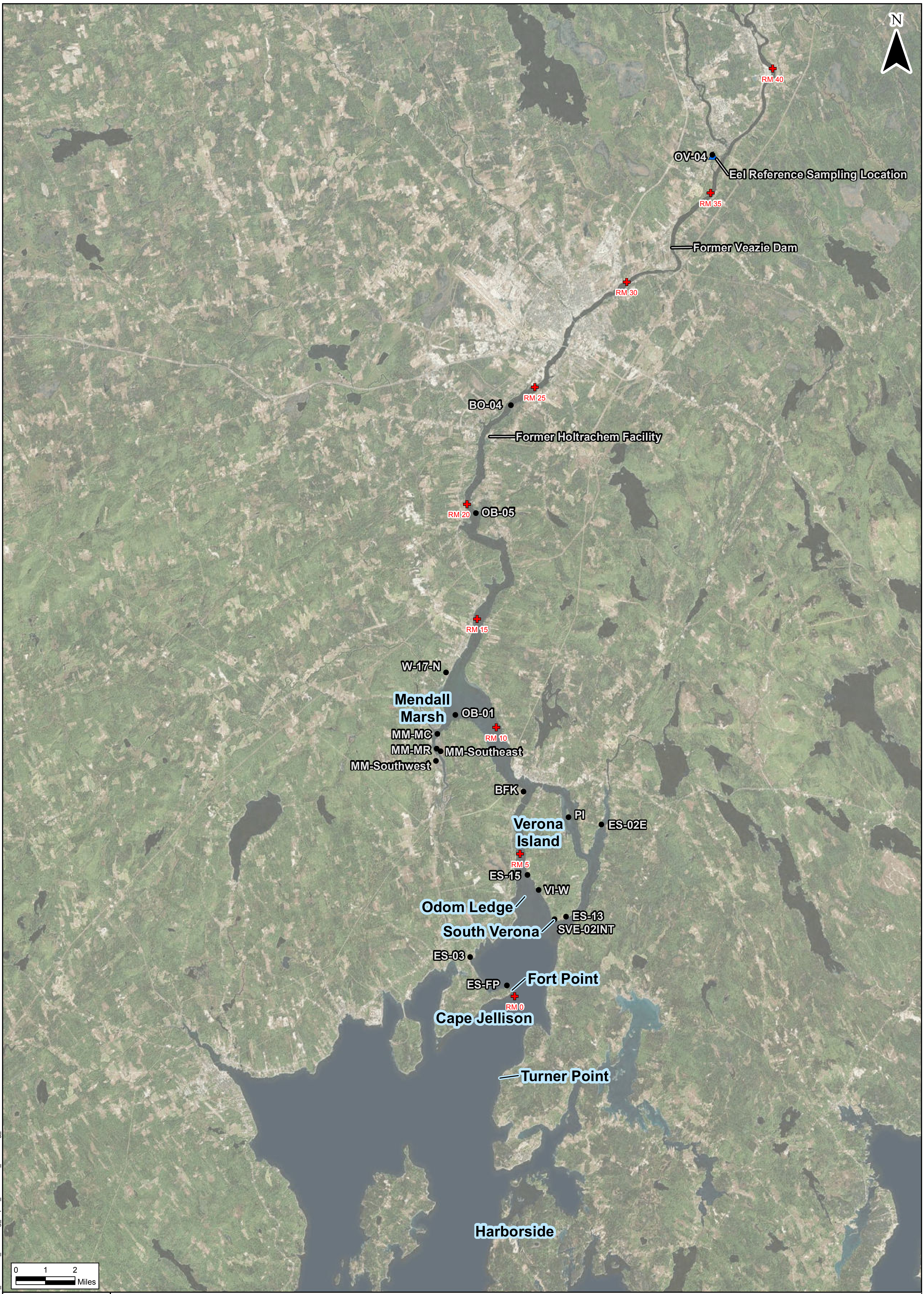
Figure 1-1
Site Location

amec foster wheeler

2017 Biota Monitoring Report
Penobscot River Phase III Engineering Study

| Project: 3616166052 | Prepared/Date: RD 1/2/2018 | Checked/Date: LSV 1/2/2018 |
| --- | --- | --- |

Document:G:\Penobscot River\mxds\Report_Figures_2017\Biota_Monitoring_Report_2017\Site_Location.mxd 1/2/2018 1:38:15 PM rachel.desmond




Legend

- River Mile Marker
- Biota Sampling Location
- Eel Reference Sampling Location
- **Mendall Marsh** Geographic Area Label

amec foster wheeler

Figure 2-1
2017 Penobscot
Biota Sampling Locations

2017 Biota Monitoring Report
Penobscot River Phase III Engineering Study

| Project: 3616166052 | Prepared/Date: RD 1/11/2018 | Checked/Date: LSV 1/11/2018 |
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**Legend**

- ▲ Fish Sampling Location (Mummichog, Rainbow Smelt, and Tomcod)
- ■ Lobster Sampling Location
- ● Nelson Sparrow, Red-winged Blackbird, Spider, and Terrestrial Insect Sampling Location
- ⊙ Blue Mussel Sampling Location
- ☆ American Black Duck Sampling Location
- ⬢ Polychaete Sampling Location
- **Pleasant River** Geographic Area Label

Figure 2-2
2016-2017 Biota
Reference Sampling Locations

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Penobscot River Phase III Engineering Study

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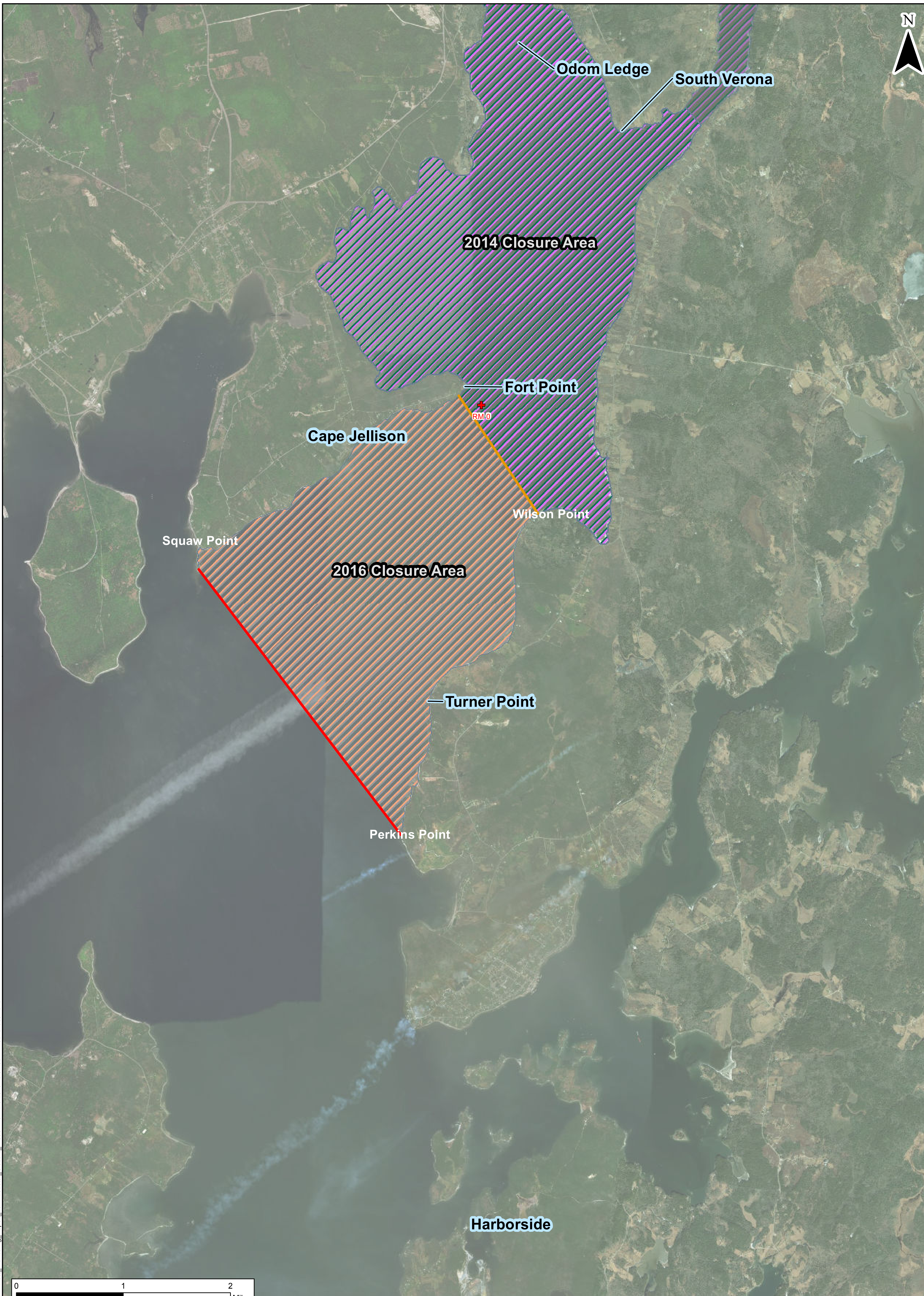


**Legend**

- River Mile Marker
- **South Verona** Geographic Area Label
- 2014 Closure Line
- 2016 Closure Line
- 2014 Closure
- 2016 Closure

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Figure 2-3
Lobster Closure Areas

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Document:G:\Penobscot River\mxds\Report_Figures_2017\Biota_Monitoring_Report_2017\Lobster_Closure_Areas.mxd 2/6/2018 10:54:36 AM rachel.desmond


Note:
J - The reported concentration is considered an estimated value

Concentrations reported in wet weight (ww)

**Legend**

▲ 2016 Terrestrial Insect Sample
● 2017 Terrestrial Insect Sample
W-17-N Sampling Location
**Mendall Marsh** Geographic Area Label

Figure 3-1a
2016-2017 Individual Terrestrial Insects
Mercury Analytical Results (ng/g)

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Note:
J - The reported concentration is considered an estimated value

Concentrations reported in wet weight (ww)

**Legend**

▲ 2016 Terrestrial Insect Sample

● 2017 Terrestrial Insect Sample

W-17-N Sampling Location

**Mendall Marsh** Geographic Area Label

Figure 3-1b
2016-2017 Individual Terrestrial Insects
Methyl Mercury Analytical Results (ng/g)

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Note:
J - The reported concentration is considered an estimated value.

Concentrations reported in wet weight (ww)

**Legend**

- 2016 Spider Sample
- 2017 Spider Sample
- W-17-N Sampling Location
- **Mendall Marsh** Geographic Area Label

Figure 3-2a
2016-2017 Individual Spiders
Mercury Analytical Results (ng/g)

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Note:
J - The reported concentration is considered an estimated value

Concentrations reported in wet weight (ww)

**Legend**

▲ 2016 Spider Sample

● 2017 Spider Sample

W-17-N Sampling Location

**Mendall Marsh** Geographic Area Label

Figure 3-2b
2016-2017 Individual Spiders
Methyl Mercury Analytical Results (ng/g)

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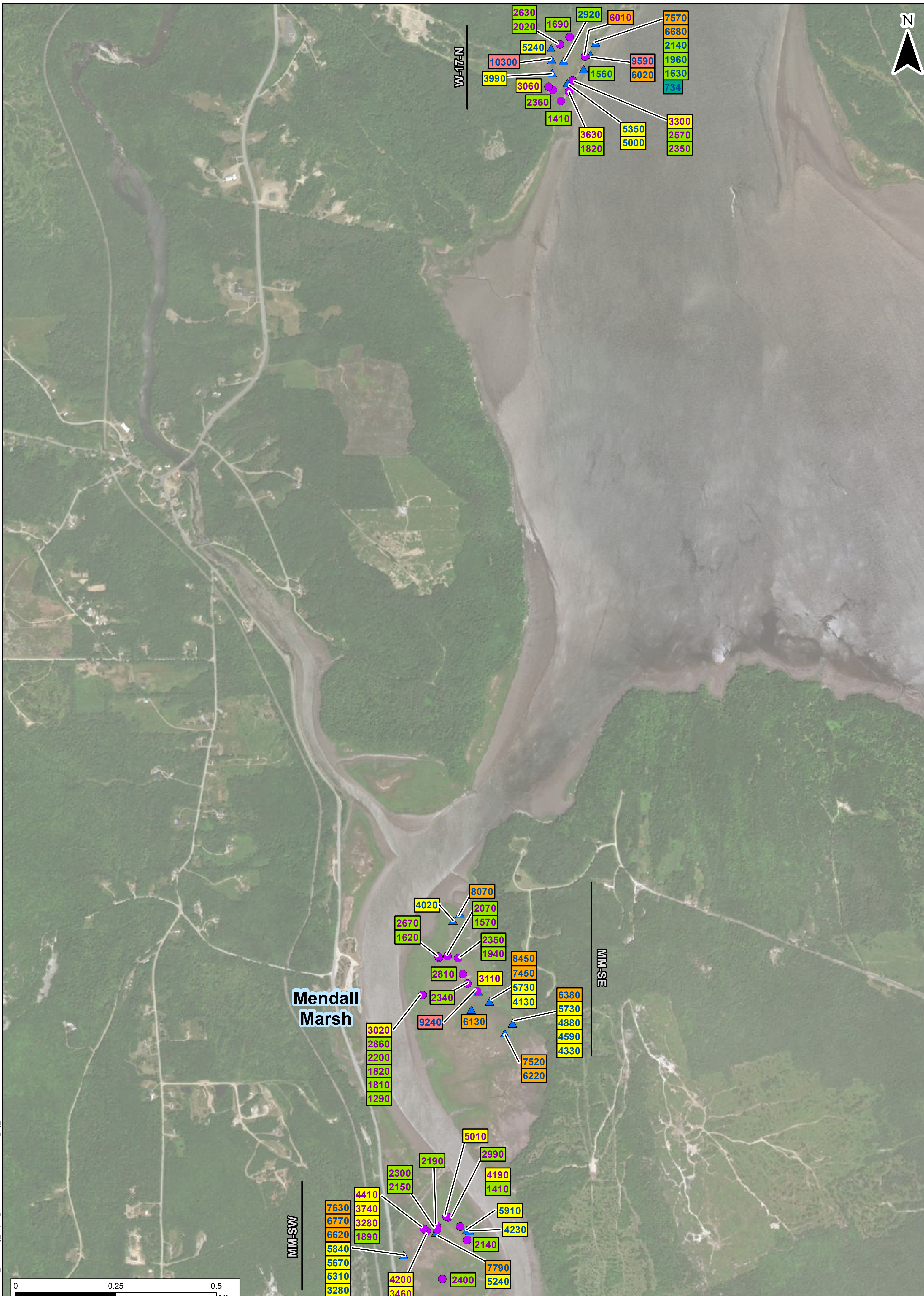


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Note:
Concentrations reported in wet weight (ww)

**Legend**

▲ 2016 Nelson's Sparrow Sample

● 2017 Nelson's Sparrow Sample

W-17-N Sampling Location

**Mendall Marsh** Geographic Area Label

**Mercury Results (ng/g)**

- < 1000
- 1000 - 3000
- 3000 - 6000
- 6000 - 9000
- > 9000

Figure 3-3
2016-2017 Individual Nelson's Sparrow Mercury Analytical Results (ng/g)

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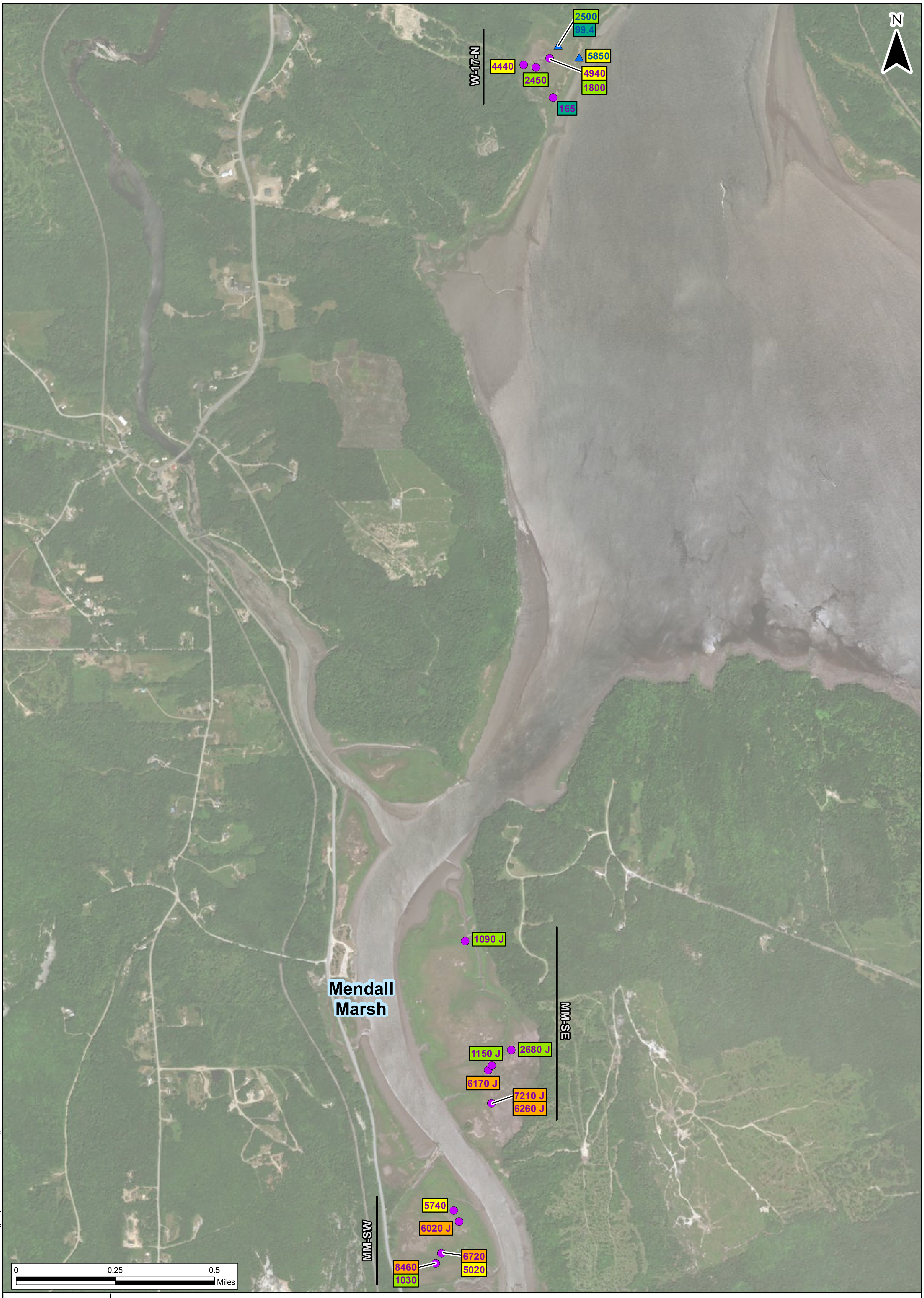
|---|---|---|




amec foster wheeler

Note:
J - The reported concentration is considered an estimated value

Concentrations reported in wet weight (ww)

**Legend**

▲ 2016 Red-winged Blackbird Sample

● 2017 Red-winged Blackbird Sample

**W-17-N** Sampling Location

**Mendall Marsh** Geographic Area Label

**Mercury Results (ng/g)**

- < 1000
- 1000 - 3000
- 3000 - 6000
- 6000 - 9000

Figure 3-4
2016-2017 Individual Red-winged Blackbird Mercury Analytical Results (ng/g)

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|---|---|---|

Document:G:\Penobscot River\mxds\Report_Figures_2017\Biota_Monitoring_Report_2017\Blackbird2017_Hg_results.mxd 1/3/2018 8:54:28 AM rachel.desmond


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Note:
American Black Ducks were sampled during January and February 2017 and January 2018 due to seasonal restrictions

Concentrations reported in wet weight (ww)

**Legend**

- River Mile Marker
- 2017 Black Duck Sample
- 2018 Black Duck Sample
- OB-01 Sampling Location

**Mercury Results (ng/g)**

- < 1000
- 1000 - 3000

**Mendall Marsh** Geographic Area Label

Figure 3-5a
2017-2018 Individual American Black Duck Blood Mercury Analytical Results (ng/g)

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Note:
J - The reported concentration is considered an estimated value

American Black Ducks were sampled during January and February 2017 due to seasonal restrictions

Concentrations reported in wet weight (ww)

**Legend**

- River Mile Marker
- 2017 Black Duck Sample
- OB-01 Sampling Location
- Mendall Marsh Geographic Area Label

**Mercury Results (ng/g)**

- < 100
- 100 - 200
- 200 - 500
- 500 - 1000

Figure 3-5b
2017 American Black Duck Tissue Mercury Analytical Results (ng/g)

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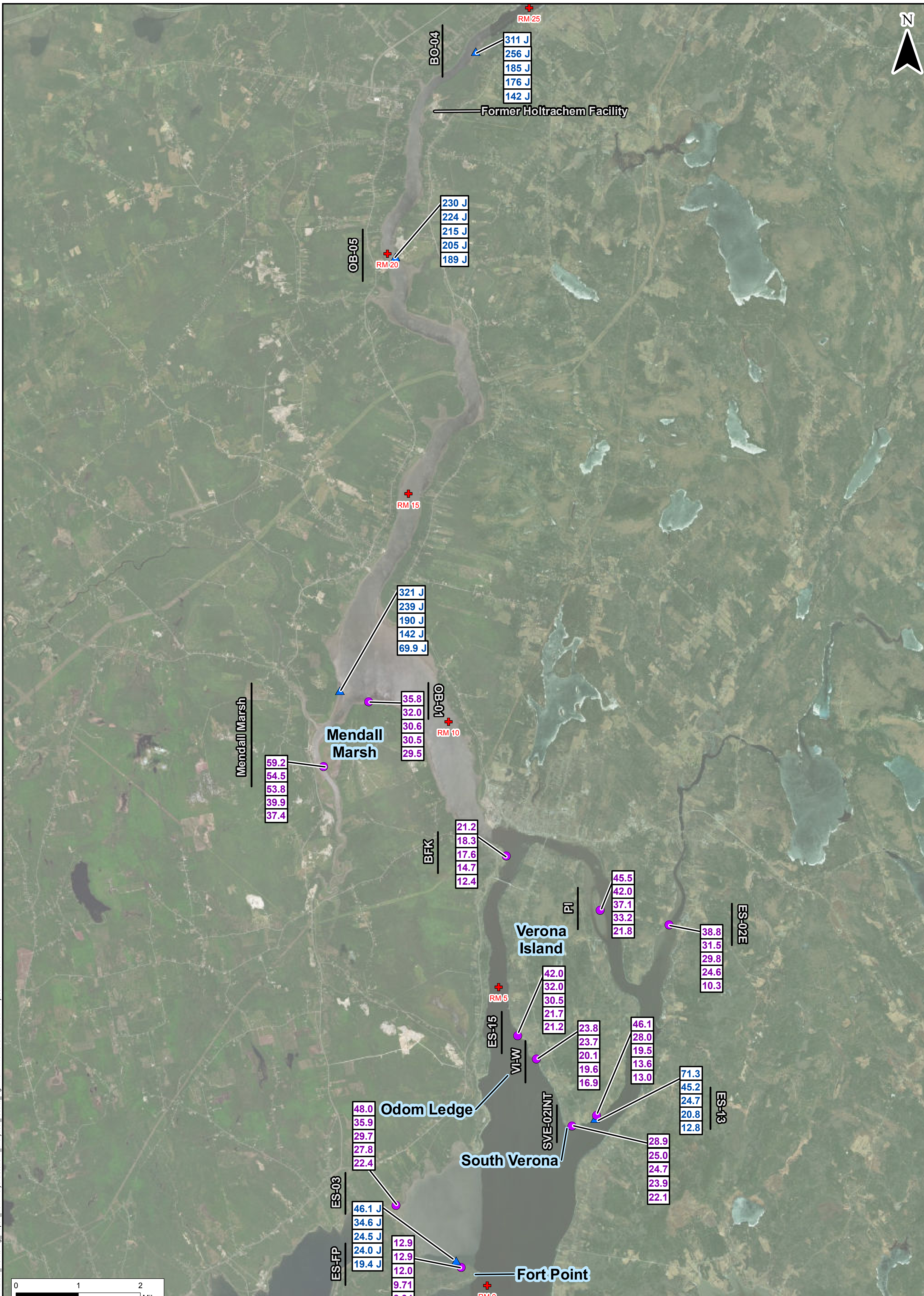
Project: 3616166052 | Prepared/Date: RD 1/11/2018 | Checked/Date: LSV 1/11/2018

Document:G:\Penobscot River\mxds\Report_Figures_2017\Biota_Monitoring_Report_2017\BlackDuck\2017_analytical_results_Hg_Tissue.mxd 1/11/2018 3:10:16 PM rachel.desmond




Note:
J - The reported concentration is considered an estimated value

Concentrations reported in wet weight (ww)

**Legend**

- River Mile Marker
- 2016 Polychaete Sample
- 2017 Polychaete Sample
- OB-01 Sampling Location
- Mendall Marsh Geographic Area Label

Figure 3-6a
2016-2017 Individual Polychaetes Mercury Analytical Results (ng/g)

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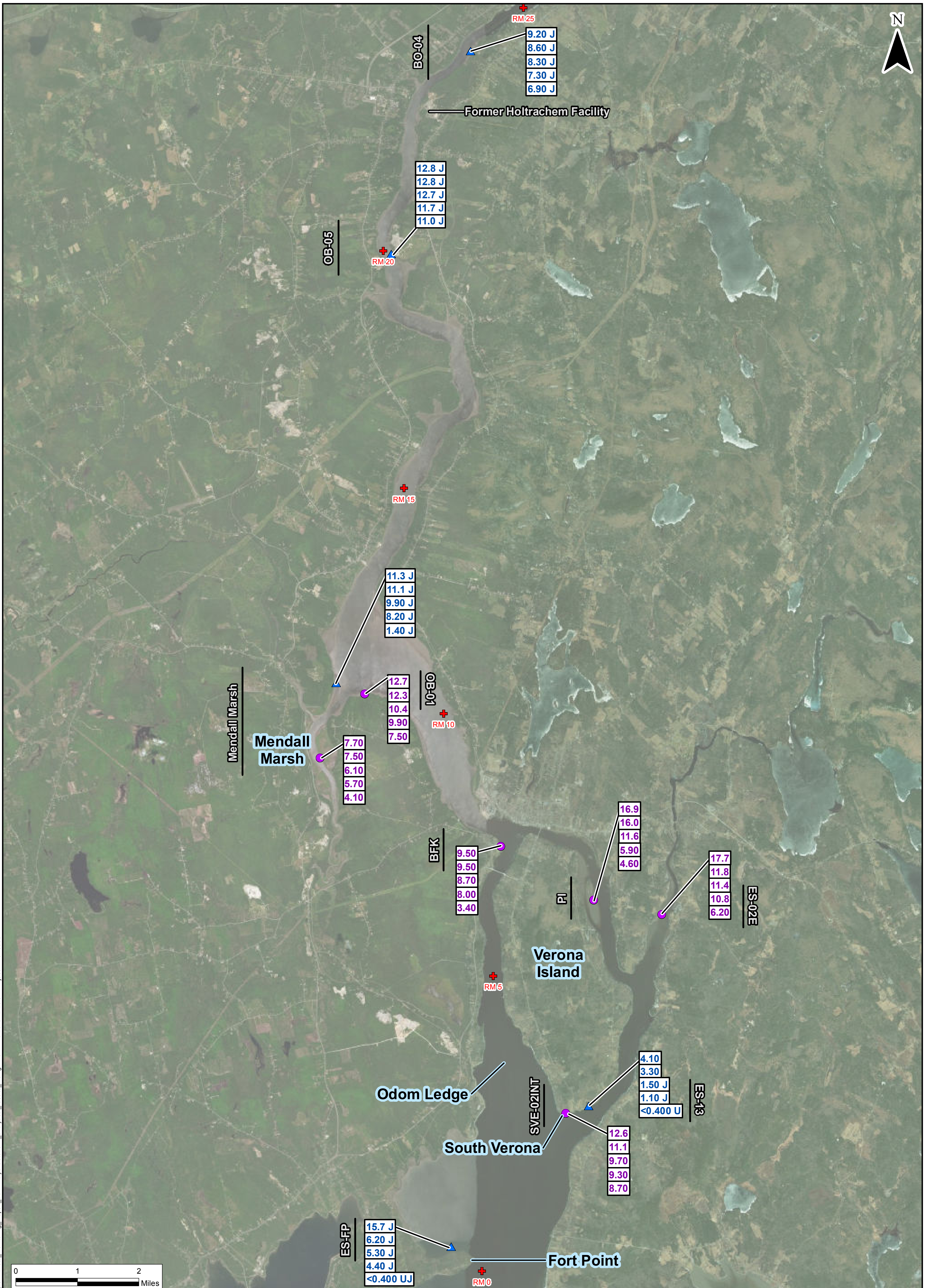
|---|---|---|

Document:G:\Penobscot River\mxds\Report_Figures_2017\Biota_Monitoring_Report_2017\Polychaete\2017_analytical_results_Hg.mxd 1/19/2018 12:29:52 PM jason.muhlbauer




Note:
J - The reported concentration is considered an estimated value

U - The target compound was not detected above the method detection limit

Concentrations reported in wet weight (ww)

**Legend**

- River Mile Marker
- 2016 Polychaete Sample
- 2017 Polychaete Sample
- OB-01 Sampling Location
- Mendall Marsh Geographic Area Label

Figure 3-6b
2016-2017 Individual Polychaetes
Methyl Mercury Analytical Results (ng/g)

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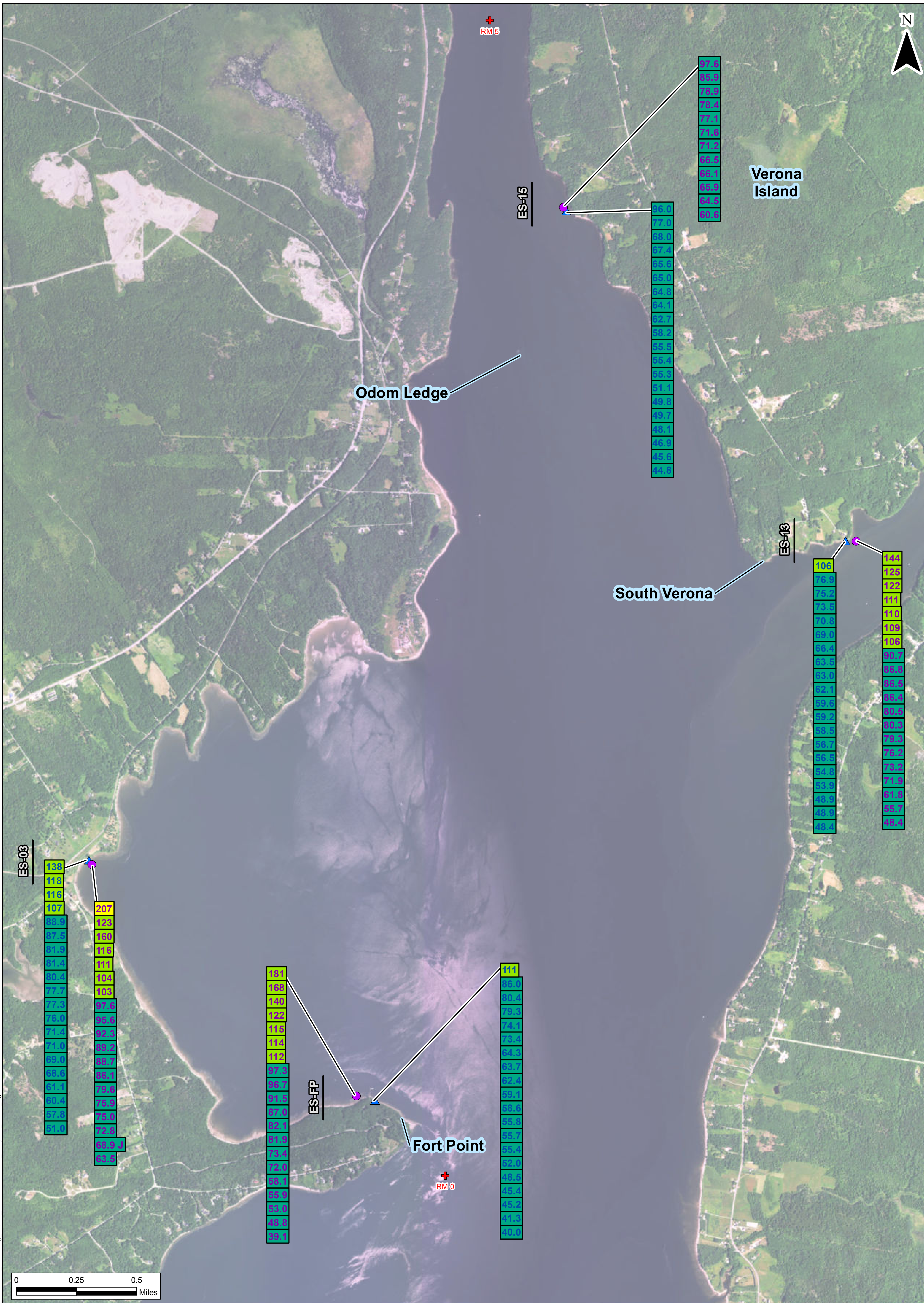
|---|---|---|

Document:G:\Penobscot River\mxds\Report_Figures_2017\Biota_Monitoring_Report_2017\Polychaete\2017_analytical_results_MeHg.mxd 1/19/2018 12:29:54 PM jason.muhlbauer




amec foster wheeler

Note:
J - The reported concentration is considered an estimated value

Concentrations reported in wet weight (ww)

**Legend**

- River Mile Marker
- 2016 Blue Mussel Sample
- 2017 Blue Mussel Sample

OB-01 Sampling Location

South Verona Geographic Area Label

**Mercury Results (ng/g)**

- < 100
- 100 - 200
- 200 - 500
- 500 - 1000
- > 1000

Figure 3-7
2016-2017 Individual Blue Mussel Mercury Analytical Results (ng/g)

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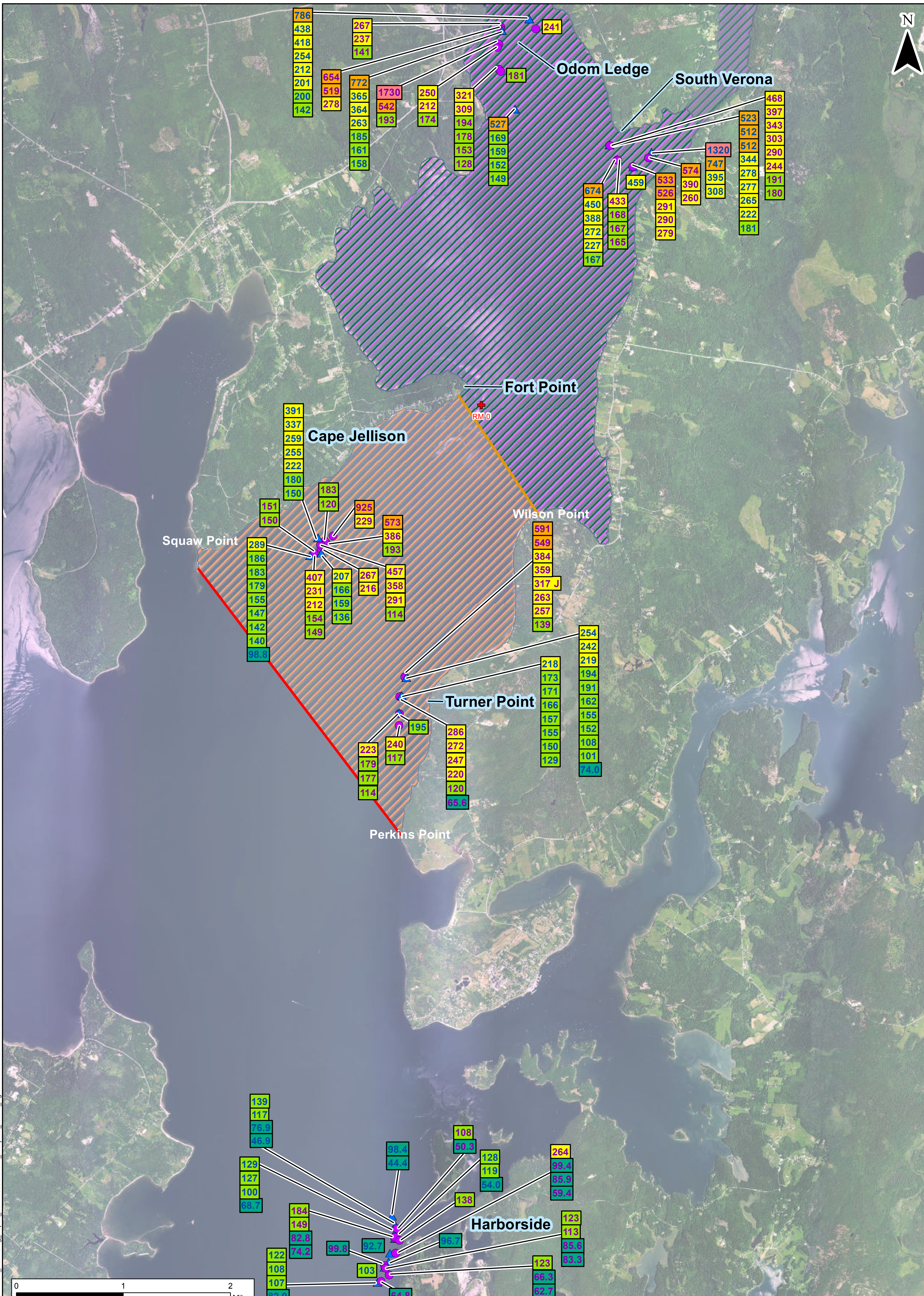


amec foster wheeler

Notes:
J - The reported concentration is considered an estimated value

Concentrations reported in wet weight (ww)

**Legend**

- River Mile Marker
- 2016 Lobster Sample
- 2017 Lobster Sample
- South Verona — Geographic Area Label
- 2014 Closure Line
- 2016 Closure Line
- 2014 Closure
- 2016 Closure

**Mercury Results (ng/g)**

- < 100
- 100 - 200
- 200 - 500
- 500 - 1000
- > 1000

Figure 3-8
2016-2017 Individual Lobster Mercury Analytical Results (ng/g)

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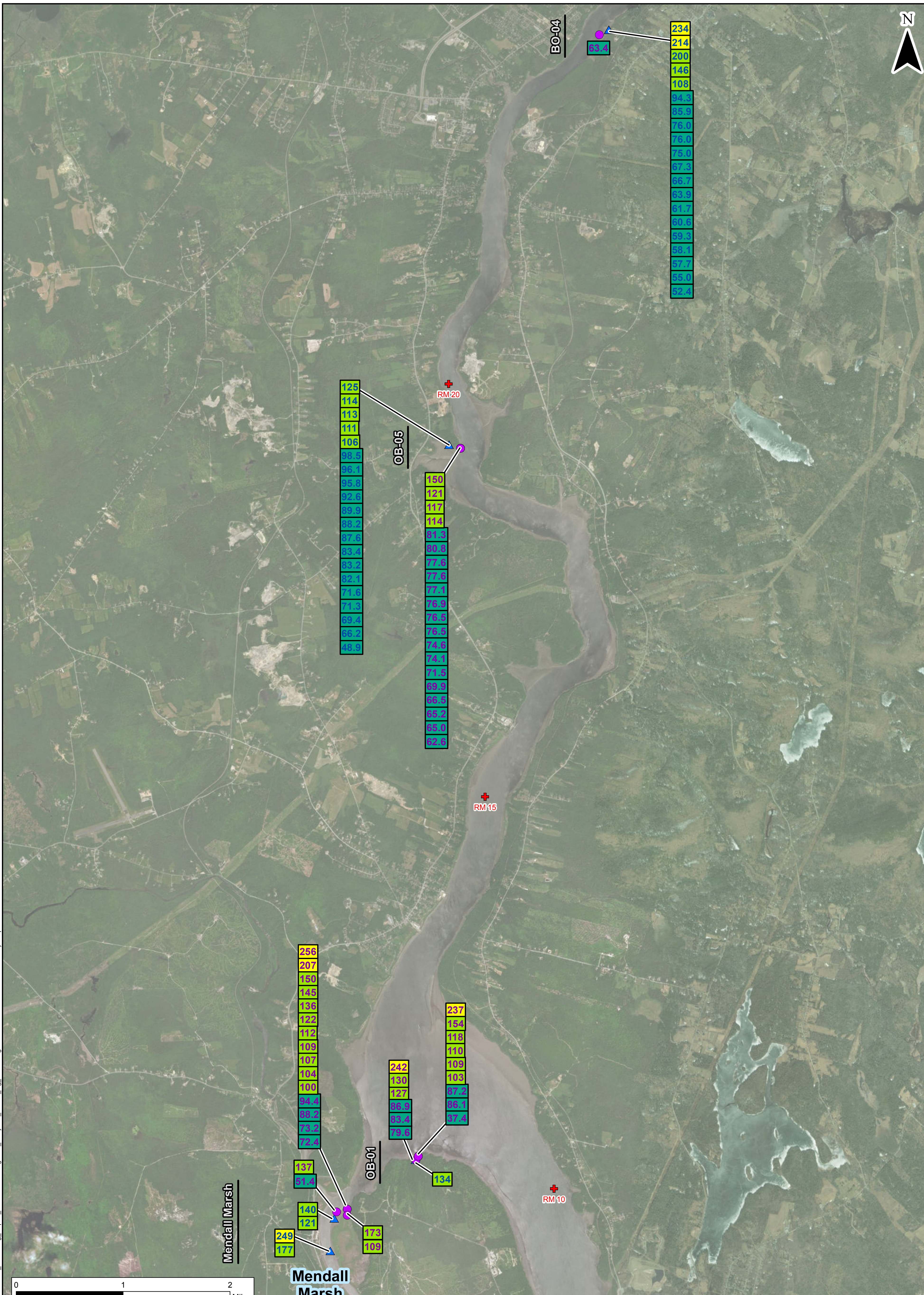


Note:
Concentrations reported in wet weight (ww)

**Legend**

- River Mile Marker
- 2016 Mummichog Sample
- 2017 Mummichog Sample
- **Mendall Marsh** Geographic Area Label
- **OB-01** Sampling Location

**Mercury Results (ng/g)**

- < 100
- 100 - 200
- 200 - 440
- 440 - 1000
- > 1000

Figure 3-9
2016-2017 Individual Mummichog Mercury Analytical Results (ng/g)

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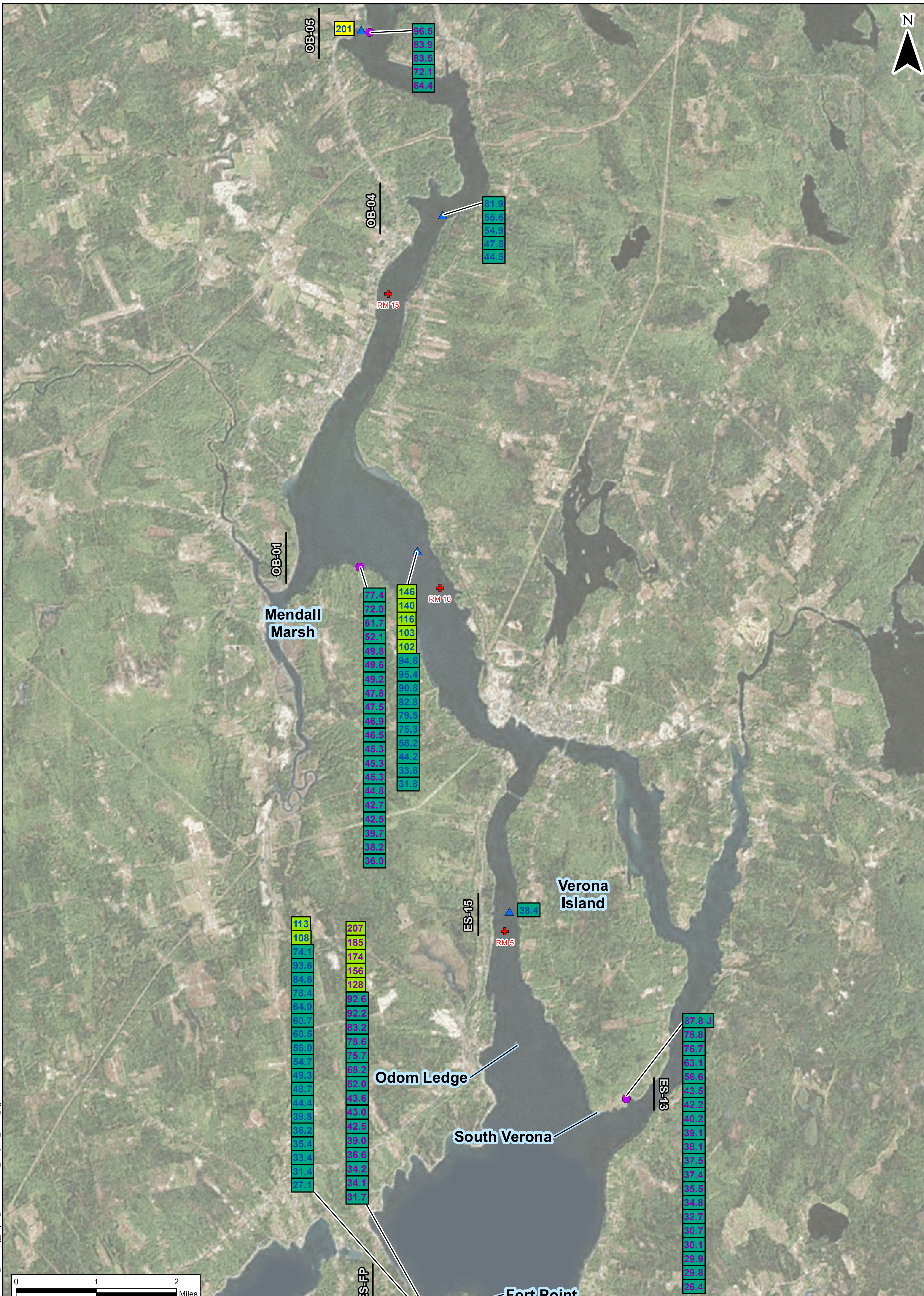
Project: 3616166052 | Prepared/Date: RD 2/16/2018 | Checked/Date: LSV 2/16/2018

Document:G:\Penobscot River\mxds\Report_Figures_2017\Biota_Monitoring_Report_2017\Mummichog2017_analytical_results_Hg_New Ranges.mxd 2/16/2018 9:14:59 AM cody.simpson




Note:
J - The reported concentration is considered an estimated value

Concentrations reported in wet weight (ww)

**Legend**

- River Mile Marker
- 2016 Rainbow Smelt Sample
- 2017 Rainbow Smelt Sample
- OB-01 Sampling Location
- **Mendall Marsh** Geographic Area Label

**Mercury Results (ng/g)**

- < 100
- 100 - 200
- 200 - 500
- 500 - 1000
- > 1000

Figure 3-10
2016-2017 Individual Rainbow Smelt Mercury Analytical Results (ng/g)

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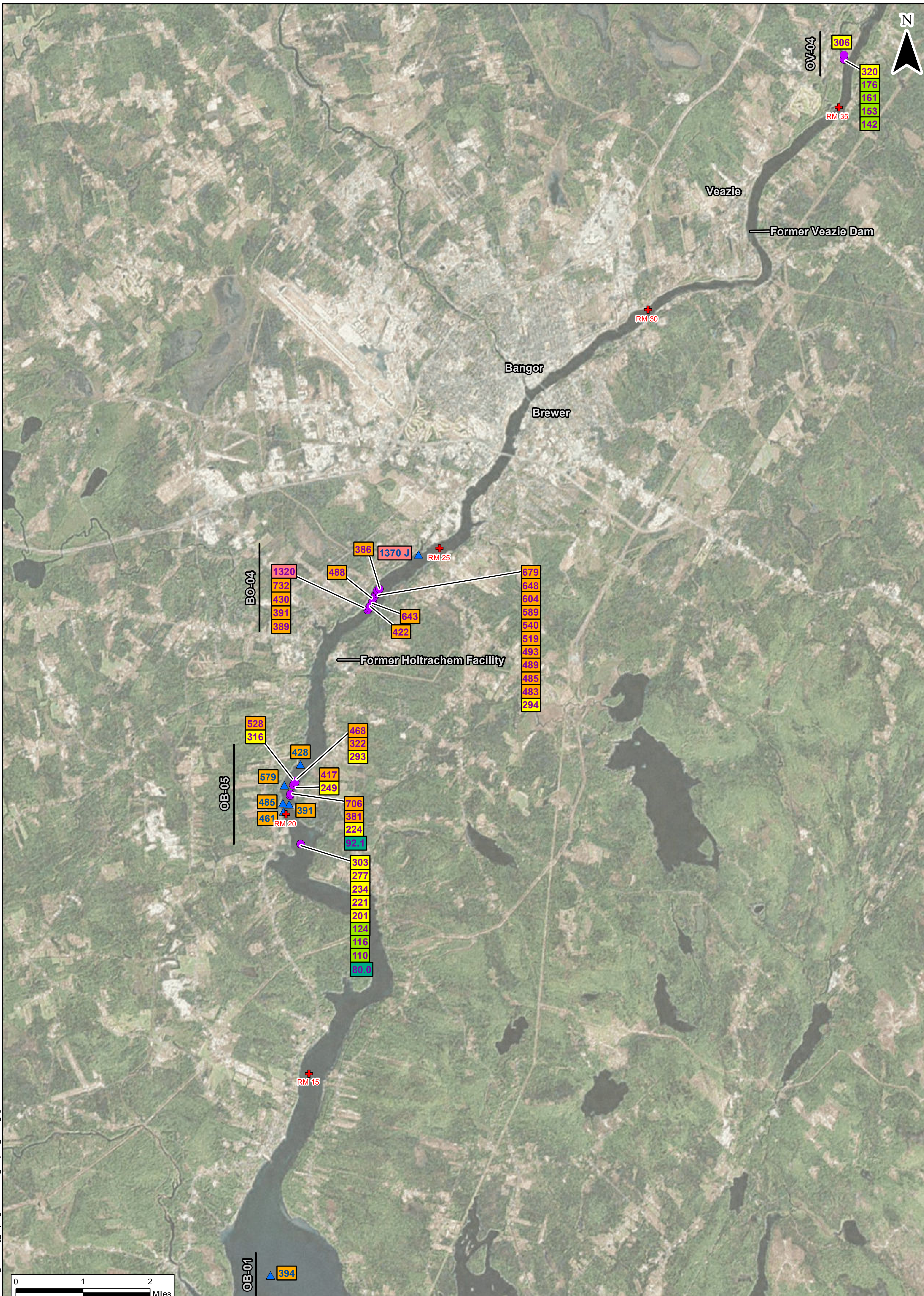
|---|---|---|

Document:G:\Penobscot River\mxds\Report_Figures_2017\Biota_Monitoring_Report_2017\Smelt\2017_analytical_results_Hg.mxd 1/12/2018 6:59:09 AM rachel.desmond




Note:
J - The reported concentration is considered an estimated value.

Concentrations reported in wet weight (ww)

**Legend**

- River Mile Marker
- 2016 Eel Sample
- 2017 Eel Sample
- OB-01 Sampling Location

**Mercury Results (ng/g)**

- < 100
- 100 - 200
- 200 - 320
- 320 - 1000
- > 1000

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Figure 3-11
2016-2017 Individual Eel
Mercury Analytical Results (ng/g)

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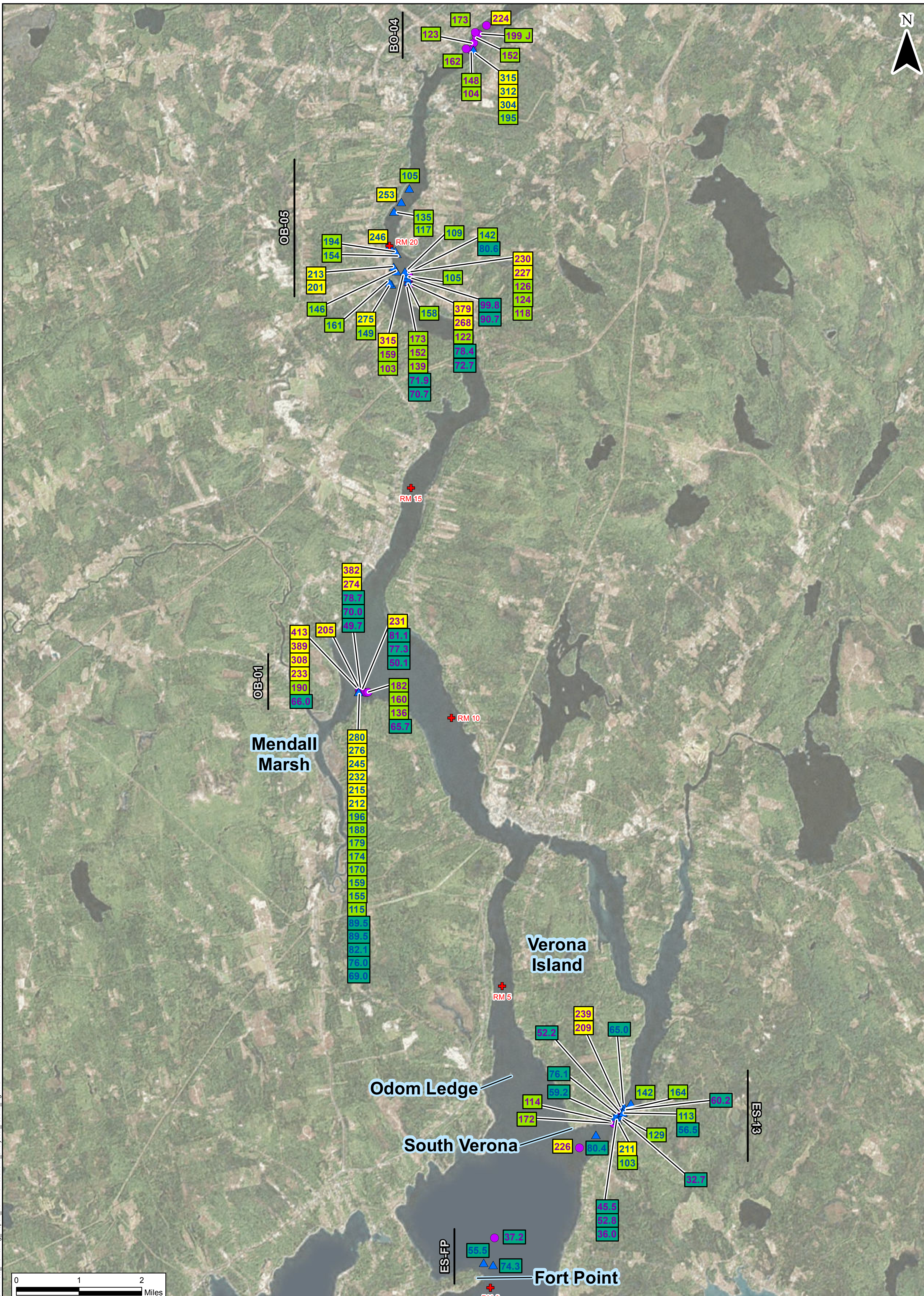


Note:
J - The reported concentration is considered an estimated value.

Concentrations reported in wet weight (ww)

**Legend**

- River Mile Marker
- 2016 Tomcod Sample
- 2017 Tomcod Sample
- OB-01 Sampling Location
- Mendall Marsh Geographic Area Label

**Mercury Results (ng/g)**

- < 100
- 100 - 200
- 200 - 500
- 500 - 1000
- > 1000

Figure 3-12
2016-2017 Individual Tomcod Mercury Analytical Results (ng/g)

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Note:
J - The reported concentration is considered an estimated value

Concentrations reported in wet weight (ww)

* Mercury result bins used only for Nelson's Sparrows

**Legend**

- 2016 Nelson's Sparrow Sample
- 2016 Spider and Terrestrial Insect Sample
- 2017 Nelson's Sparrow Sample
- 2017 Spider and Terrestrial Insect Sample

**Mercury Results* (ng/g)**

< 1000

**Pleasant River** Geographic Area Label

Figure 3-13a
2016-2017 Pleasant River Reference Location
Mercury Analytical Results (ng/g)

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|---|---|---|


Note:
J - The reported concentration is considered an estimated value

Concentrations reported in wet weight (ww)

**Legend**

- 2016 Spider Sample
- 2016 Terrestrial Insect Sample
- 2017 Spider Sample
- 2017 Terrestrial Insect Sample
- **Pleasant River** Geographic Area Label

Figure 3-13b
2016-2017 Pleasant River Reference Location
Methyl Mercury Analytical Results (ng/g)

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amec foster wheeler

Notes:
U - The target compound was not detected above the method detection limit

American Black Ducks were sampled during January and February 2017 and January 2018 due to seasonal restrictions

Concentrations reported in wet weight (ww)

**Legend**

- 2016 Sample
- 2017 Sample
- 2018 Black Duck Sample

**Mercury Results (ng/g)**

- 100 - 200
- < 100

**Frenchman Bay** Geographic Area Label

Figure 3-14a
2016-2017 Frenchman Bay Reference Location Mercury Analytical Results (ng/g)

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|---|---|---|


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Note:
U - The target compound was not detected above the method detection limit

Concentrations reported in wet weight (ww)

**Legend**

▲ 2016 Polychaete Sample

**Frenchman Bay** Geographic Area Label

Figure 3-14b
2016 Frenchman Bay Reference Location
Methyl Mercury Analytical Results (ng/g)

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Document:G:\Penobscot River\mxds\Report_Figures_2017\Biota_Monitoring_Report_2017\2017FrenchmanBay_Reference_analytical_results_MeHg.mxd 12/5/2017 10:53:56 AM rachel.desmond

**Figure 3–15a**
**Terrestrial Insect Mercury Concentrations by Species**

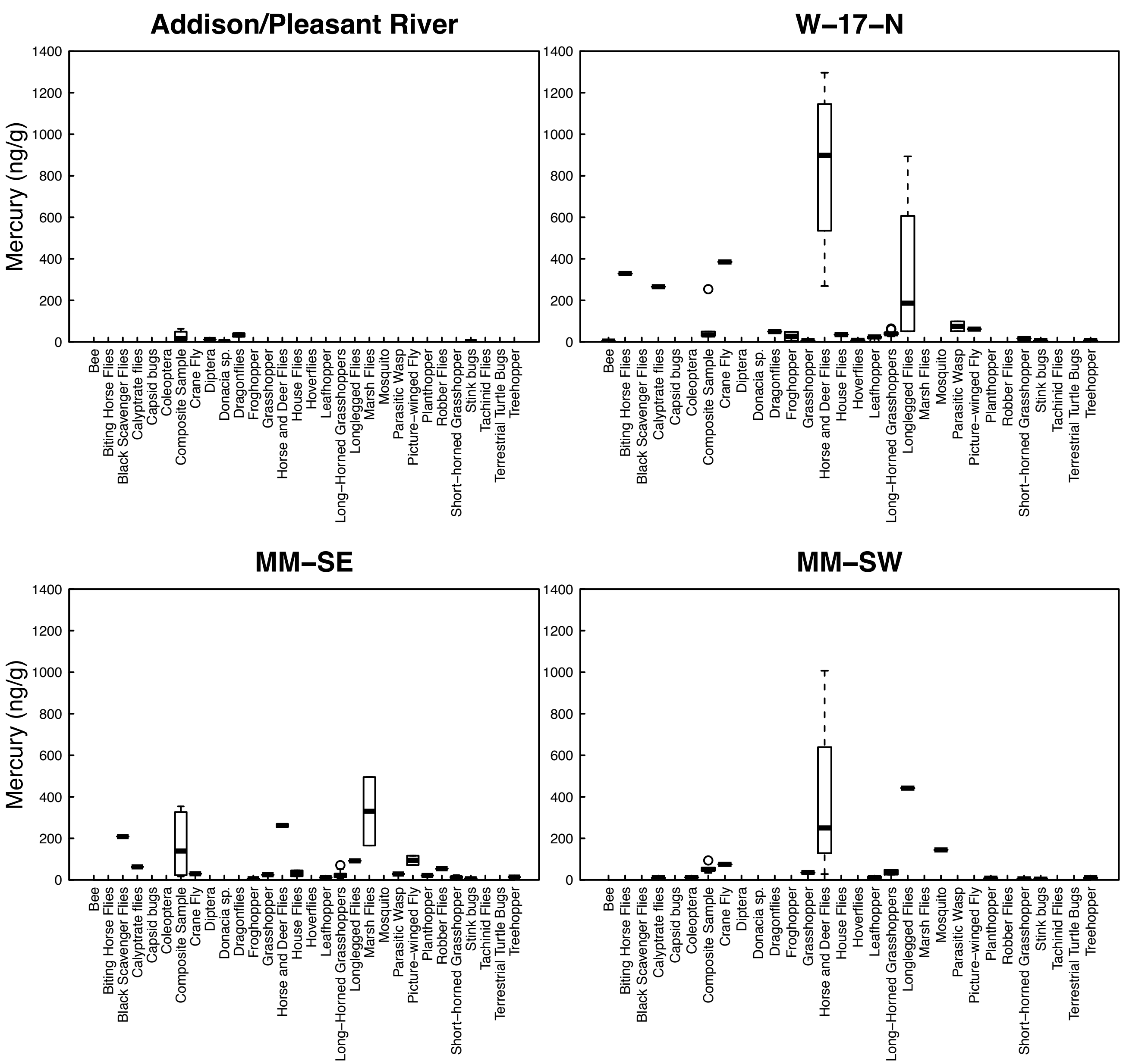


**Figure 3–15b**
**Terrestrial Insect Methyl Mercury Concentrations by Species**

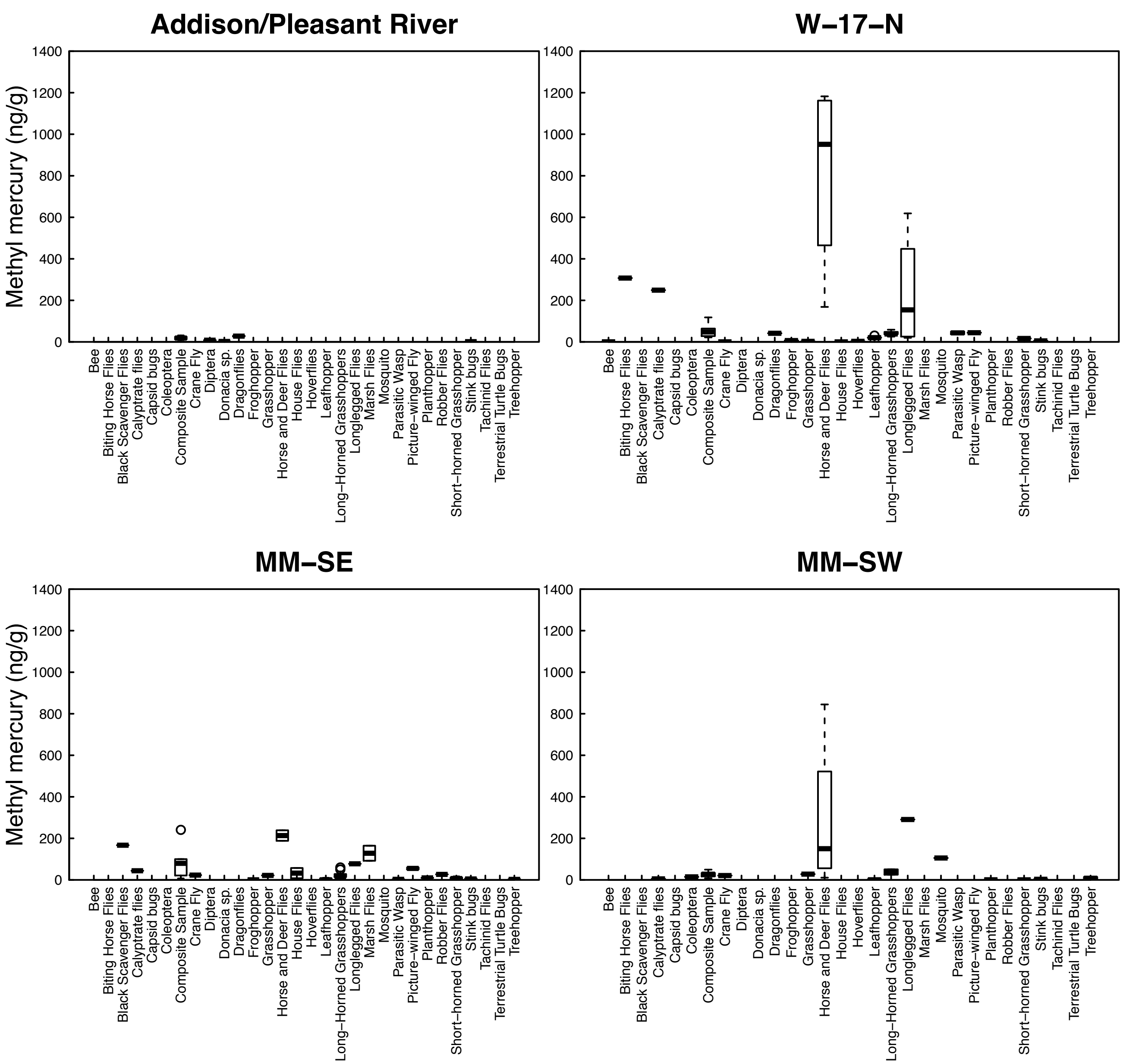


**Figure 3–16a**
**Terrestrial Insect Mercury Concentrations by Species in 2017**

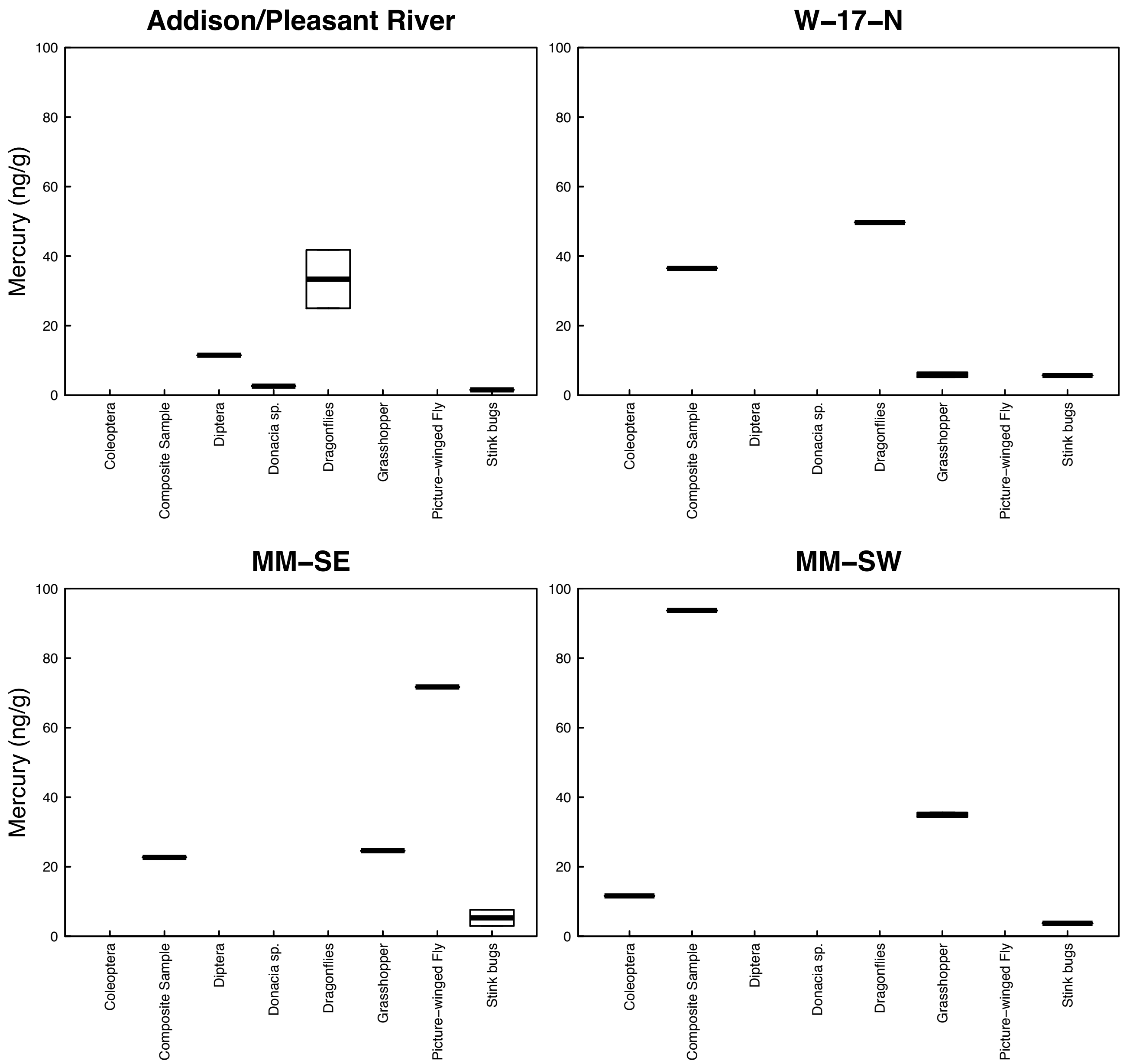


**Figure 3–16b**
**Terrestrial Insect Methyl Mercury Concentrations by Species in 2017**

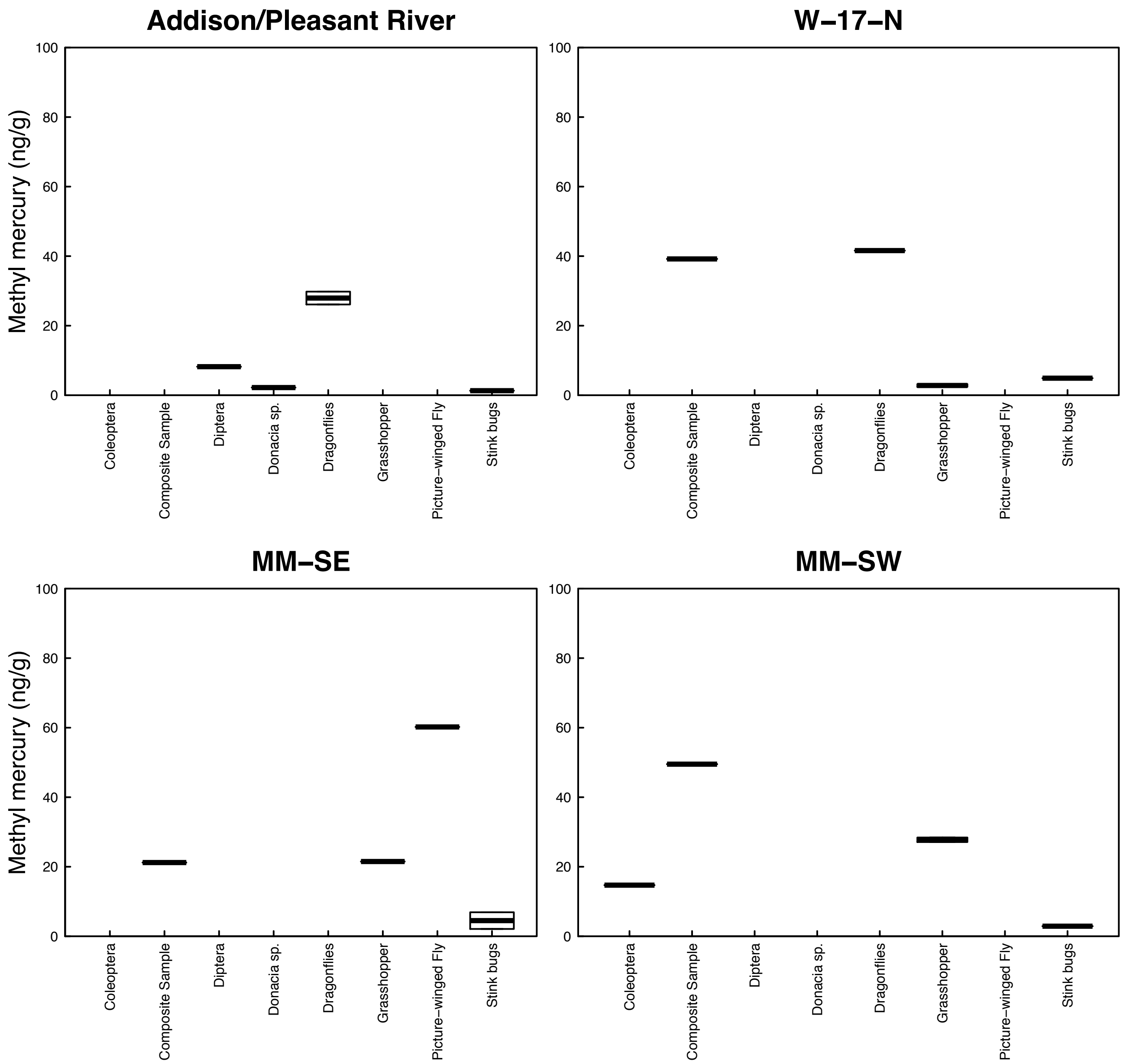


**Figure 3−17**
**Spider Concentrations**

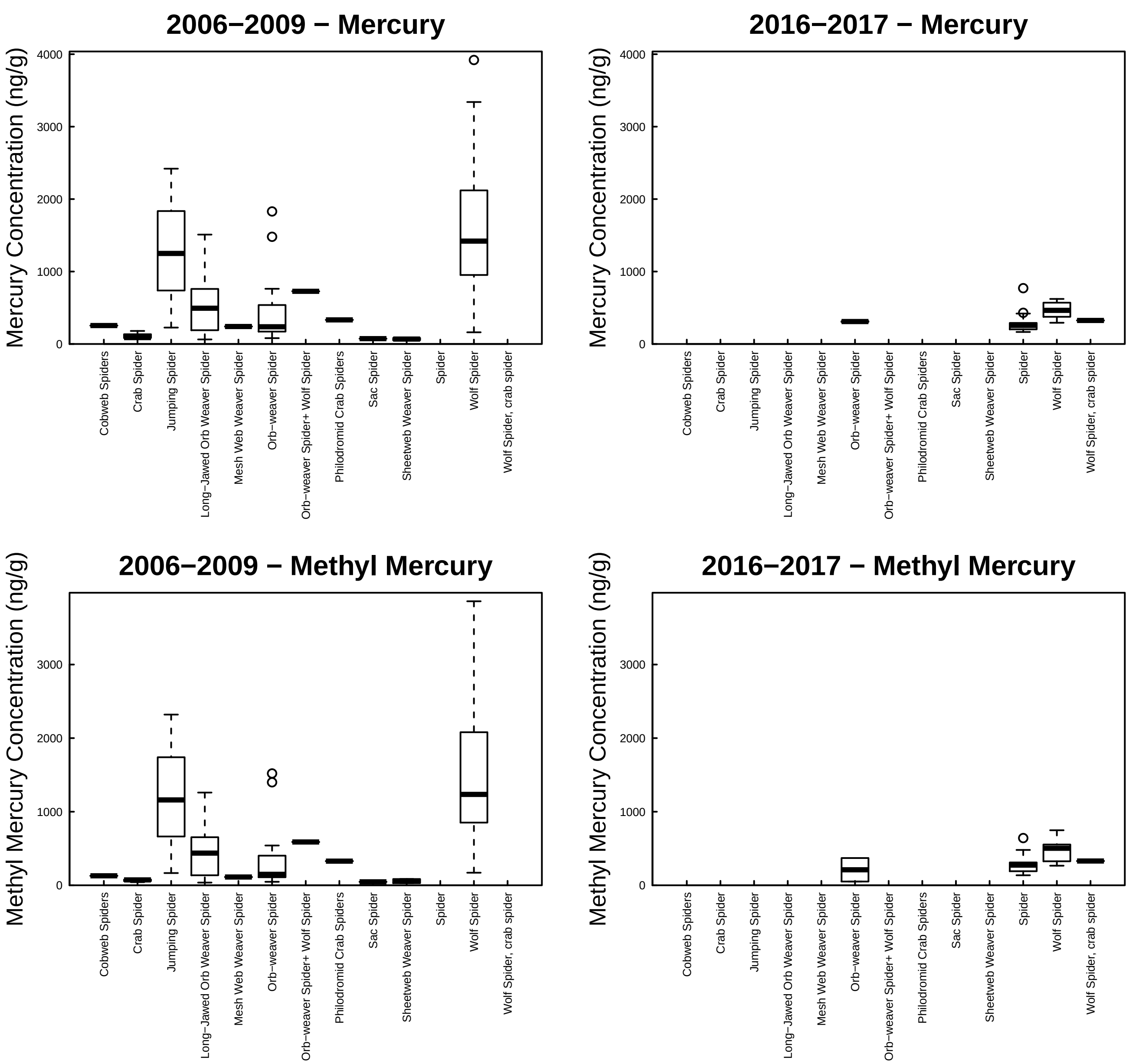
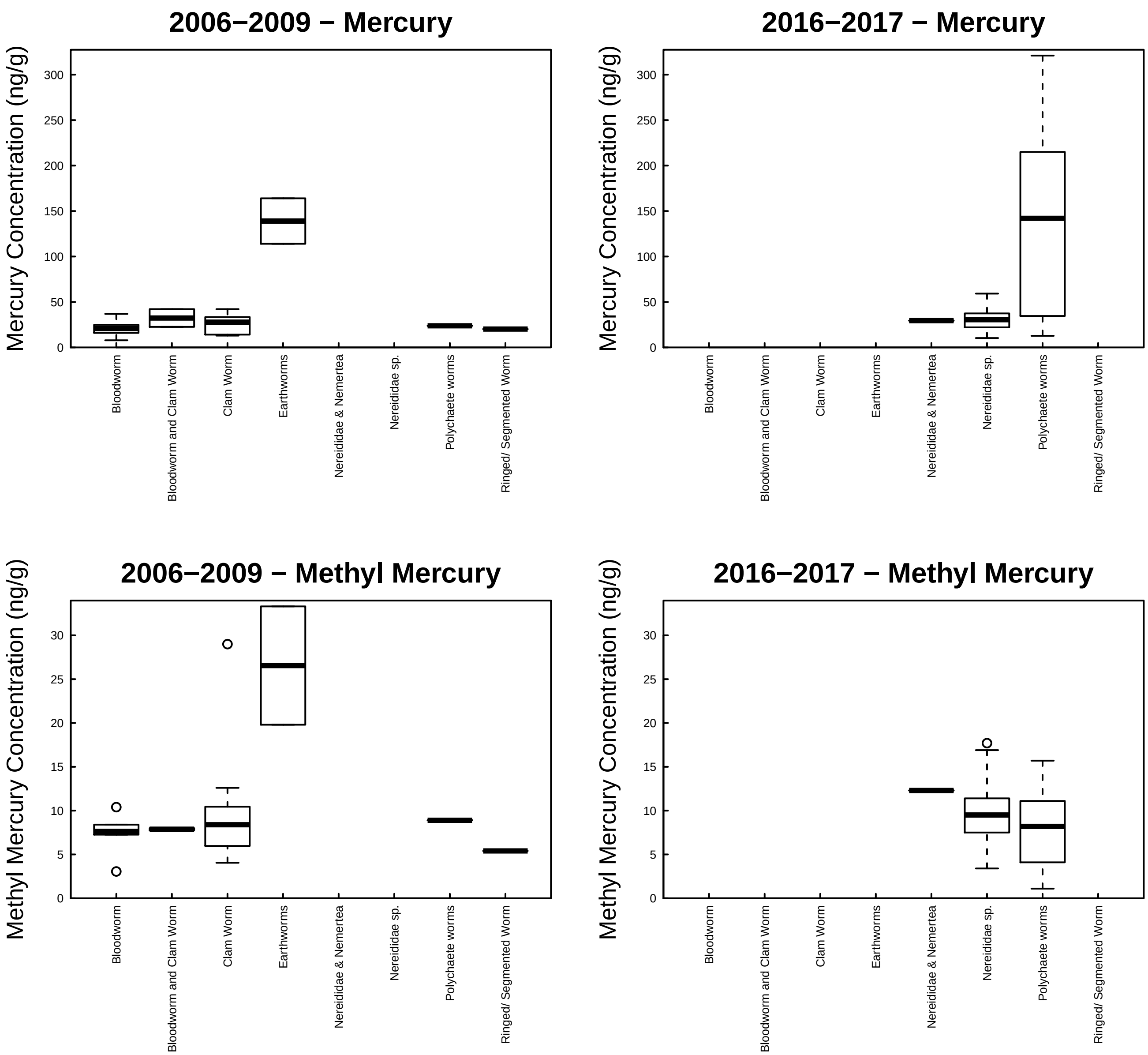
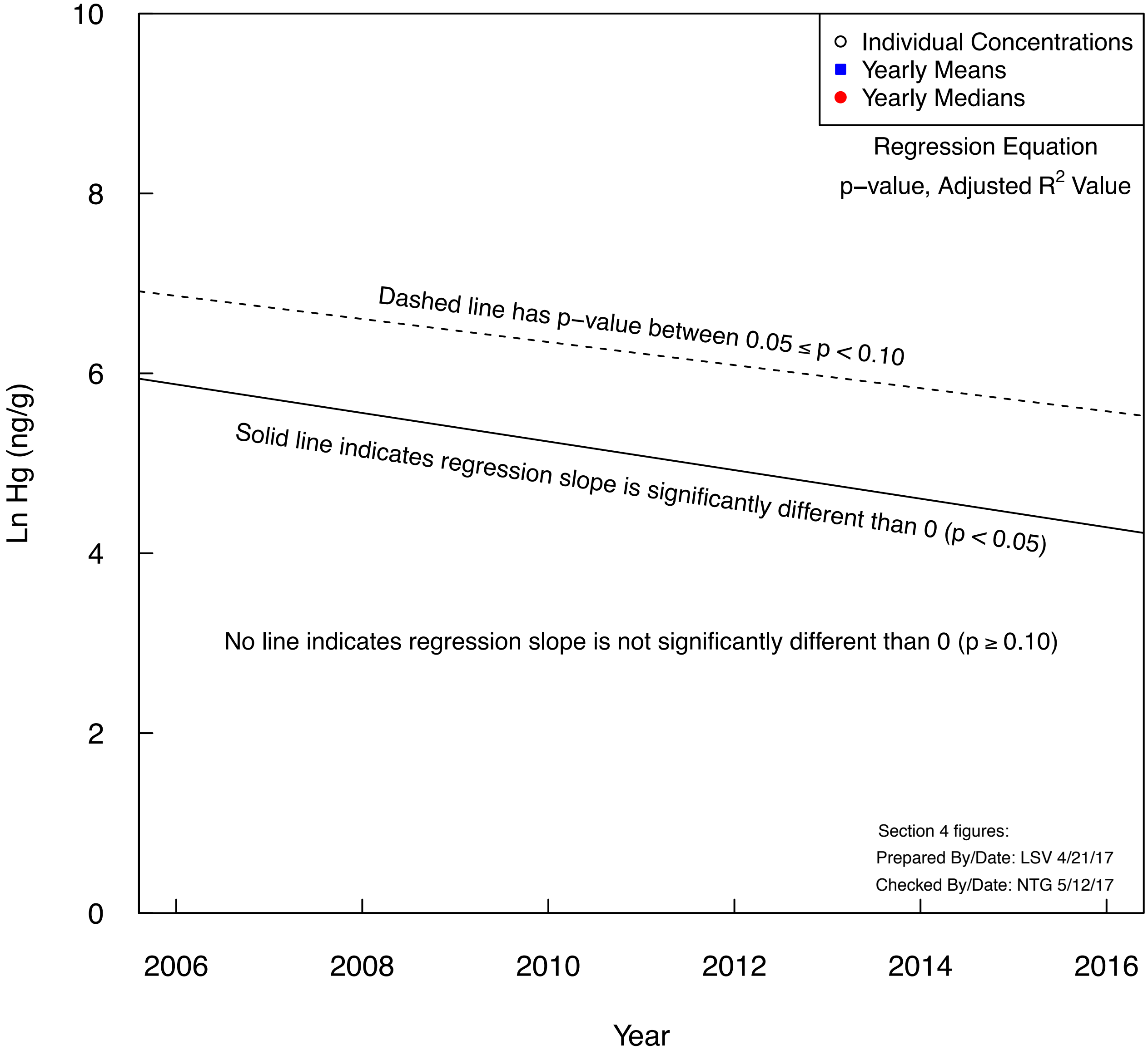


**Figure 3−18**
**Annelid Concentrations**



## Figure 4–0
## Figure Legend For Section 4 Figures




Notes: Non–detects are plotted at the detection limit.

**Figure 4−1**
**Terrestrial Insect − Reference Locations**
**Ln Mercury Concentrations**

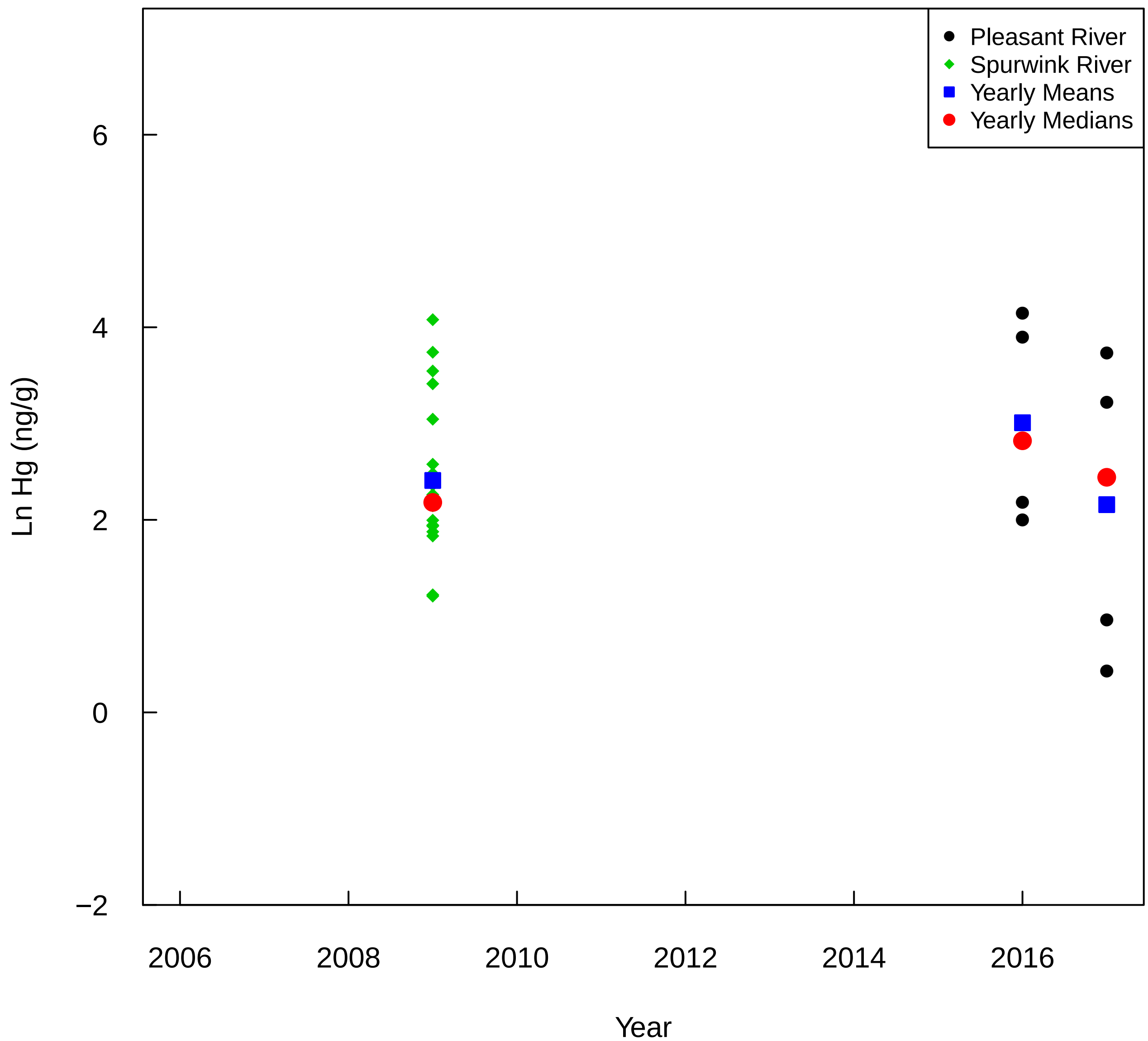
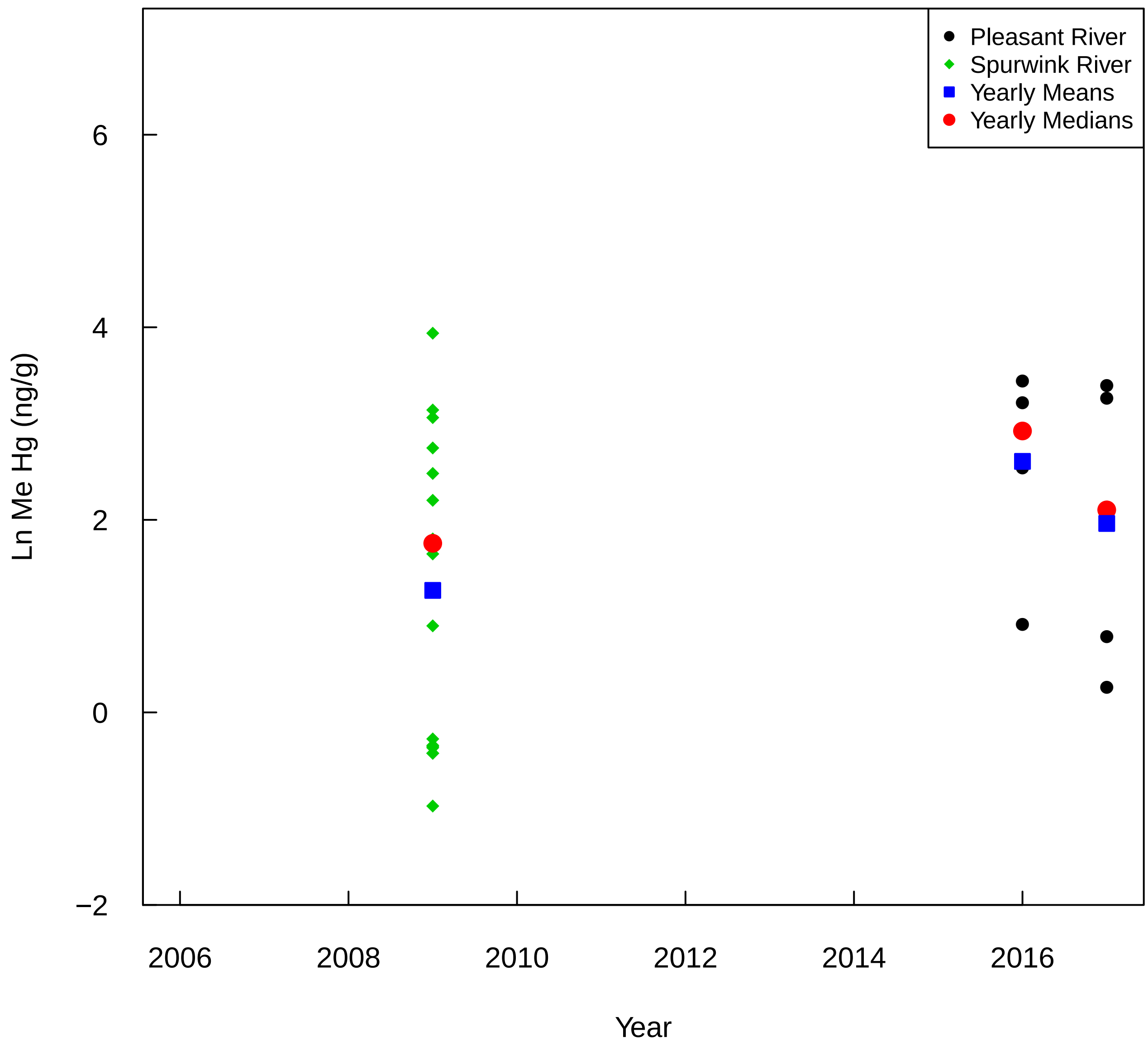
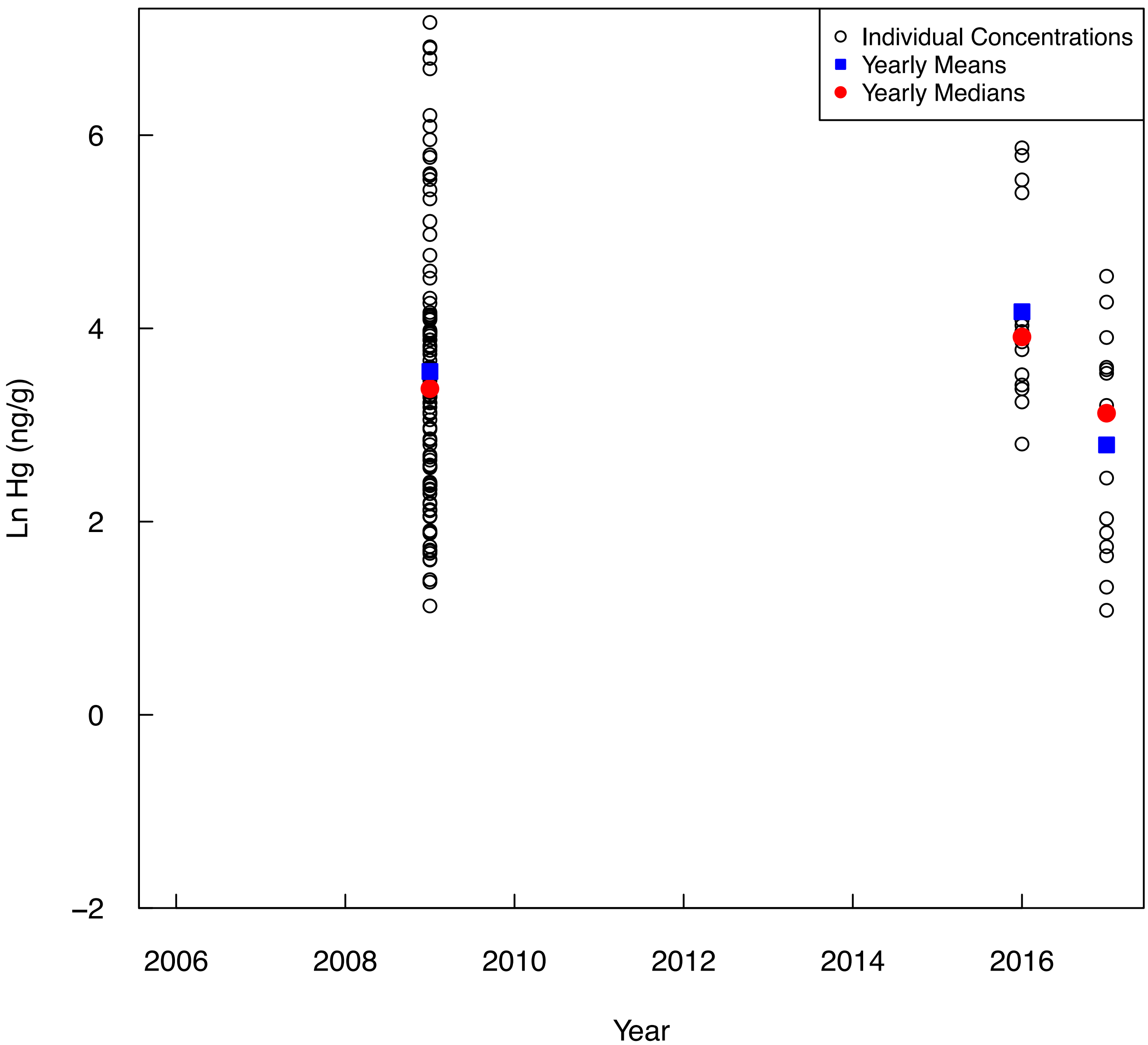


**Figure 4−2**
**Terrestrial Insect − Reference Locations**
**Ln Methyl Mercury Concentrations**




Six samples at Spurwink River were non−detect and are included on this figure at the detection limit.

**Figure 4–3**
**Terrestrial Insect – Whole River**
**Ln Mercury Concentrations**




Includes Terrestrial Insects sampled at W−17−N, MM−SE, and MM−SW

**Figure 4–4**
**Terrestrial Insect – W–17–N**
**Ln Mercury Concentrations**

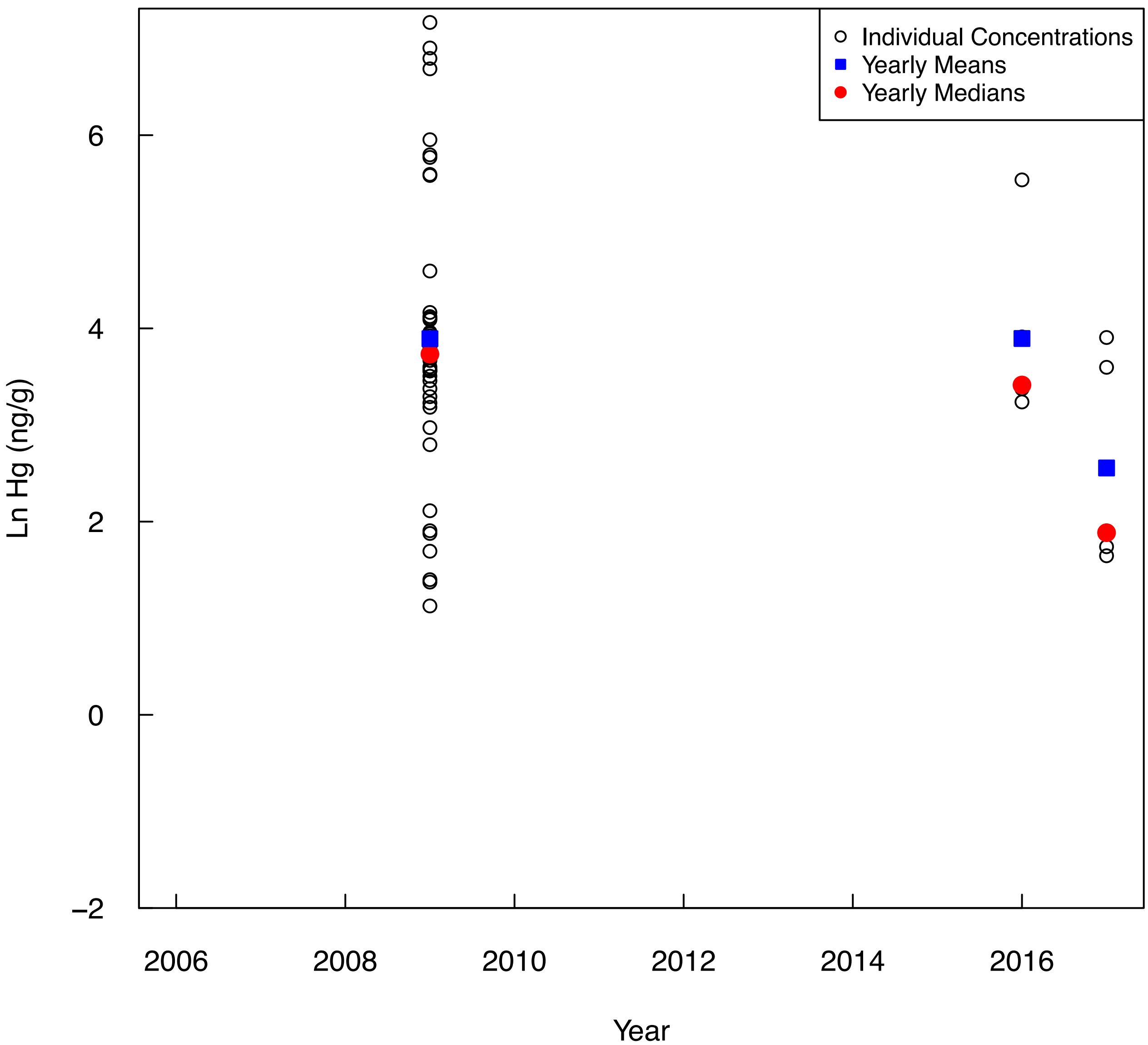


**Figure 4–5**
**Terrestrial Insect – MM–SE**
**Ln Mercury Concentrations**

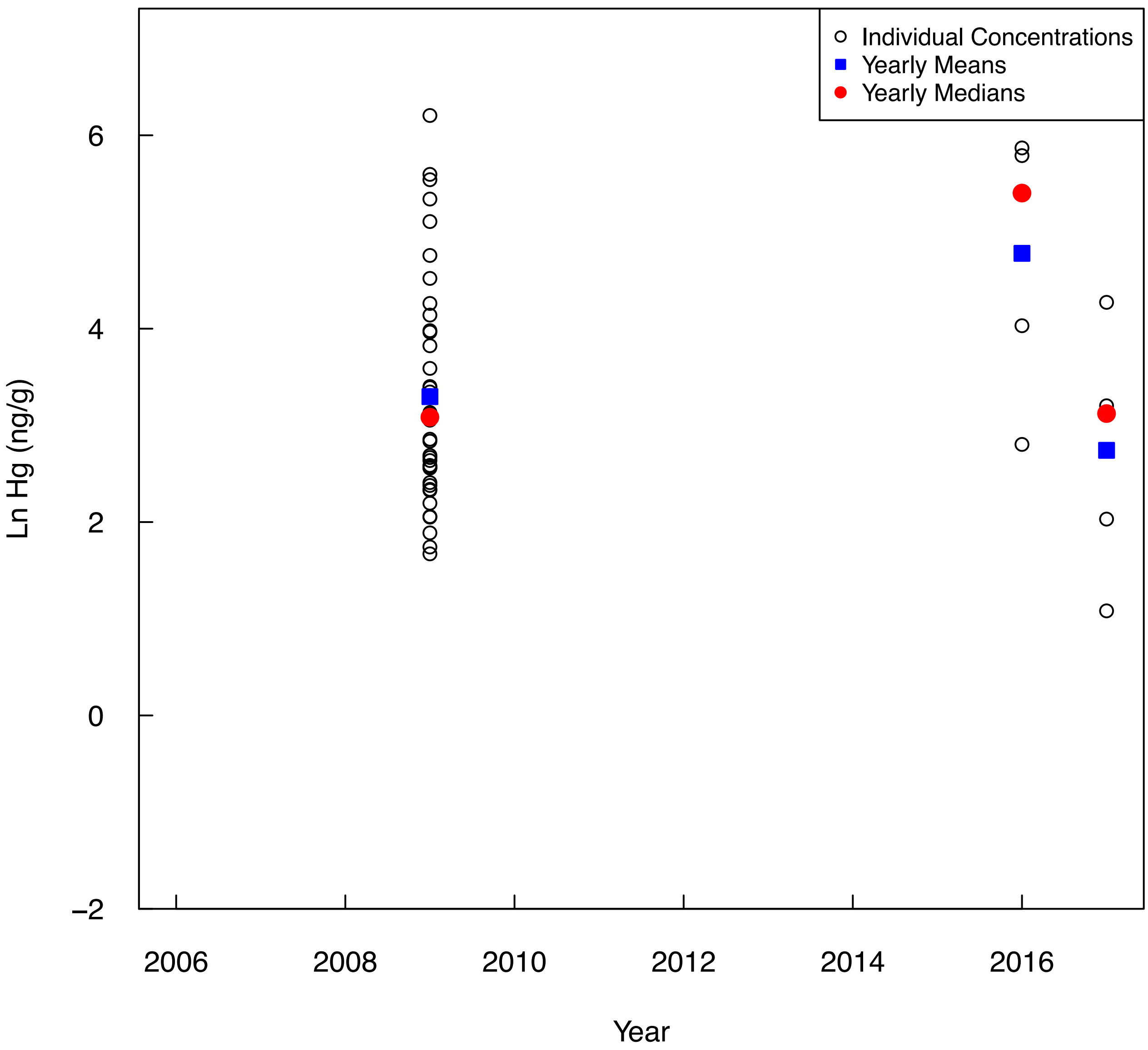


**Figure 4–6**
**Terrestrial Insect – MM–SW**
**Ln Mercury Concentrations**

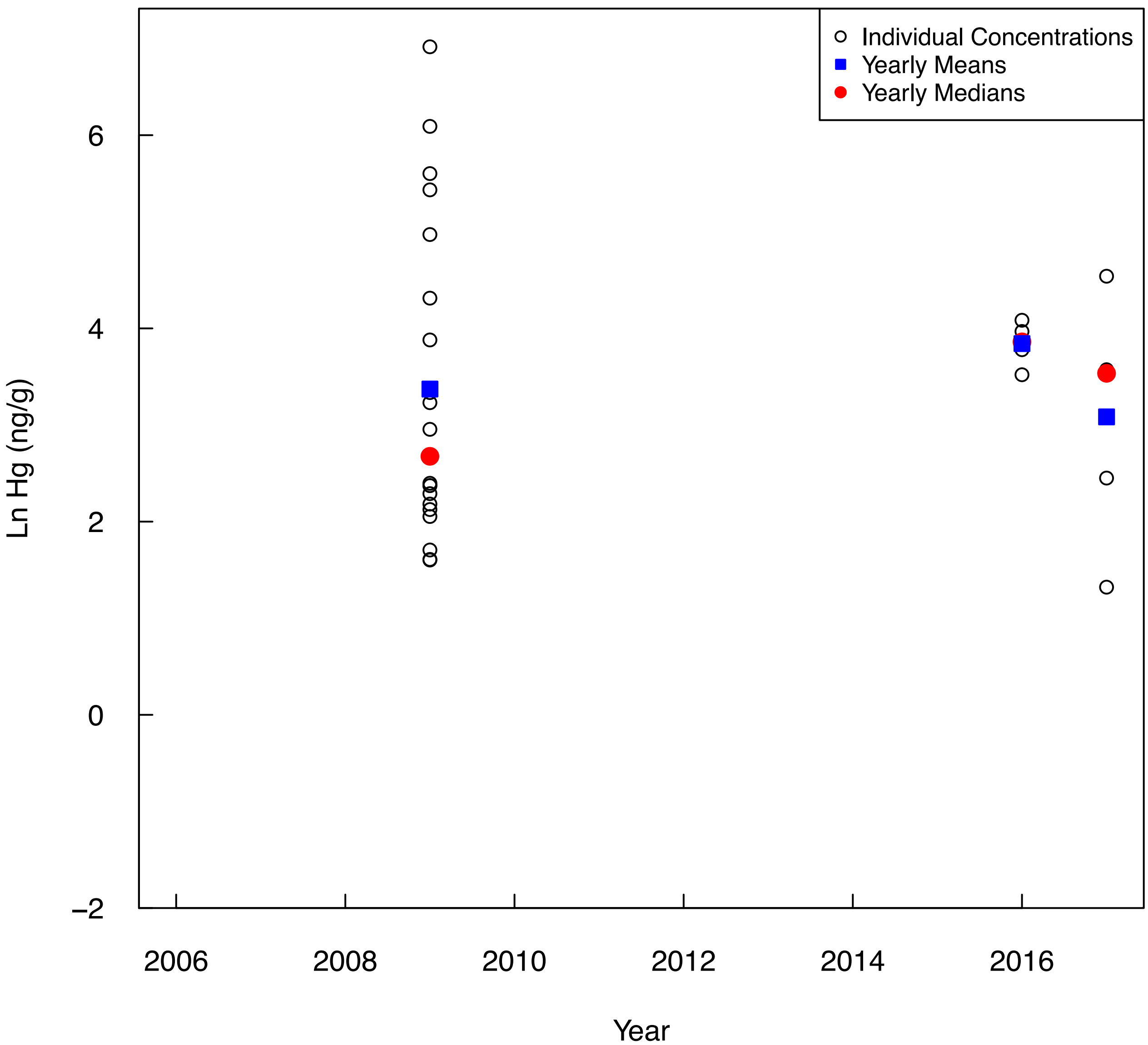
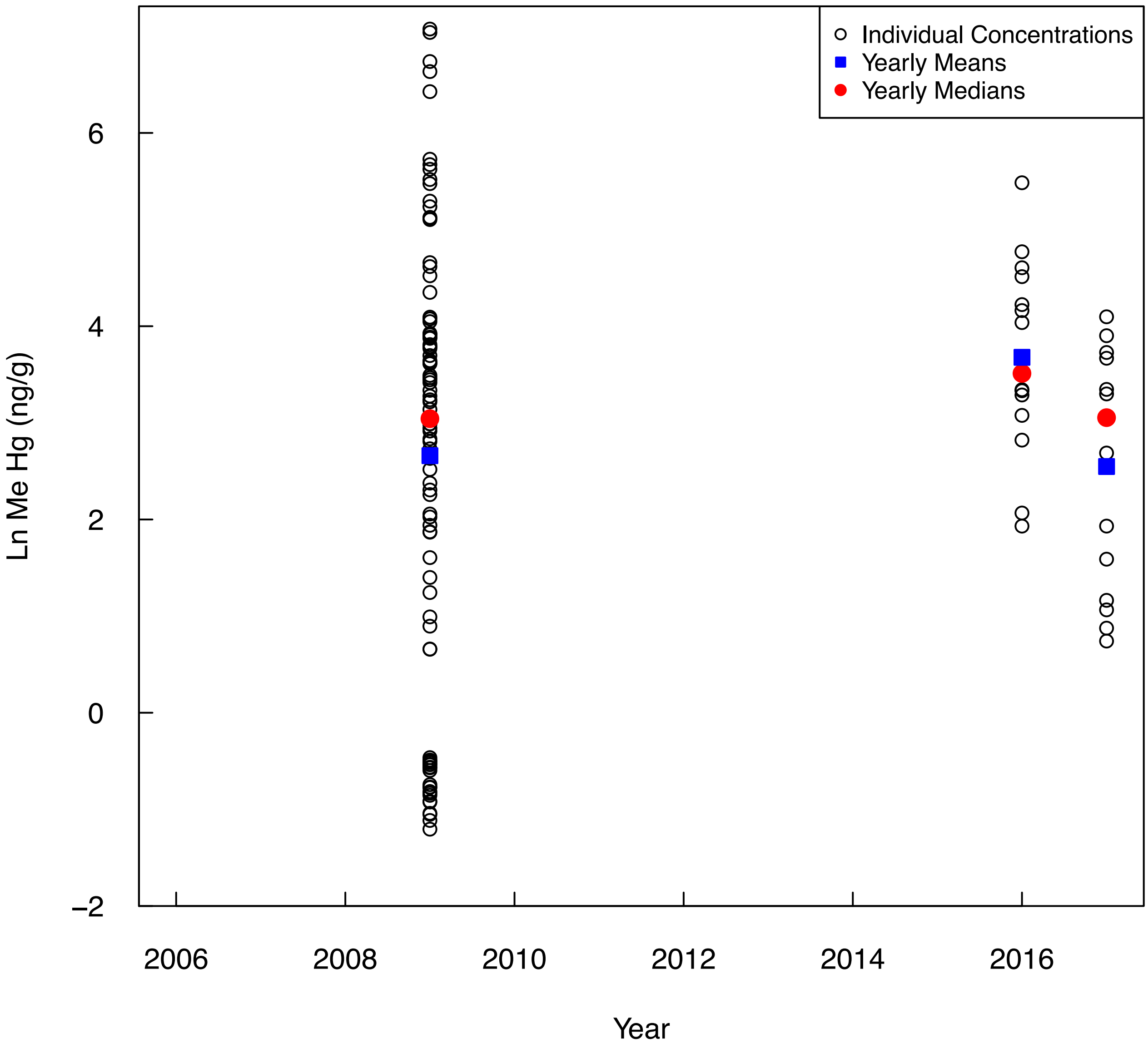
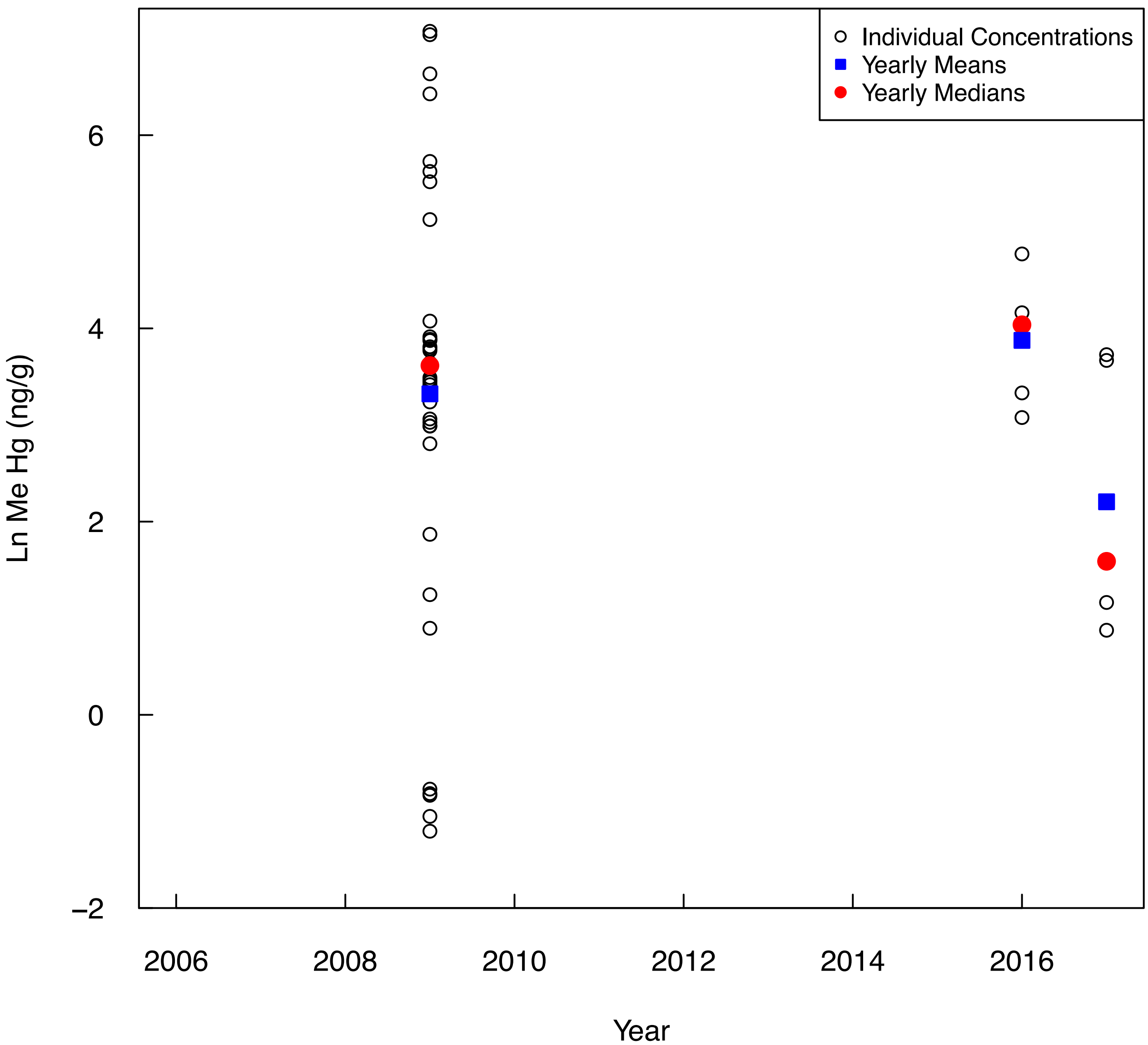


**Figure 4–7**
**Terrestrial Insect – Whole River**
**Ln Methyl Mercury Concentrations**



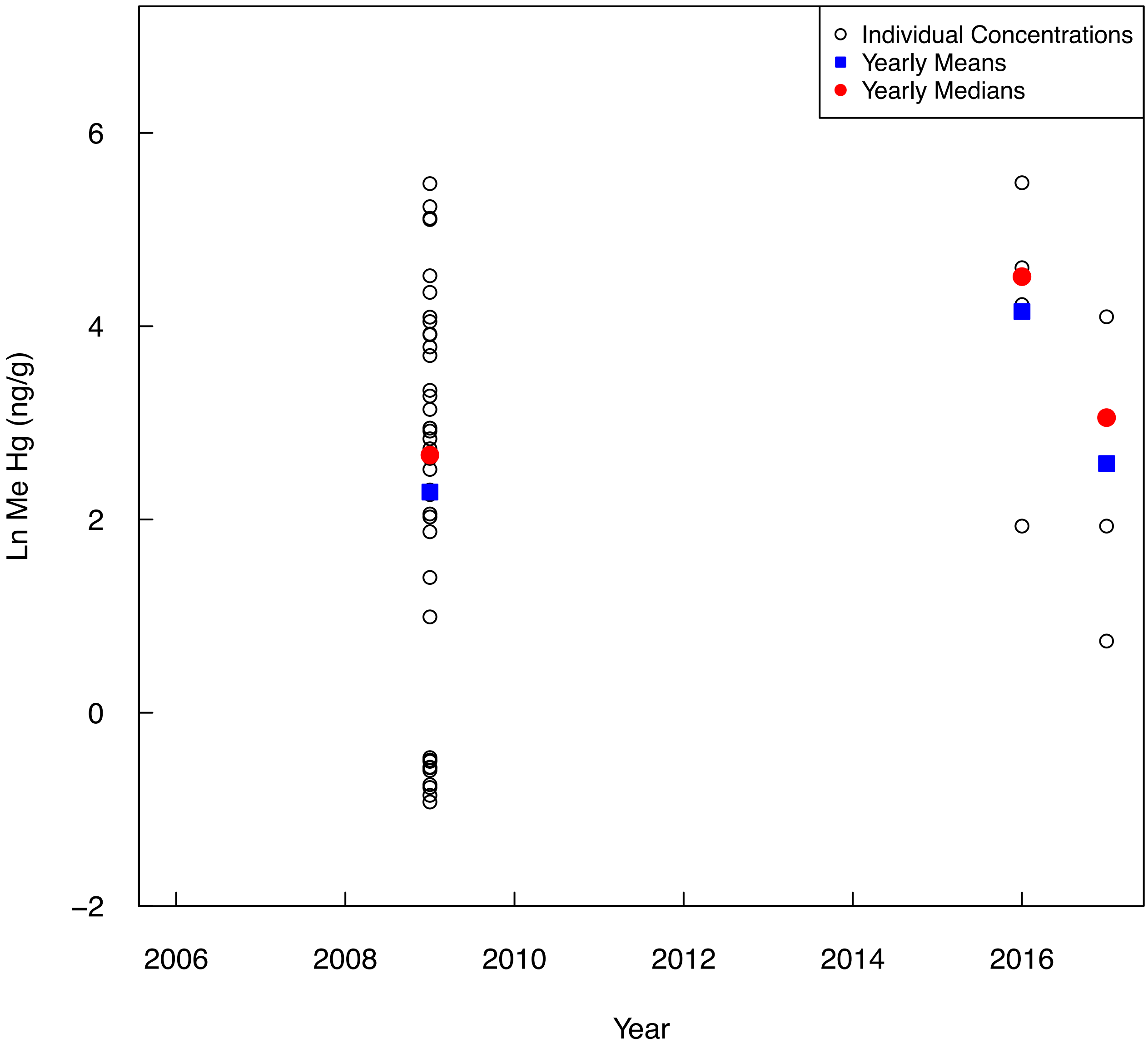

Includes Terrestrial Insects sampled at W–17–N, MM–SE, and MM–SW

**Figure 4–8**
**Terrestrial Insect – W–17–N**
**Ln Methyl Mercury Concentrations**



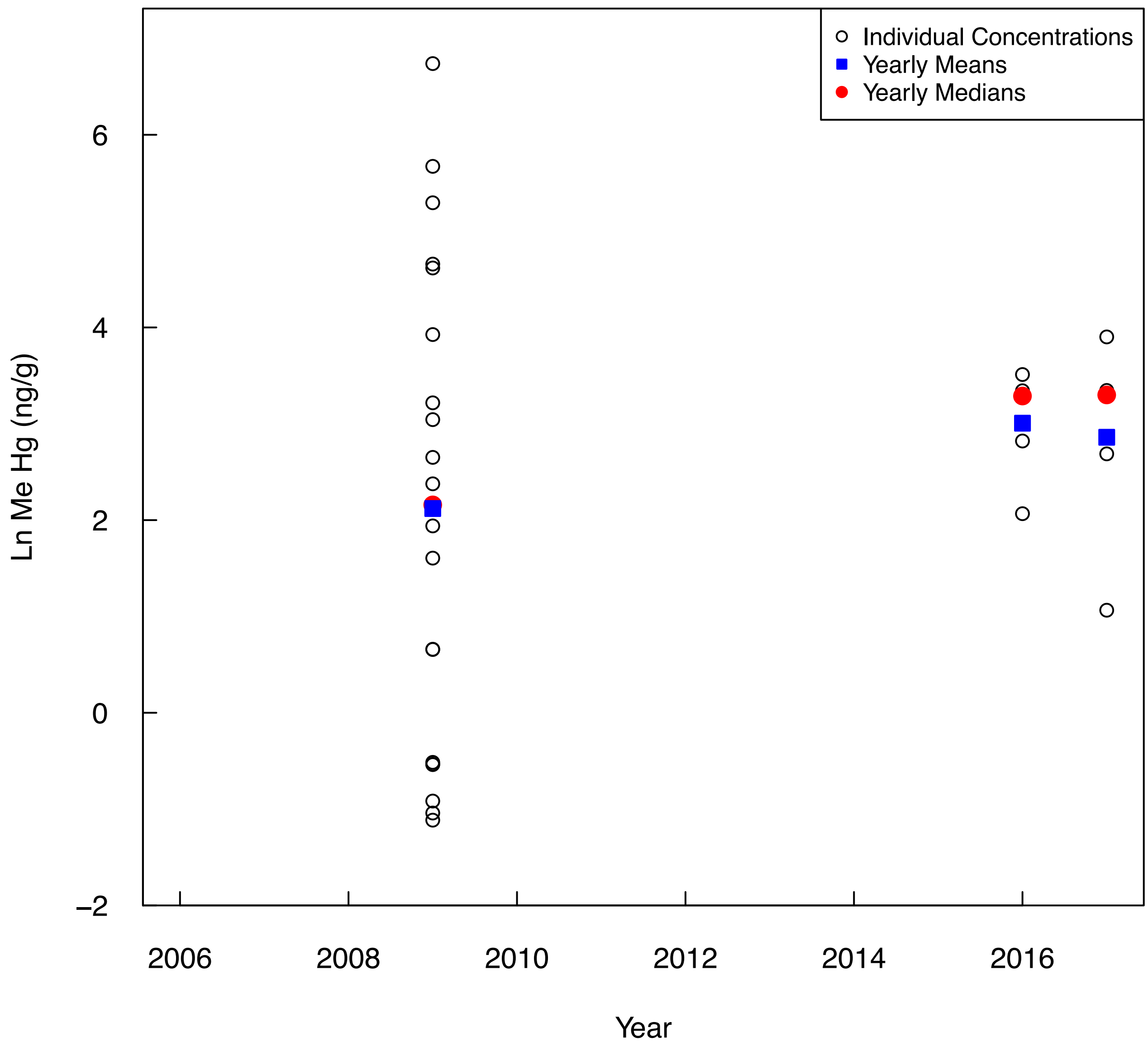

One sample collected in 2009 was non−detect and is included on this figure using the detection limit.

**Figure 4–9**
**Terrestrial Insect – MM–SE**
**Ln Methyl Mercury Concentrations**




Nine samples collected in 2009 were non−detect and are included on this figure using the detection limit.

**Figure 4–10**
**Terrestrial Insect – MM–SW**
**Ln Methyl Mercury Concentrations**




Six samples collected in 2009 were non−detect and are included on this figure using the detection limit.

**Figure 4−11**
**Spider − Reference Locations**
**Ln Mercury Concentrations**

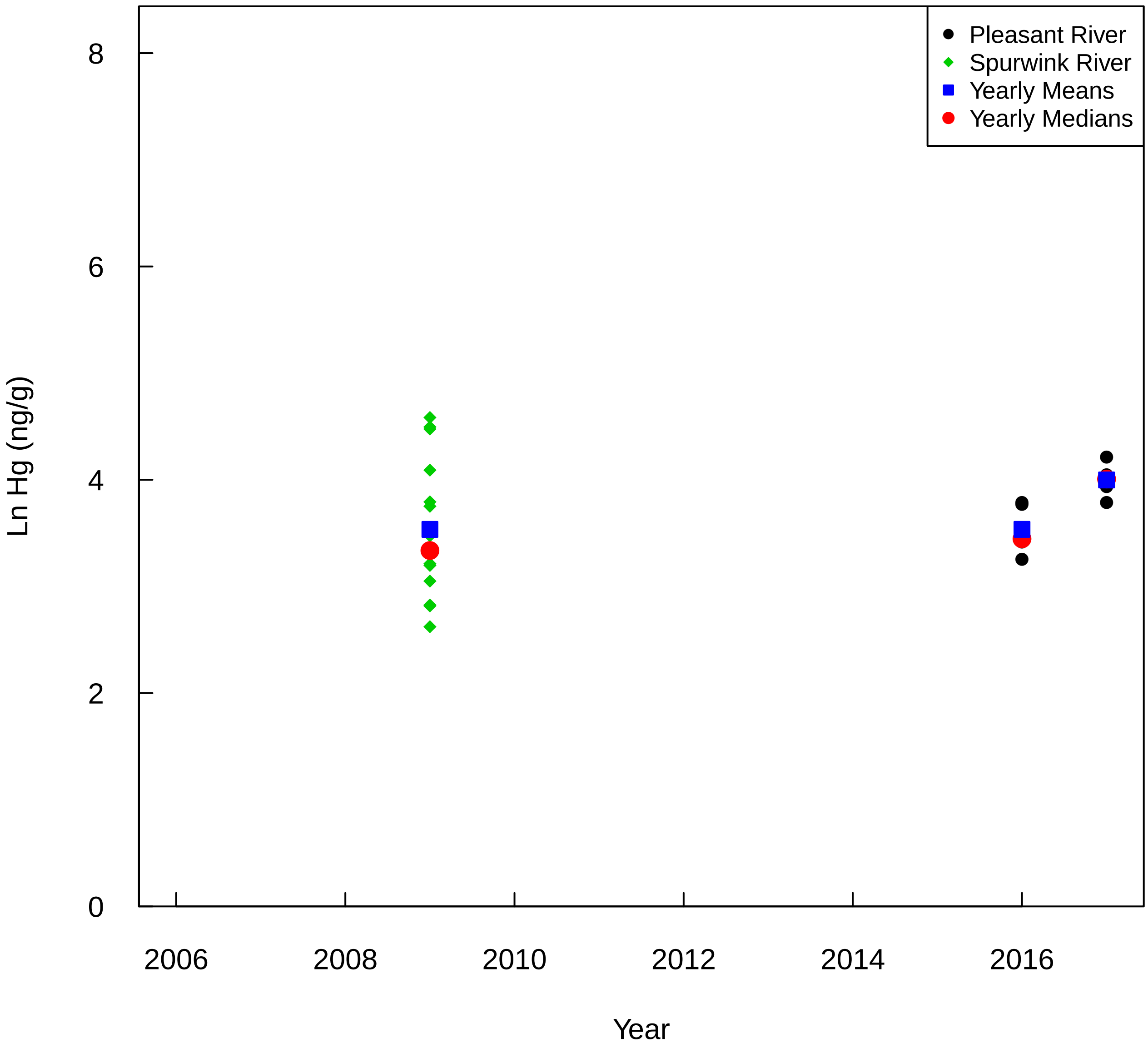


**Figure 4−12**
**Spider − Reference Locations**
**Ln Methyl Mercury Concentrations**

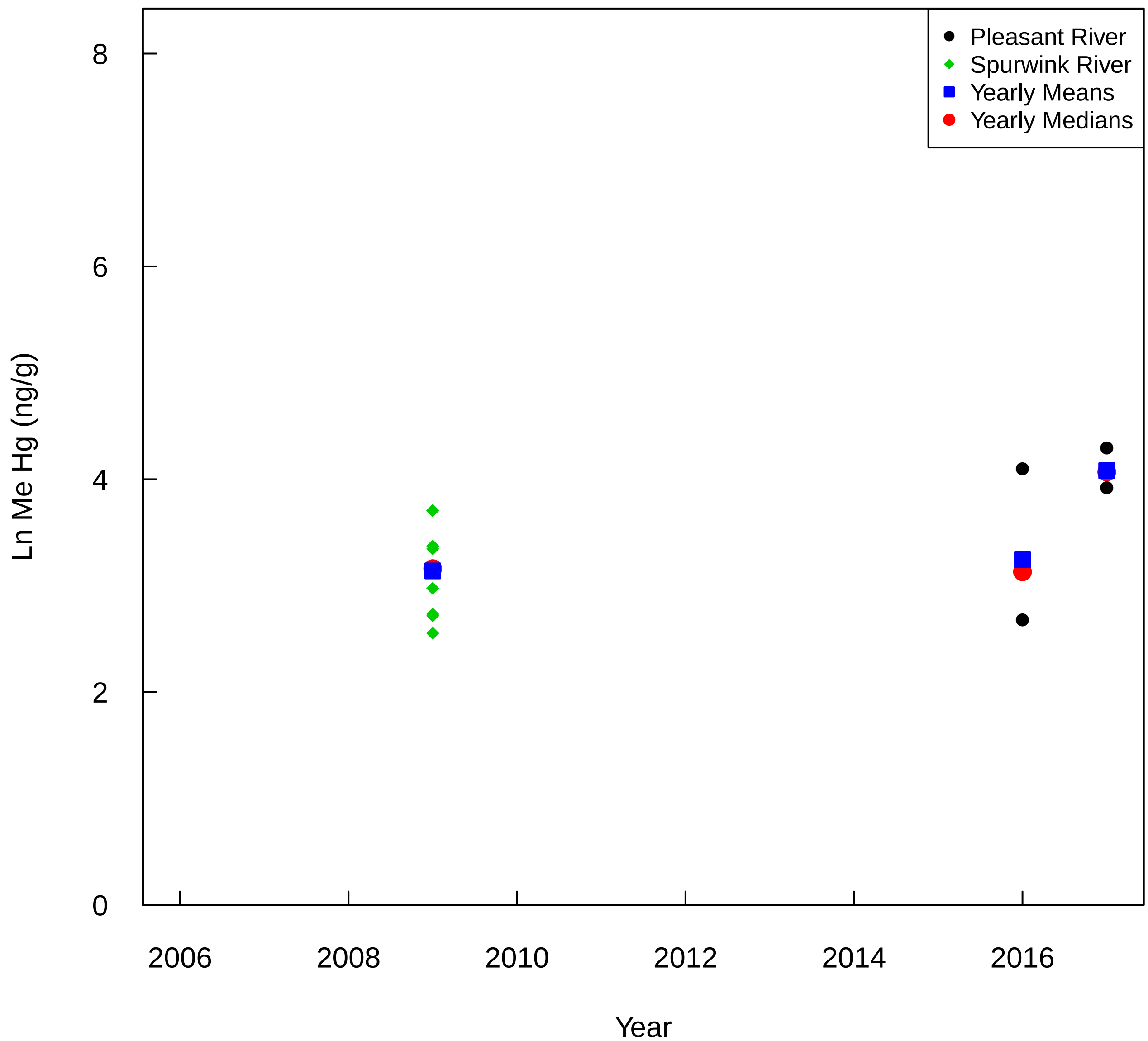
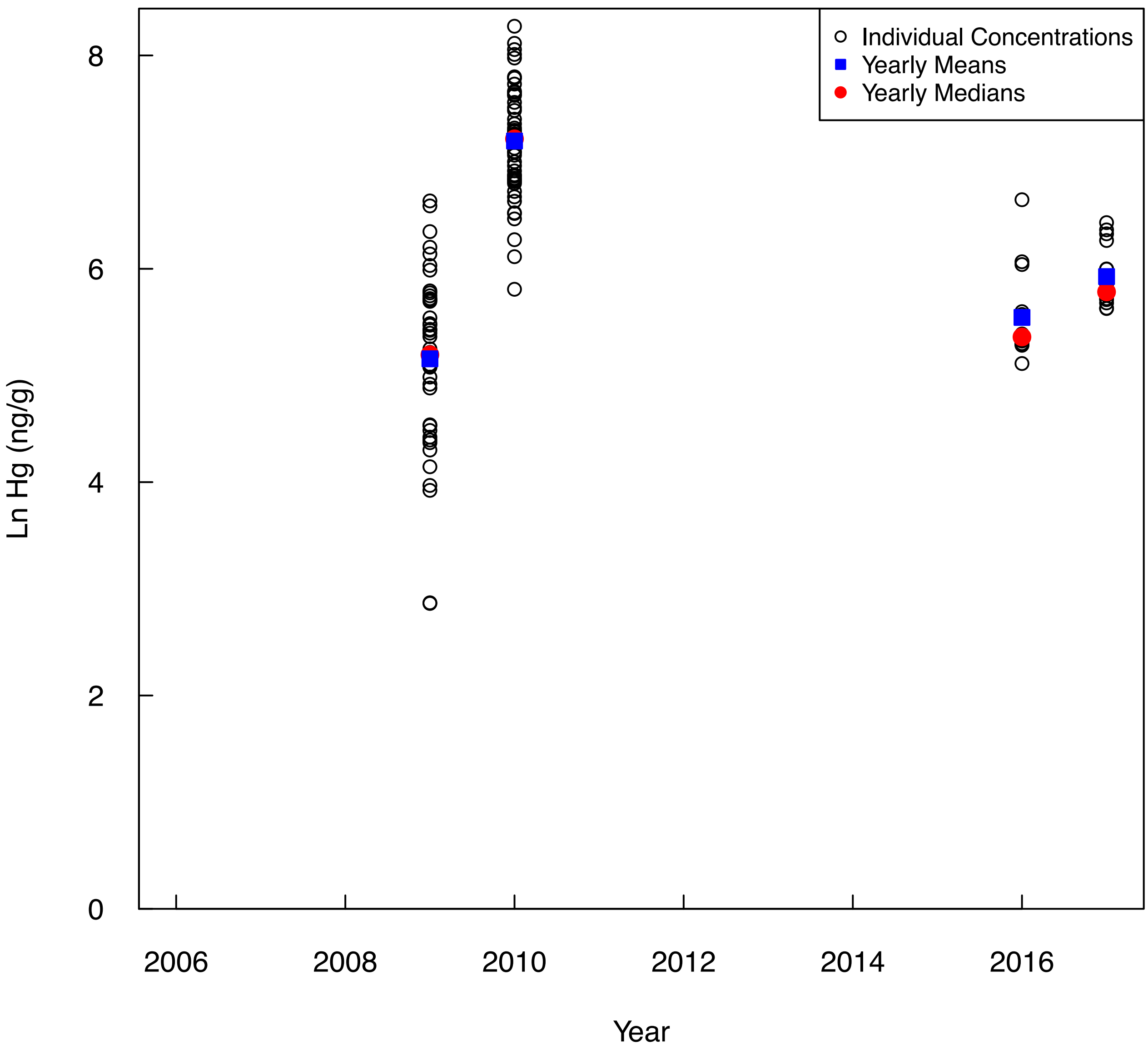
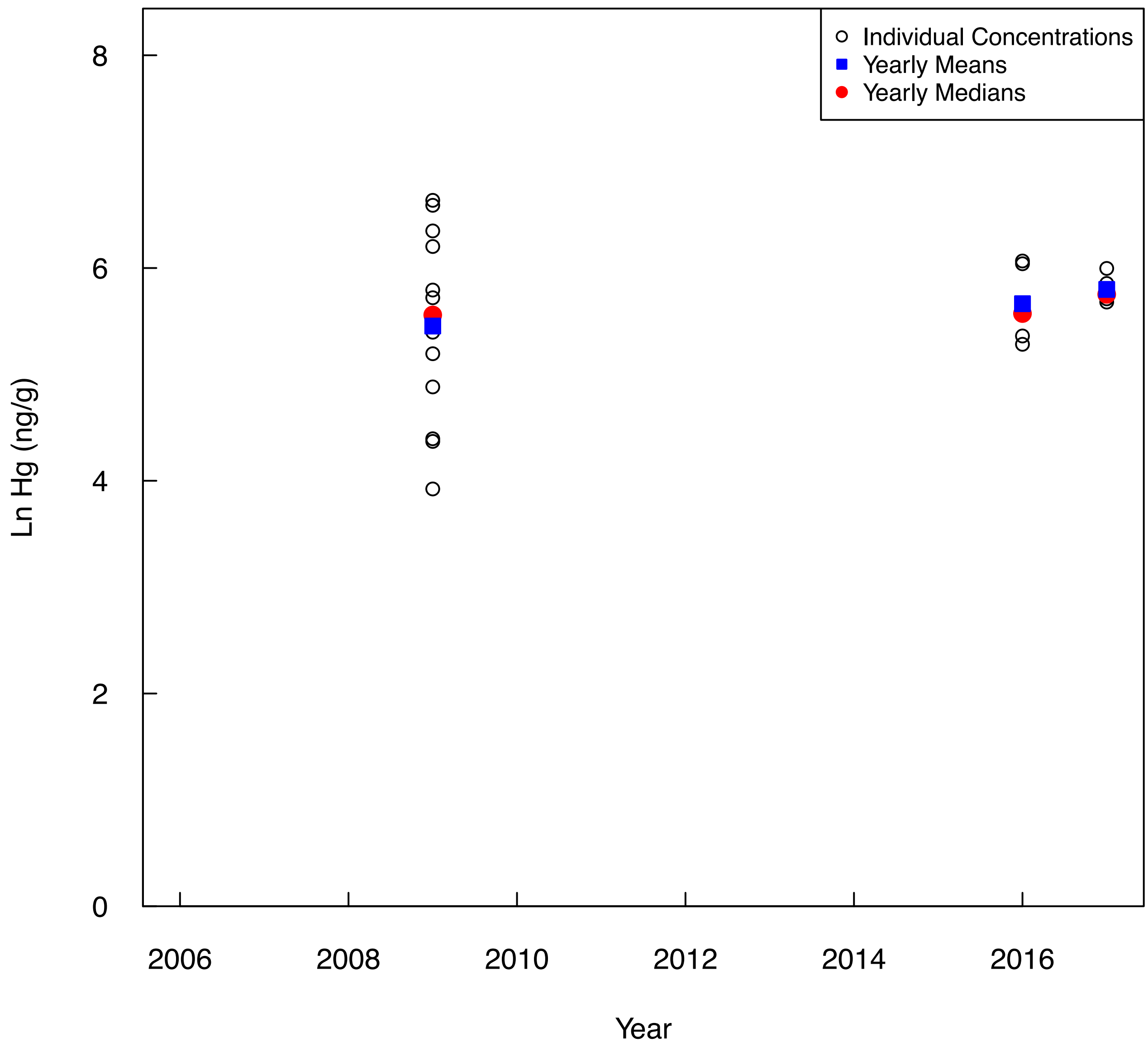


**Figure 4–13**
**Spider – Whole River**
**Ln Mercury Concentrations**




Includes Spiders sampled at W–17–N, MM–SE, and MM–SW

**Figure 4–14**
**Spider – W–17–N**
**Ln Mercury Concentrations**



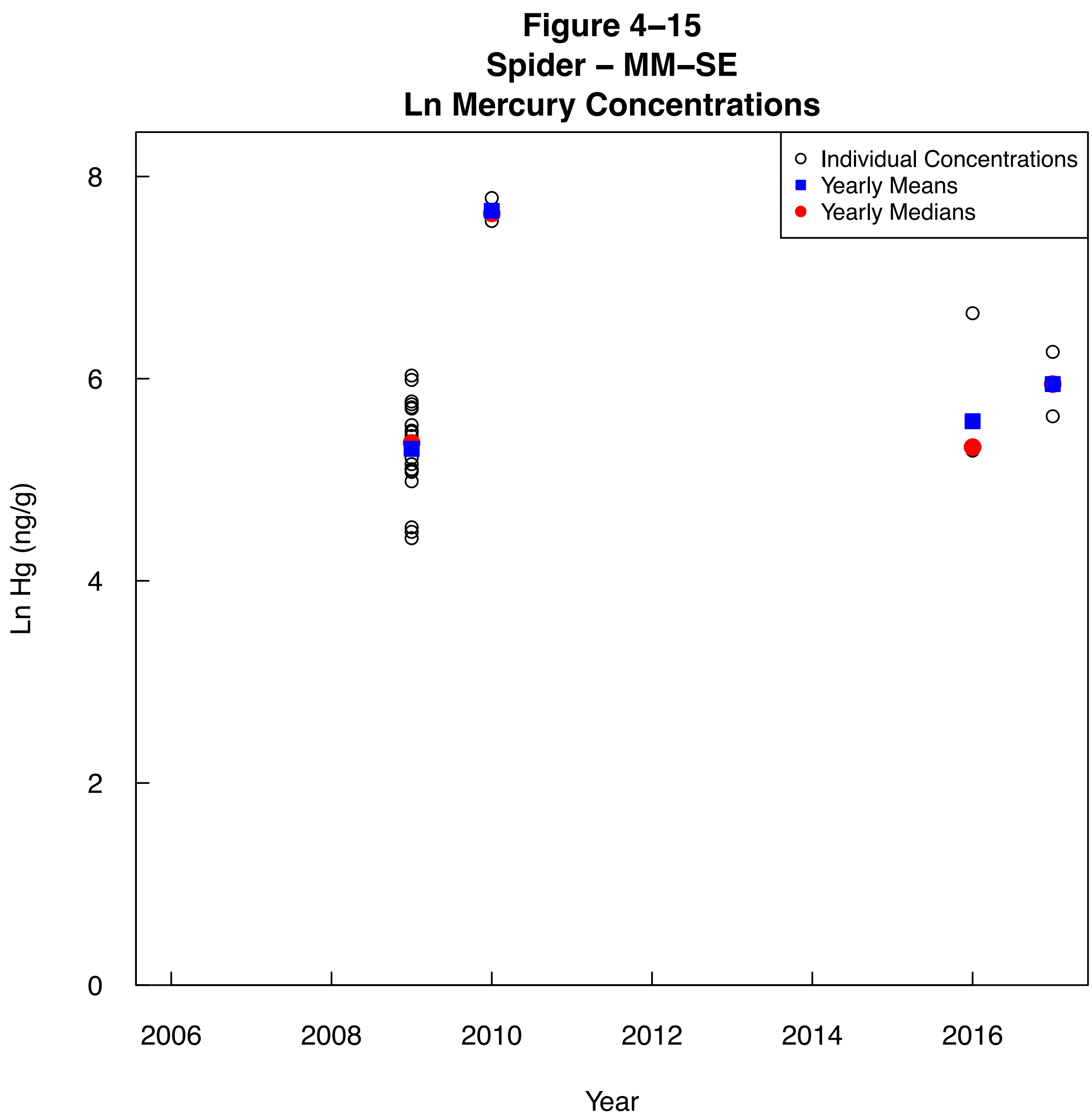


Figure 4–15
Spider – MM–SE
Ln Mercury Concentrations
Individual Concentrations
Yearly Means
Yearly Medians
Ln Hg (ng/g)
0
2
4
6
8
2006
2008
2010
2012
2014
2016
Year

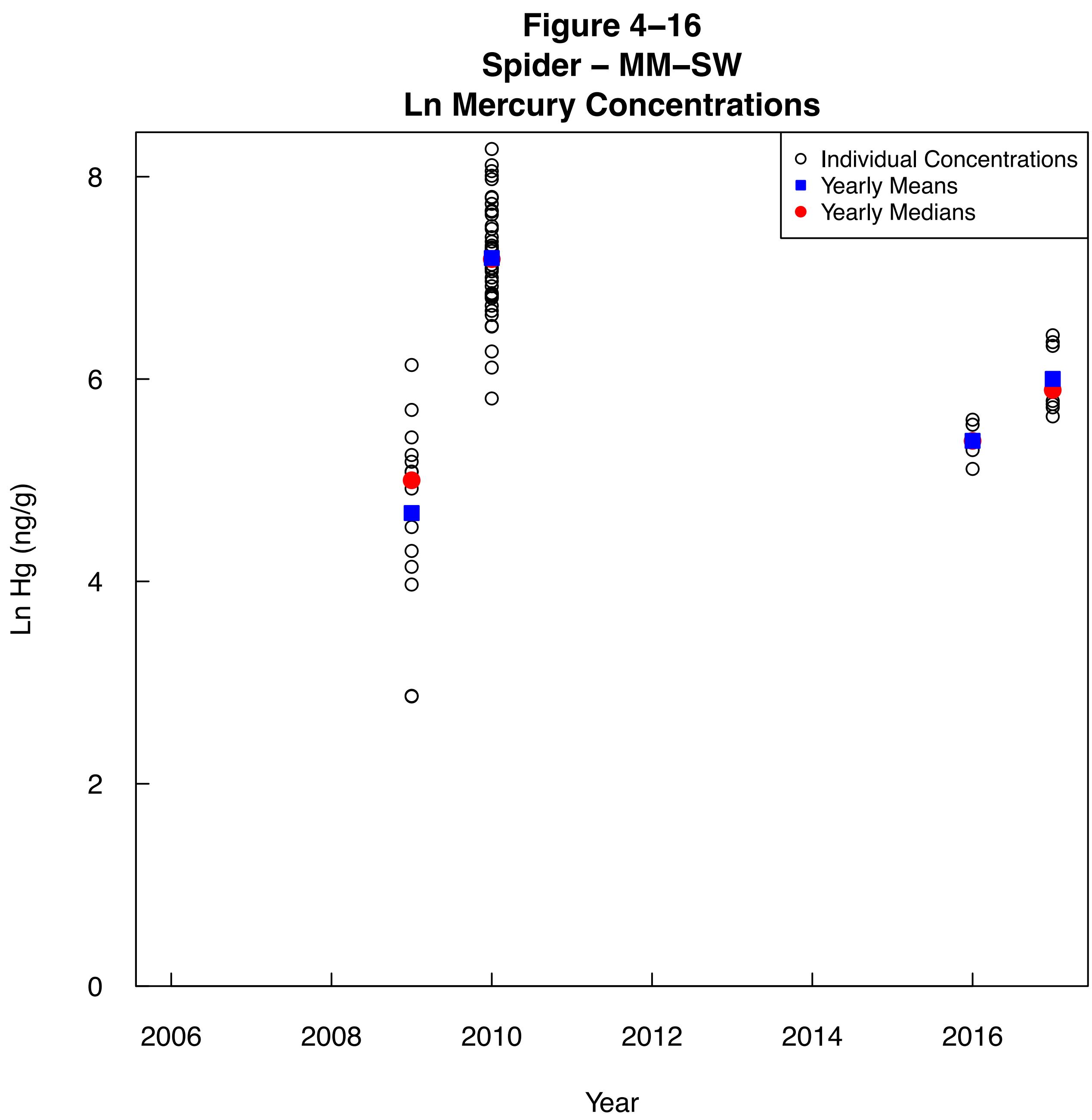
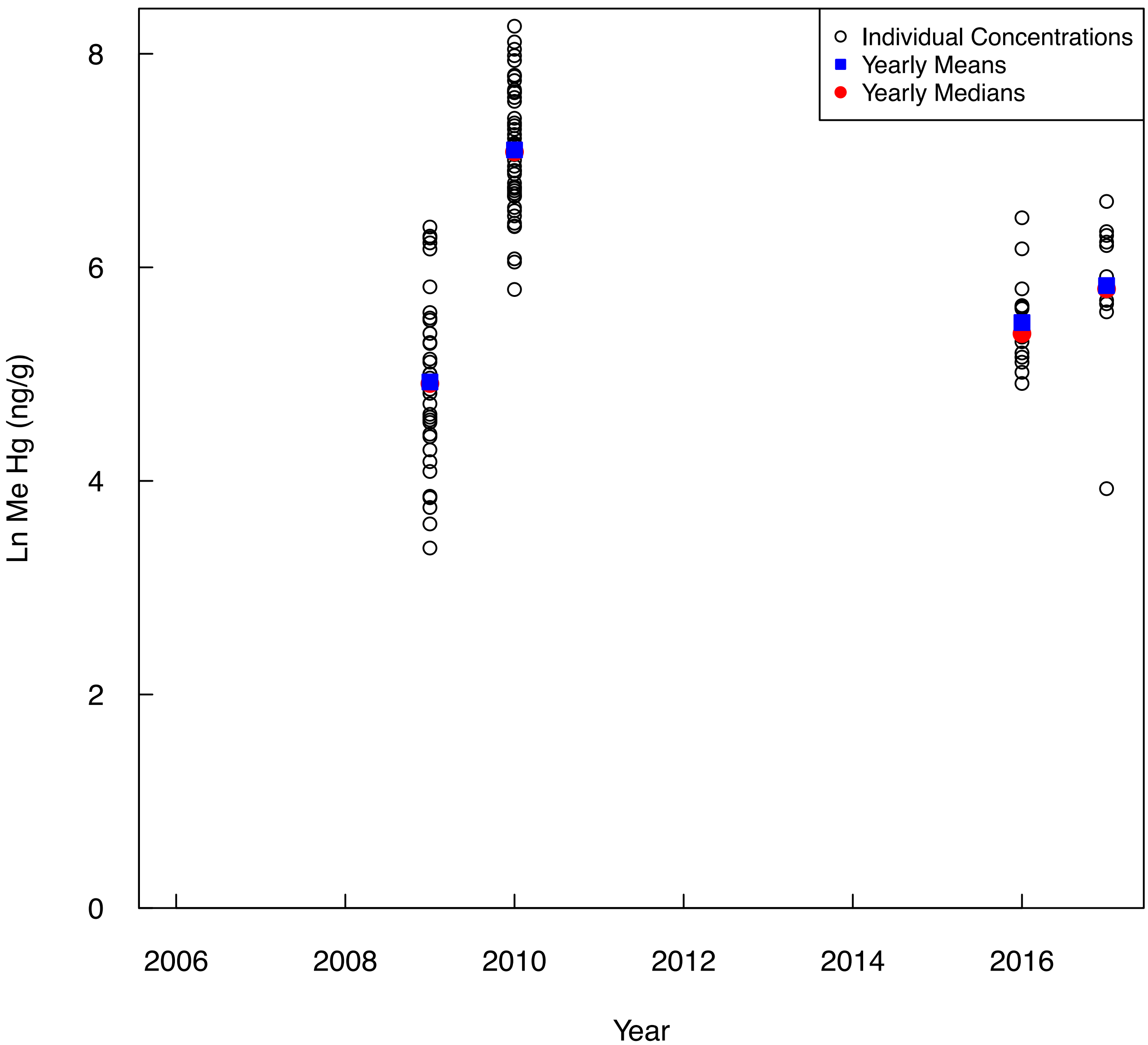


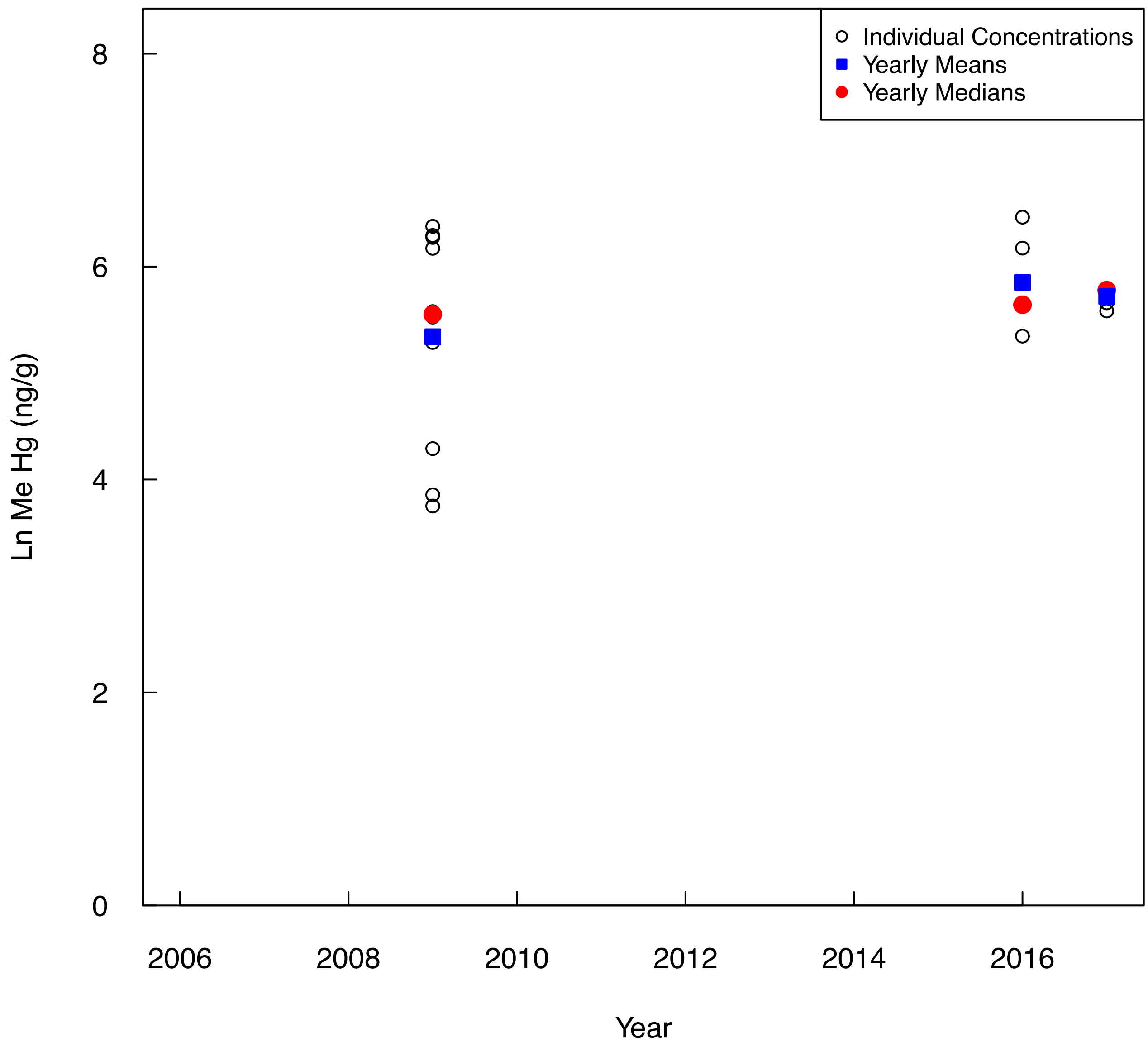
Figure 4–16
Spider – MM–SW
Ln Mercury Concentrations
Individual Concentrations
Yearly Means
Yearly Medians
Ln Hg (ng/g)
0
2
4
6
8
2006
2008
2010
2012
2014
2016
Year

**Figure 4–17**
**Spider – Whole River**
**Ln Methyl Mercury Concentrations**




Includes Spiders sampled at W–17–N, MM–SE, and MM–SW

**Figure 4–18**
**Spider – W–17–N**
**Ln Methyl Mercury Concentrations**



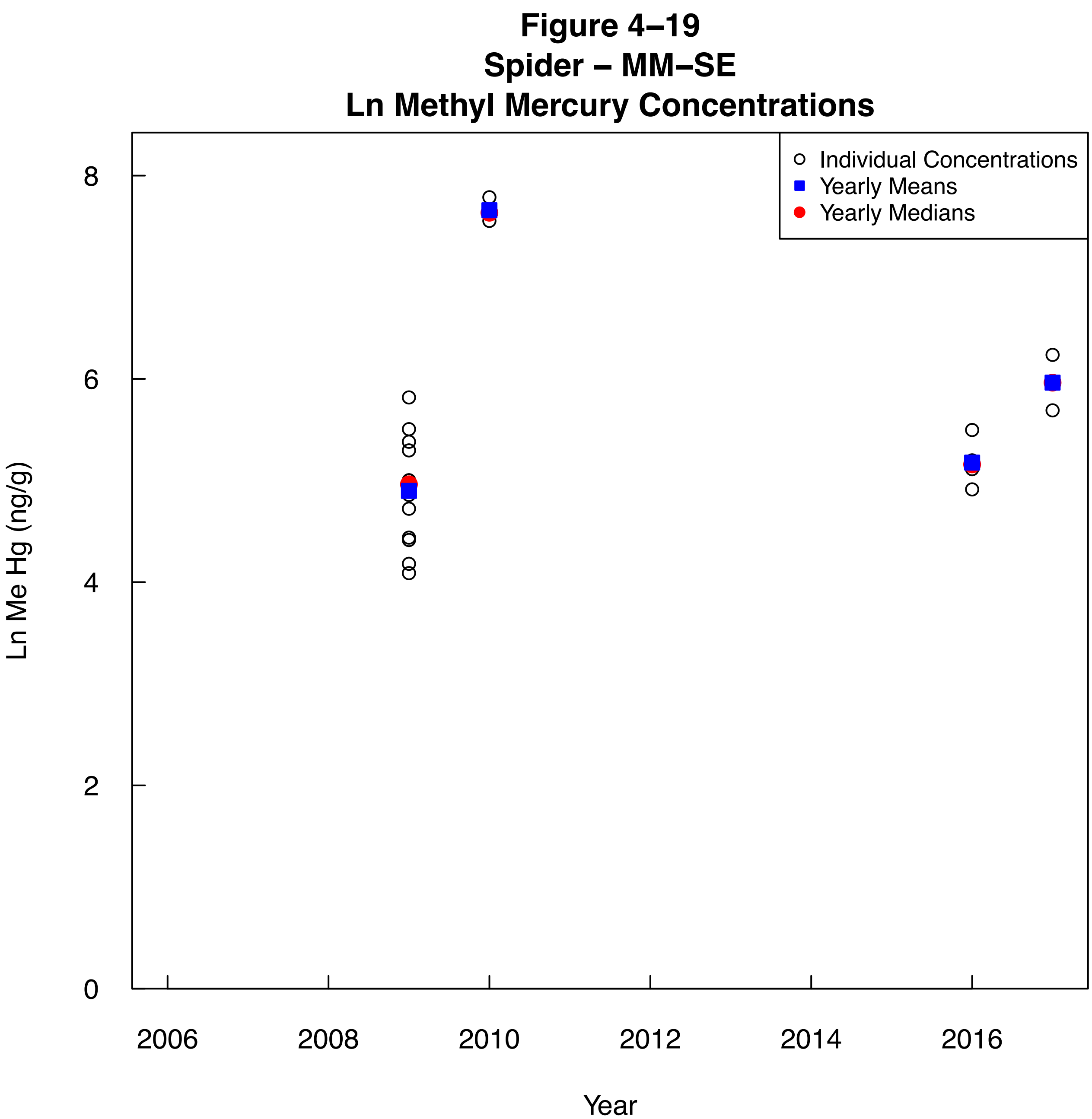


Figure 4–19
Spider – MM–SE
Ln Methyl Mercury Concentrations
Individual Concentrations
Yearly Means
Yearly Medians
Ln Me Hg (ng/g)
0
2
4
6
8
2006
2008
2010
2012
2014
2016
Year

**Figure 4–20**
**Spider – MM–SW**
**Ln Methyl Mercury Concentrations**

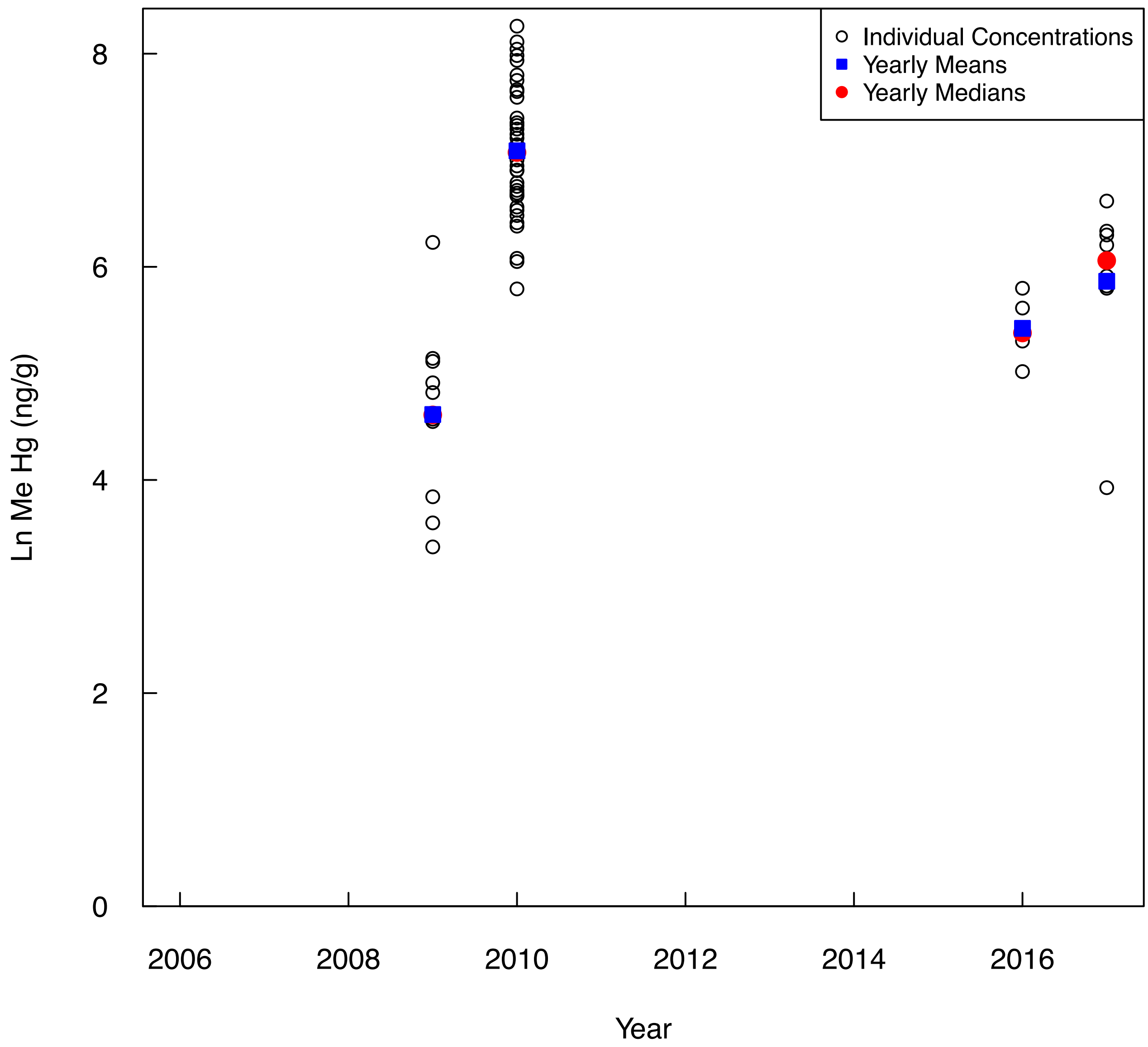
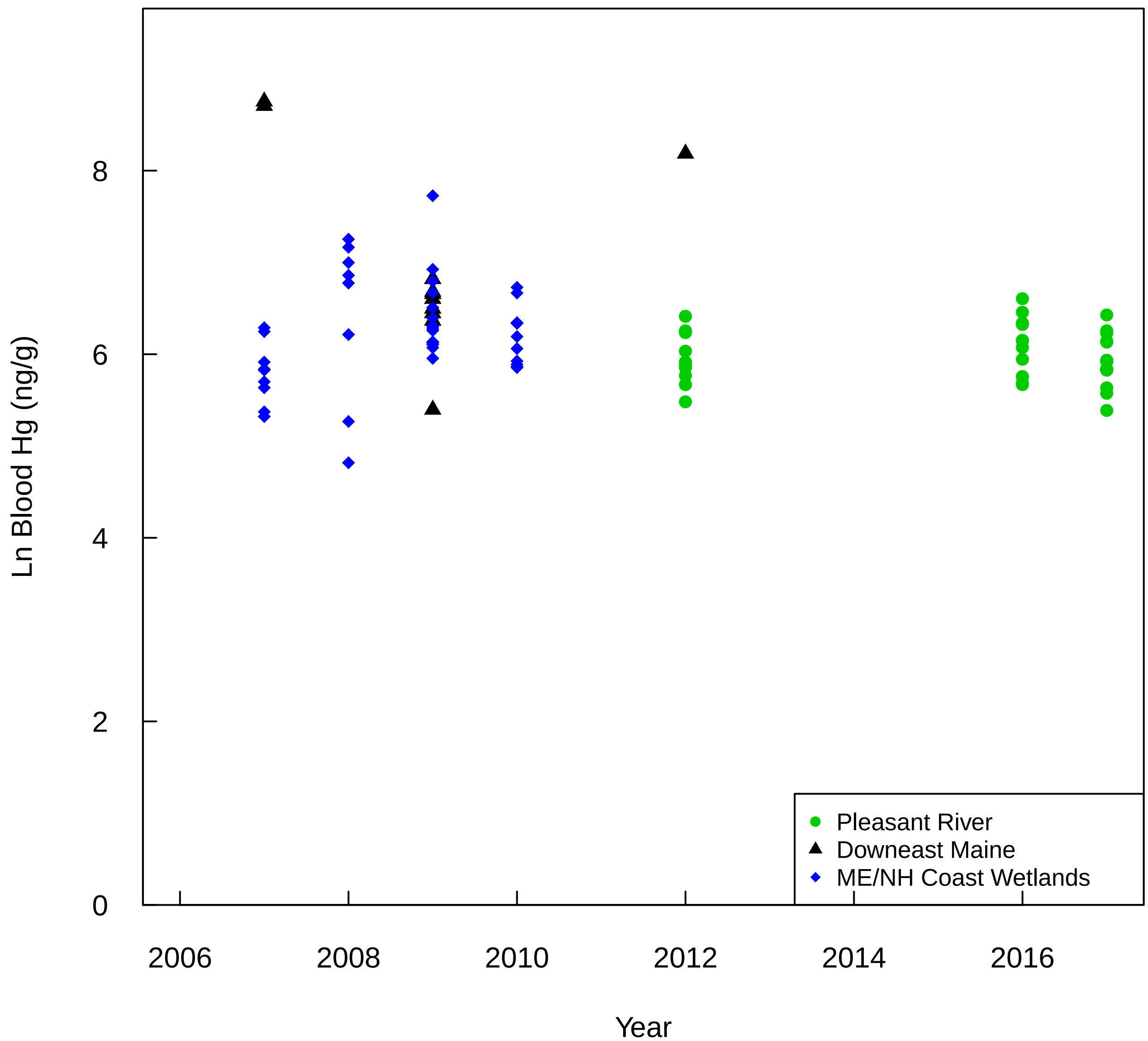
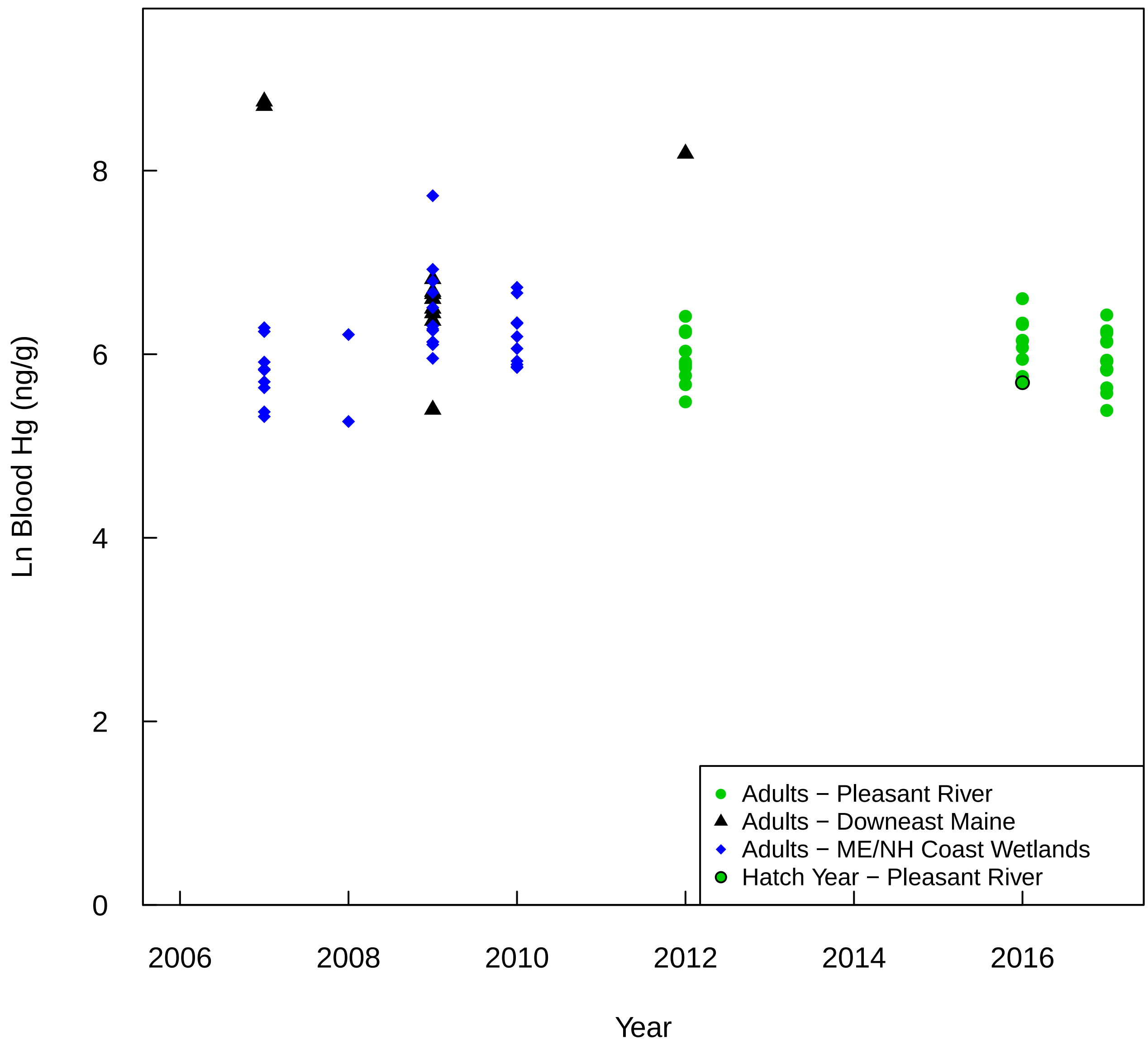


**Figure 4−21a**
**Nelson's Sparrow Blood − Reference Locations**
**Ln Mercury Concentrations**



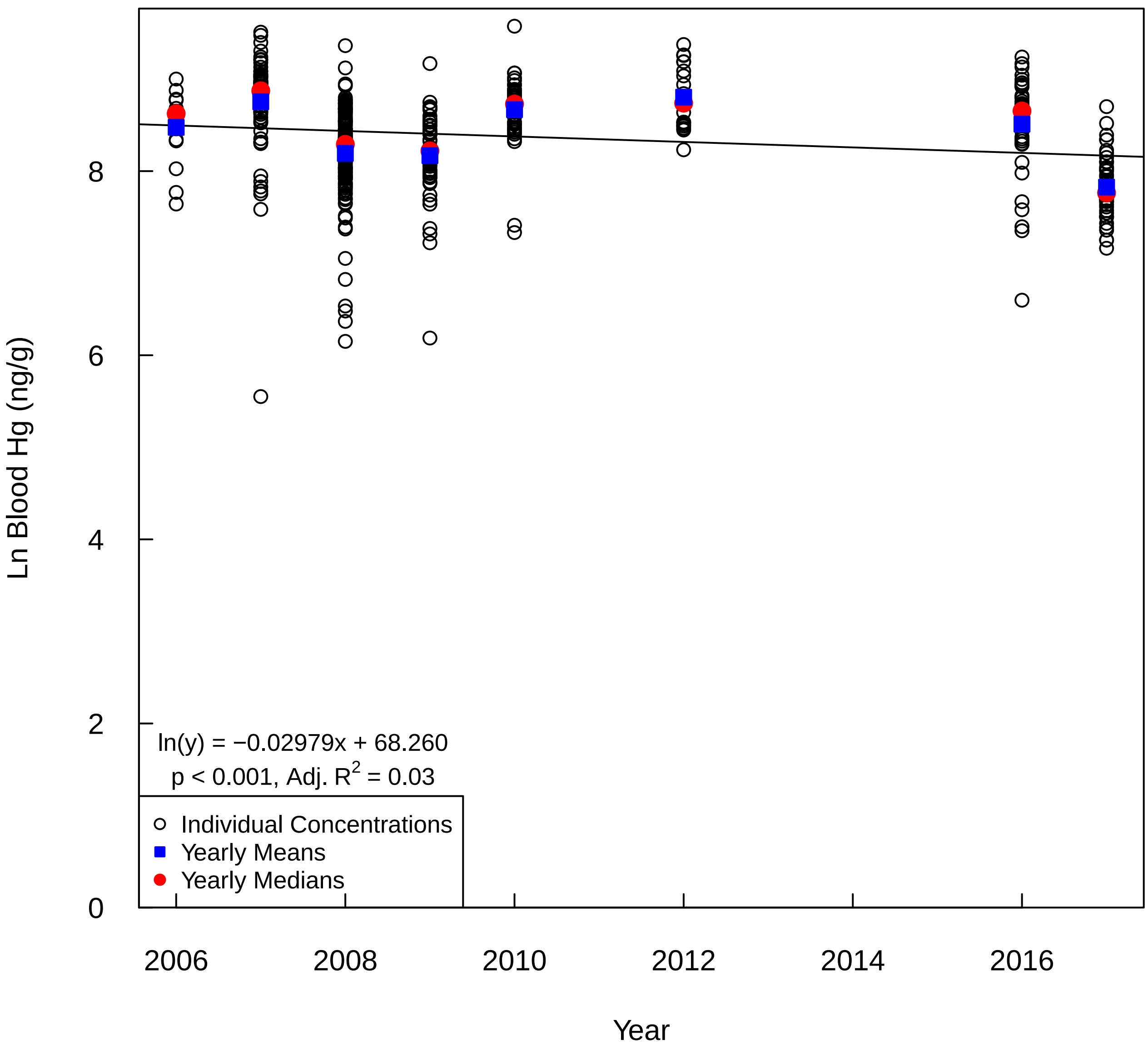

ME/NH Coast Wetlands includes: Spurwink River, Scarborough River, Moody Beach, and Great Bay areas

**Figure 4−21b**
**Nelson's Sparrow (By Age) Blood − Reference Locations**
**Ln Mercury Concentrations**



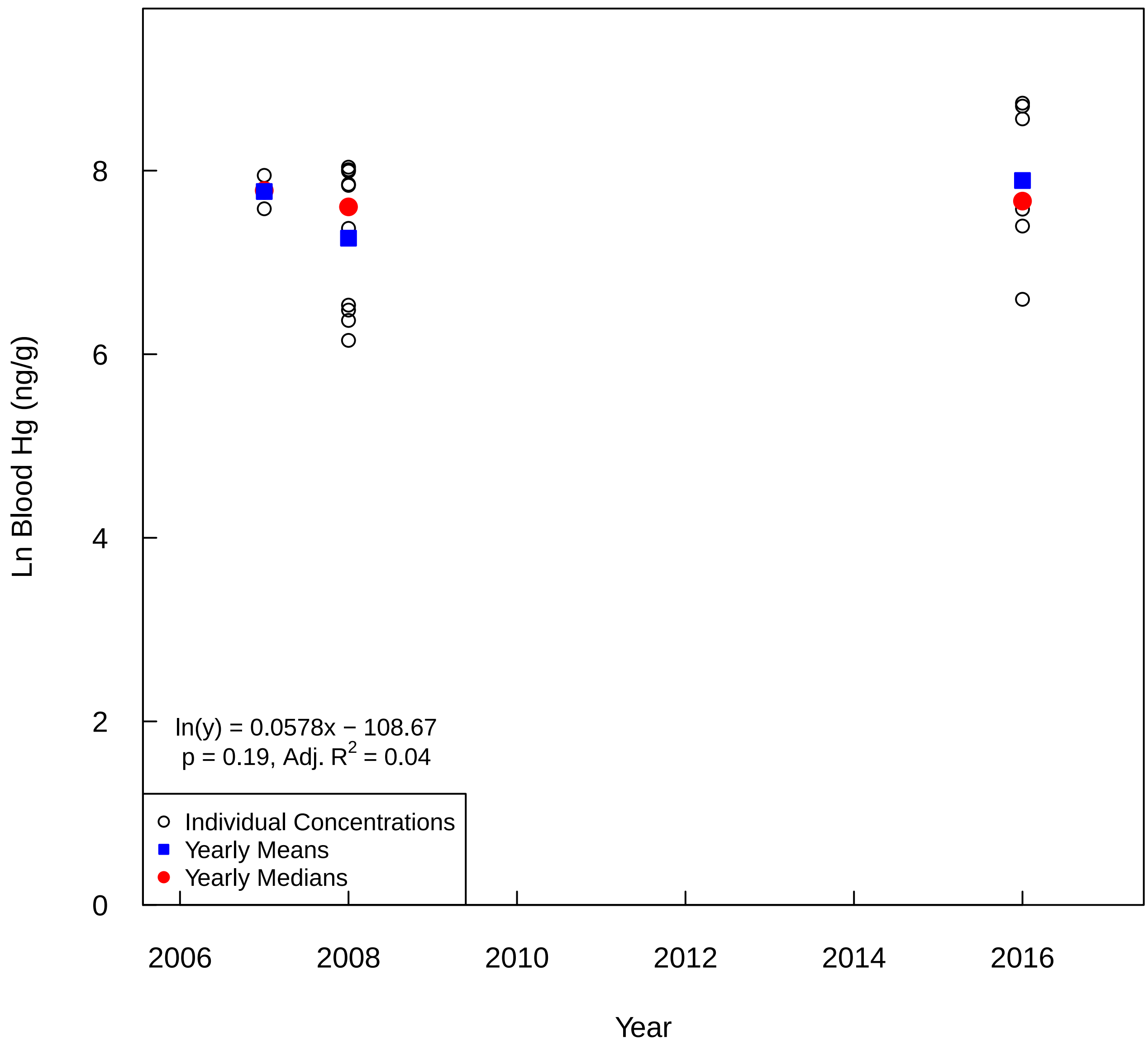

ME/NH Coast Wetlands includes: Spurwink River, Scarborough River, Moody Beach, and Great Bay areas

Figure 4−22a
Nelson's Sparrow Blood − Whole River
Loglinear Regression




Includes Nelson's Sparrows sampled at MM−SE, MM−SW, and W−17−N

**Figure 4−22b**
**Nelson's Sparrow (Hatch Year) Blood − Whole River**
**Loglinear Regression**




Includes Nelson's Sparrows sampled at MM−SE, MM−SW, and W−17−N

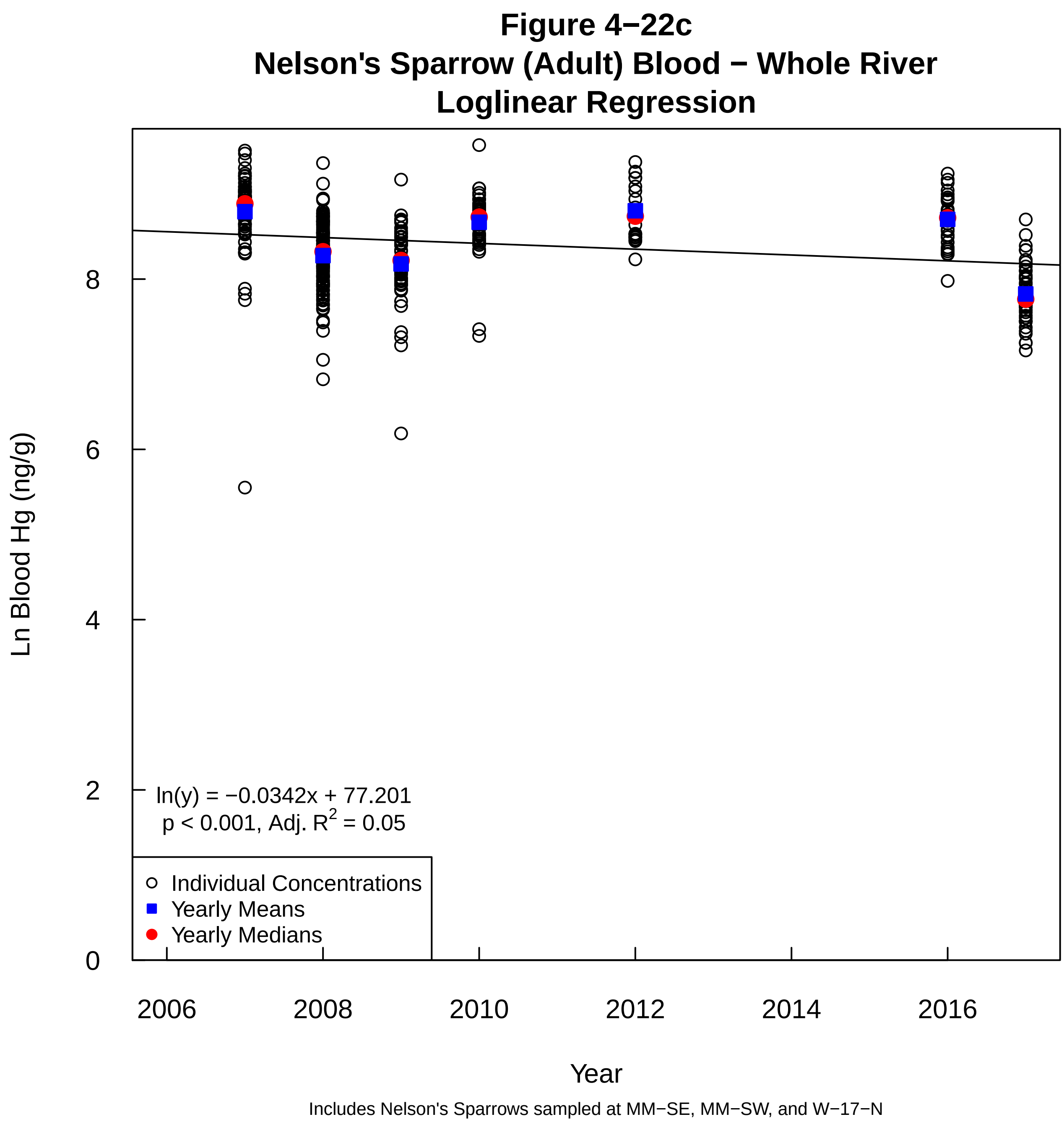
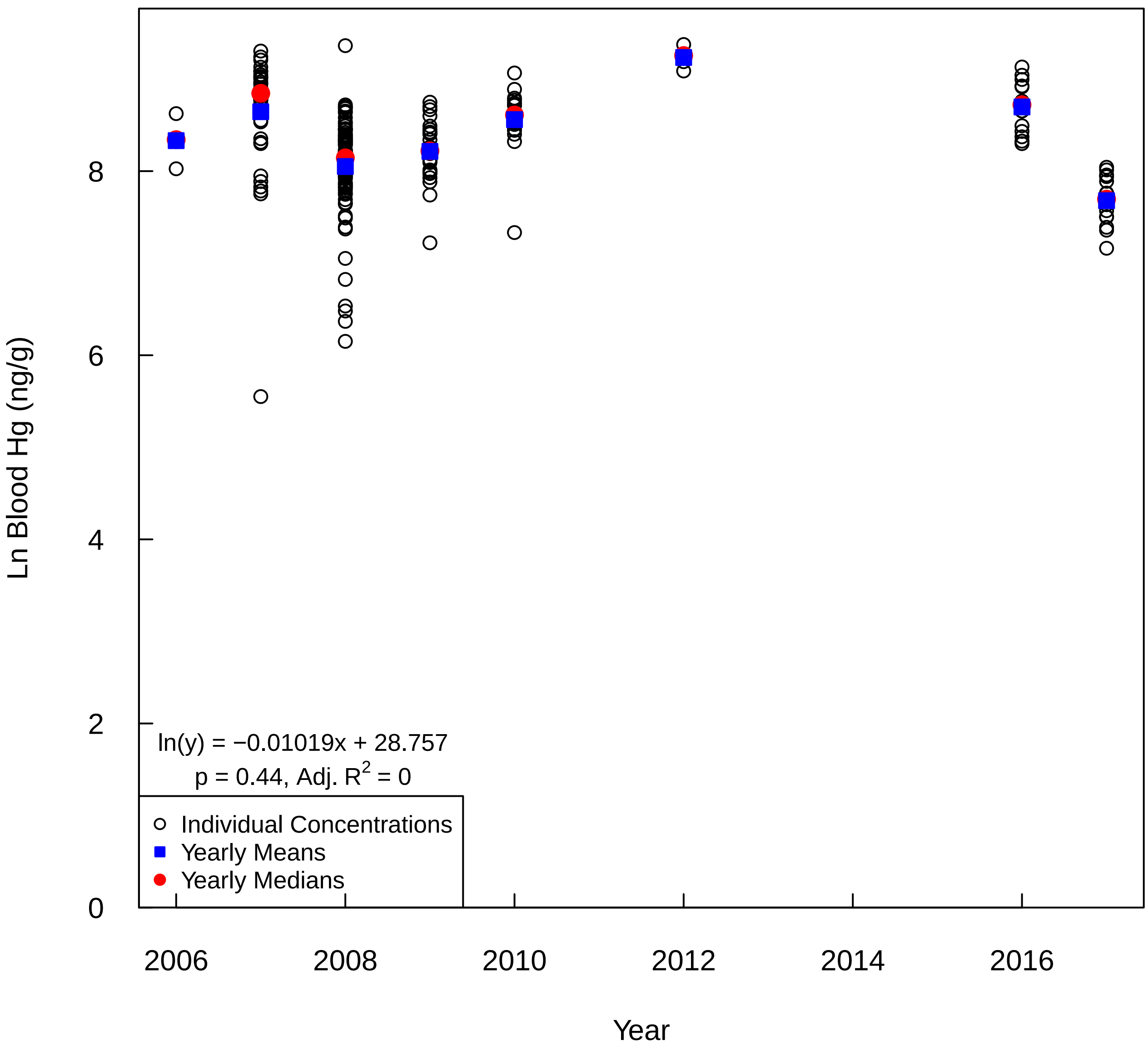


Figure 4−22c
Nelson's Sparrow (Adult) Blood − Whole River
Loglinear Regression
Ln Blood Hg (ng/g)
0
2
4
6
8
ln(y) = −0.0342x + 77.201
p < 0.001, Adj. R2 = 0.05
Individual Concentrations
Yearly Means
Yearly Medians
2006
2008
2010
2012
2014
2016
Year
Includes Nelson's Sparrows sampled at MM−SE, MM−SW, and W−17−N

**Figure 4−23a**
**Nelson's Sparrow Blood − MM−SE**
**Loglinear Regression**



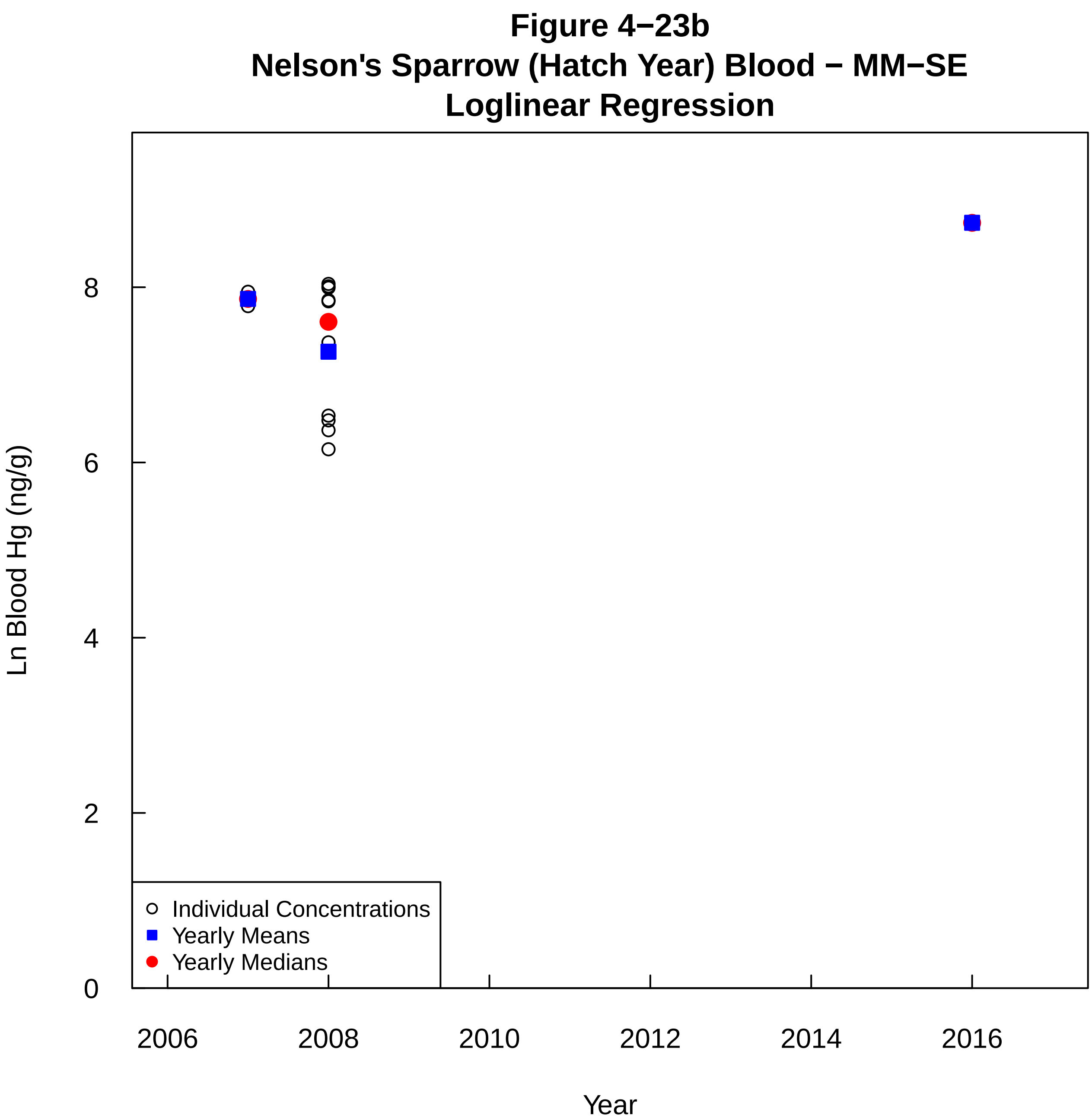


Figure 4−23b
Nelson's Sparrow (Hatch Year) Blood − MM−SE
Loglinear Regression
Ln Blood Hg (ng/g)
0
2
4
6
8
2006
2008
2010
2012
2014
2016
Year
Individual Concentrations
Yearly Means
Yearly Medians

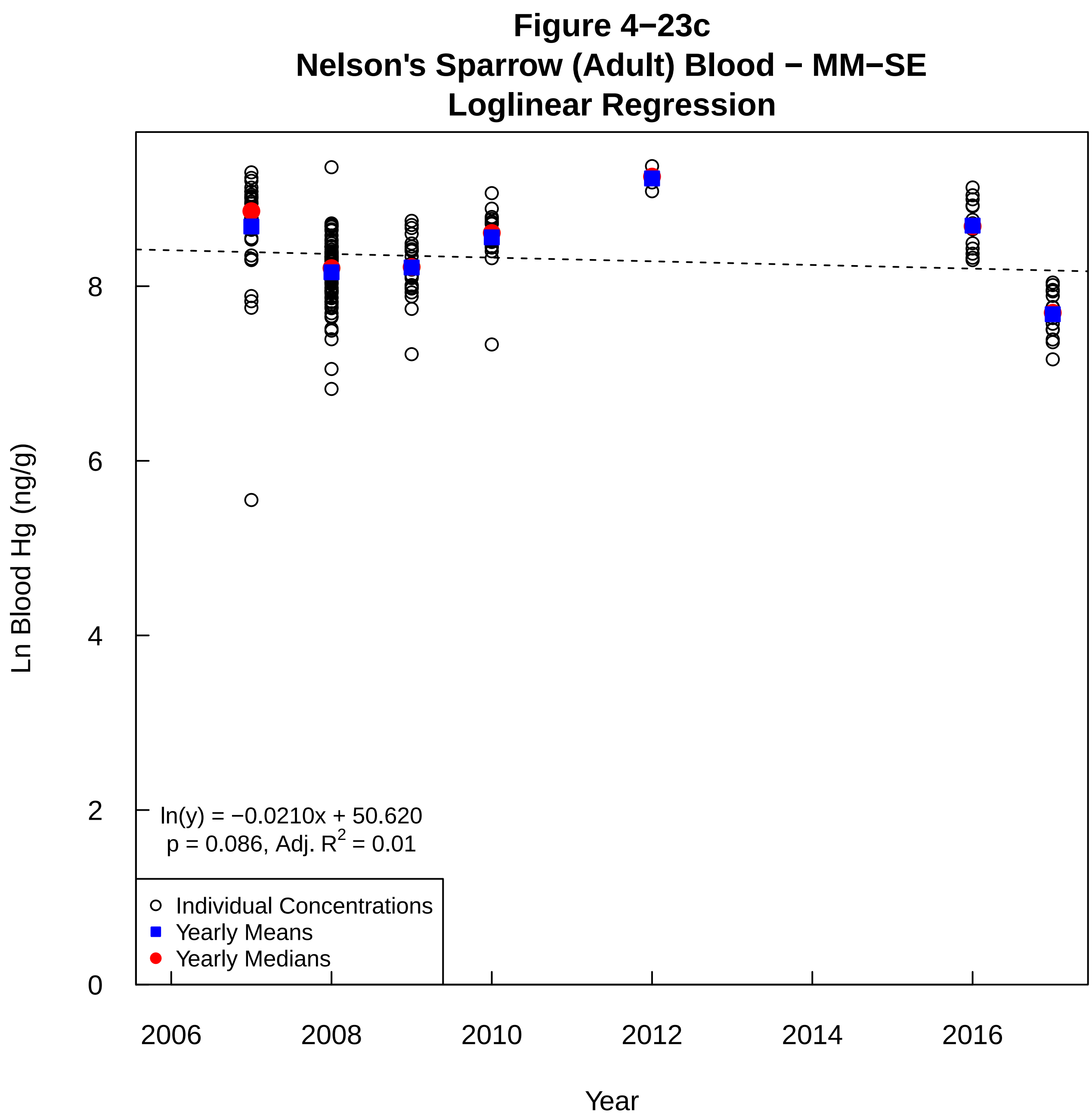


Figure 4−23c
Nelson's Sparrow (Adult) Blood − MM−SE
Loglinear Regression
Ln Blood Hg (ng/g)
0
2
4
6
8
ln(y) = −0.0210x + 50.620
p = 0.086, Adj. R2 = 0.01
Individual Concentrations
Yearly Means
Yearly Medians
2006
2008
2010
2012
2014
2016
Year

**Figure 4−24a**
**Nelson's Sparrow Blood − MM−SW**
**Loglinear Regression**

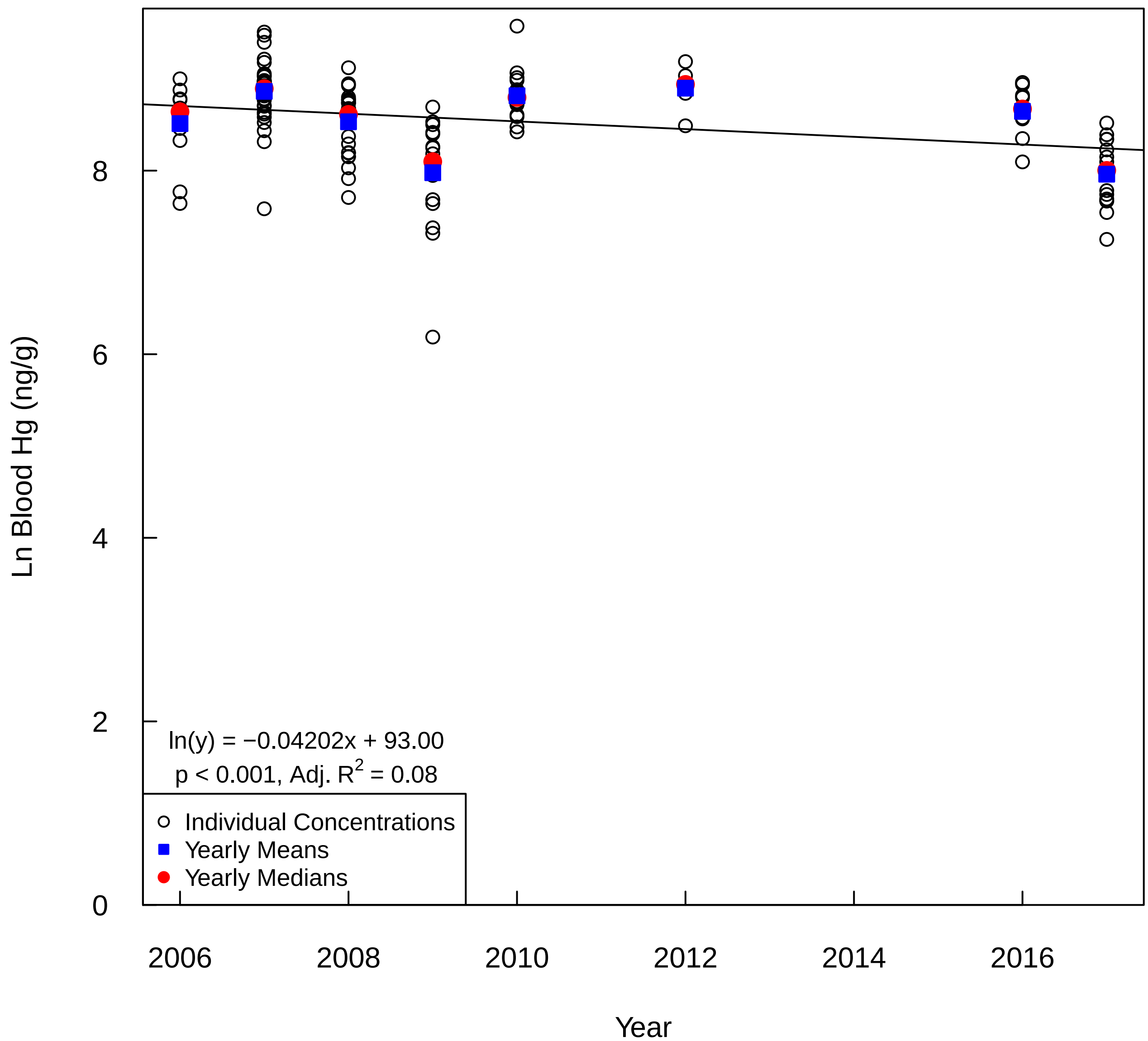


**Figure 4−24b**
**Nelson's Sparrow (Hatch Year) Blood − MM−SW**
**Loglinear Regression**

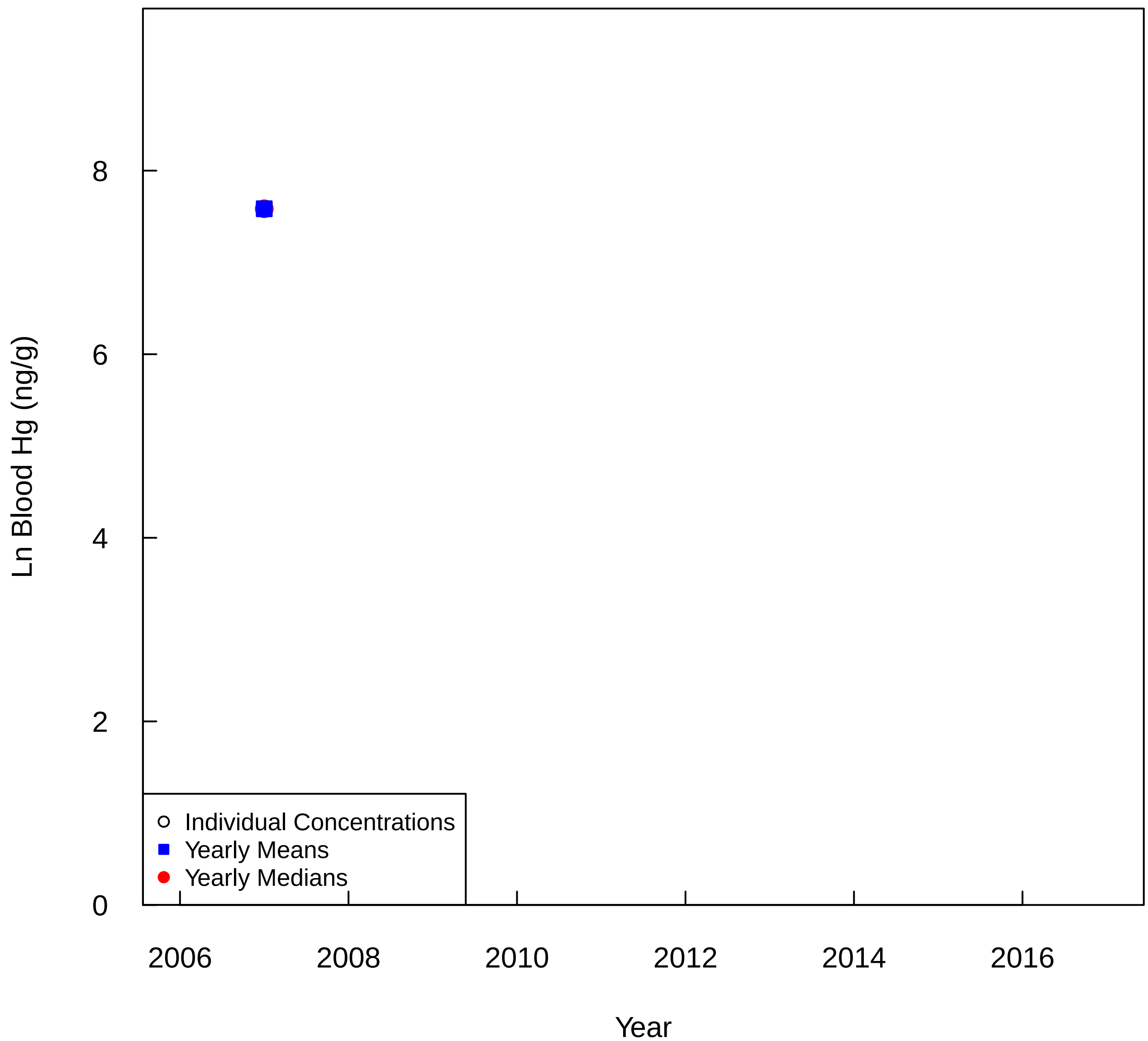
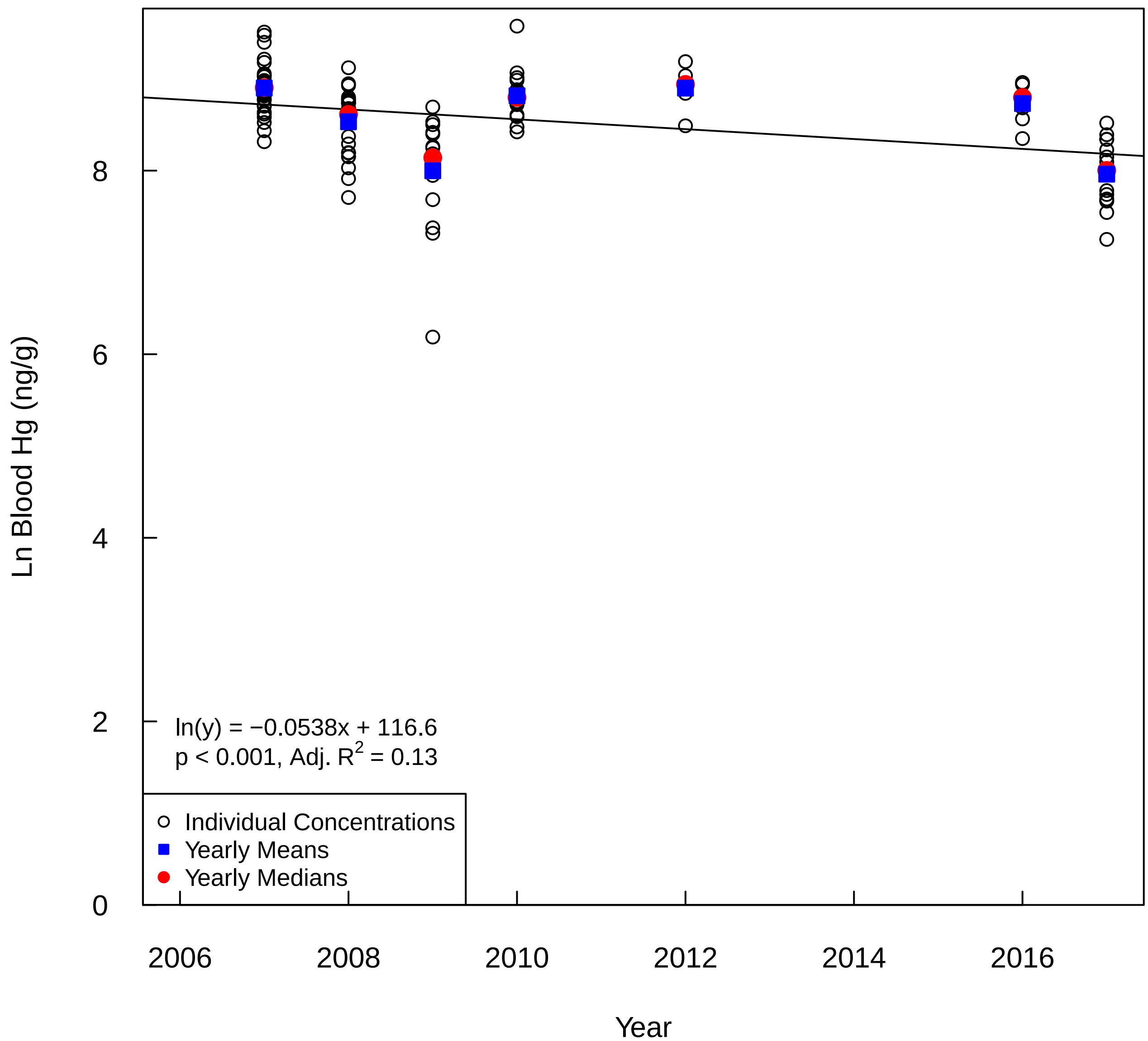


**Figure 4−24c**
**Nelson's Sparrow (Adult) Blood − MM−SW**
**Loglinear Regression**



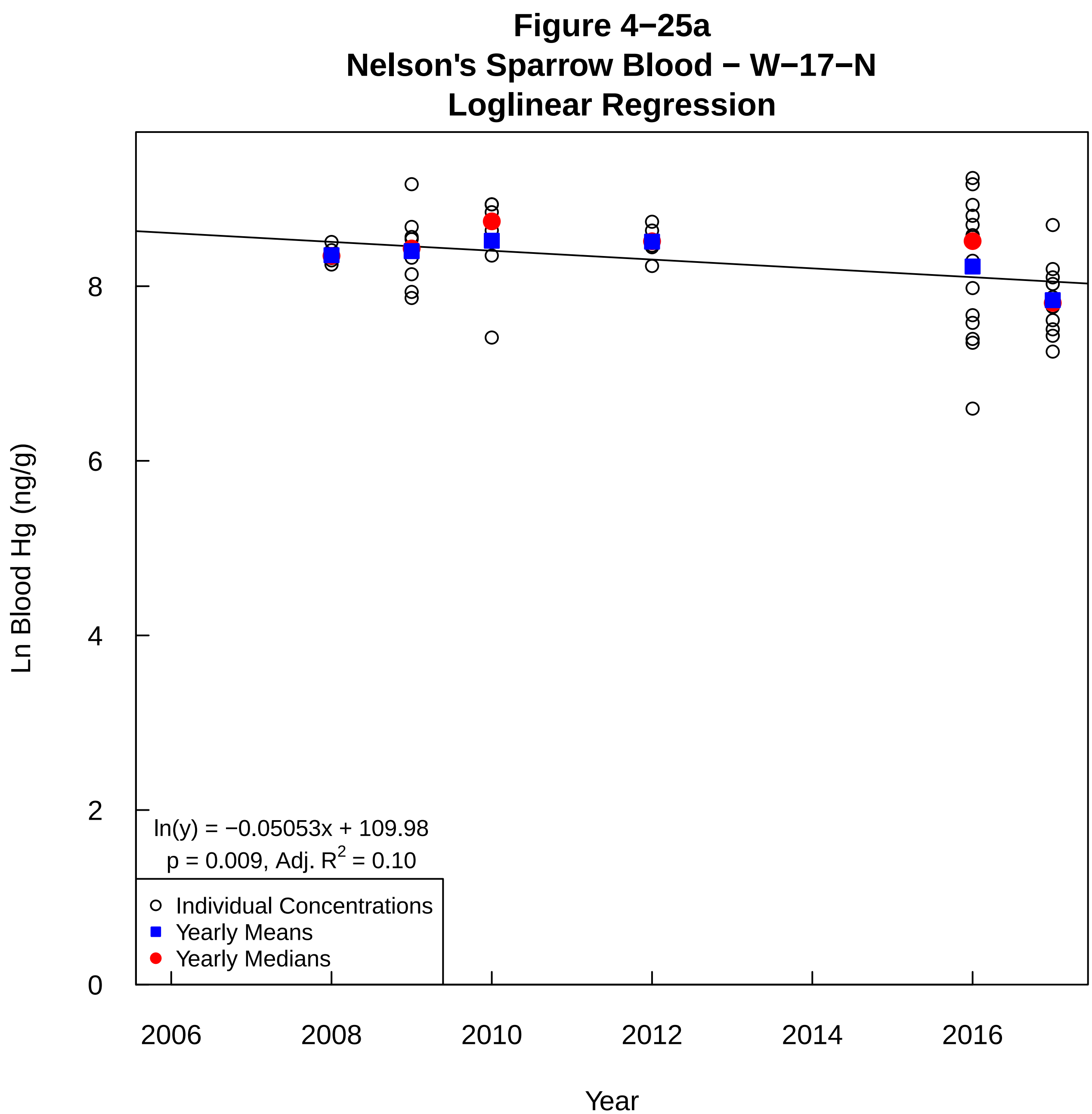


Figure 4−25a
Nelson's Sparrow Blood − W−17−N
Loglinear Regression
Ln Blood Hg (ng/g)
0
2
4
6
8
2006
2008
2010
2012
2014
2016
Year
ln(y) = −0.05053x + 109.98
p = 0.009, Adj. R2 = 0.10
Individual Concentrations
Yearly Means
Yearly Medians

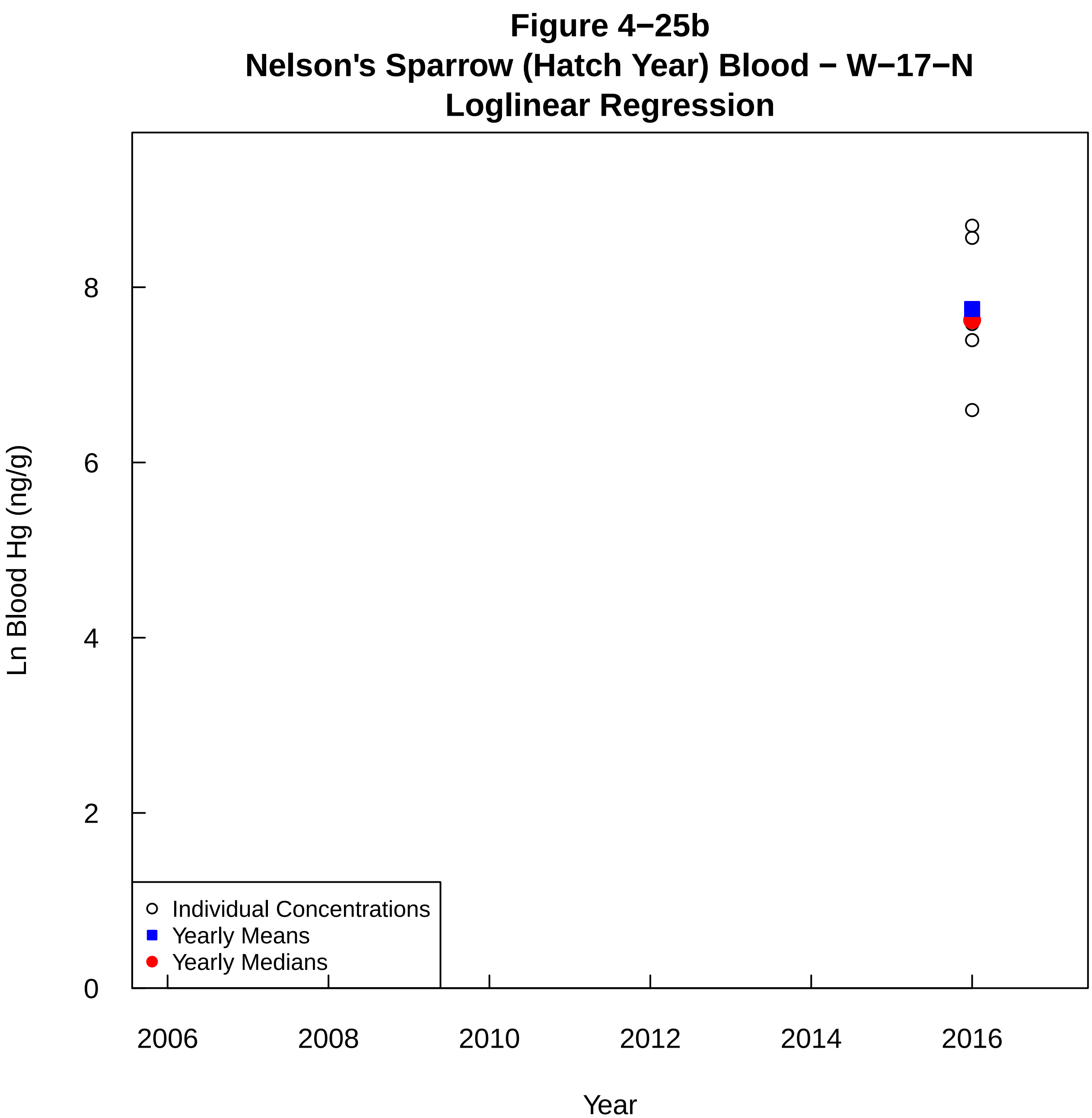


Figure 4−25b
Nelson's Sparrow (Hatch Year) Blood − W−17−N
Loglinear Regression
Ln Blood Hg (ng/g)
0
2
4
6
8
2006
2008
2010
2012
2014
2016
Year
Individual Concentrations
Yearly Means
Yearly Medians

**Figure 4−25c**
**Nelson's Sparrow (Adult) Blood − W−17−N**
**Loglinear Regression**

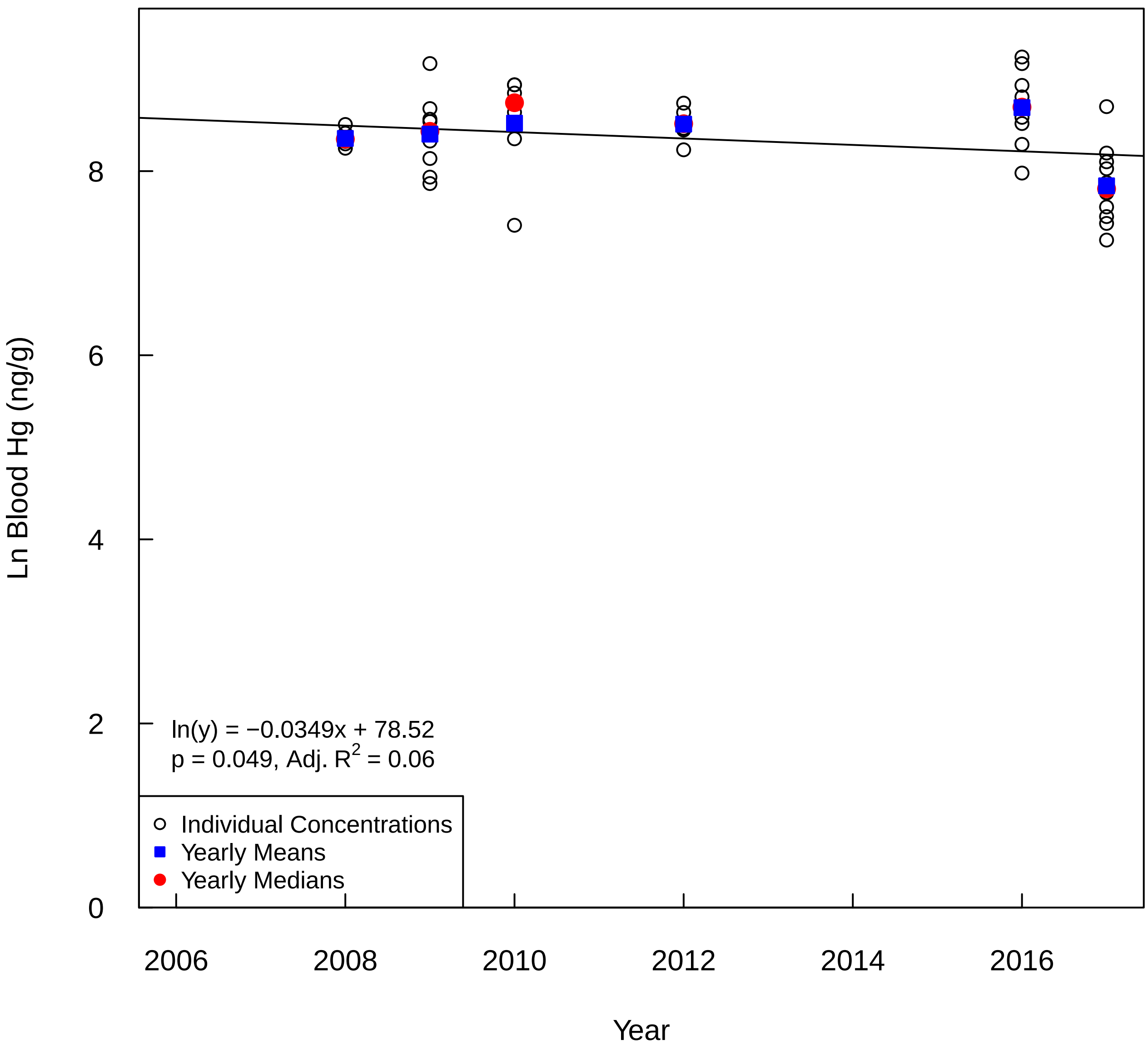
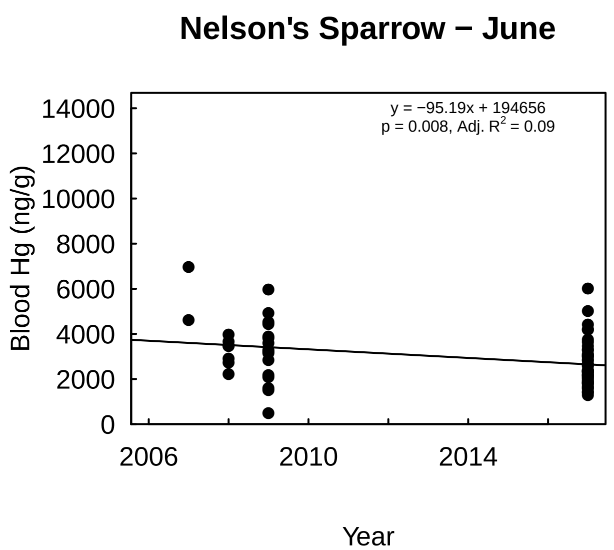
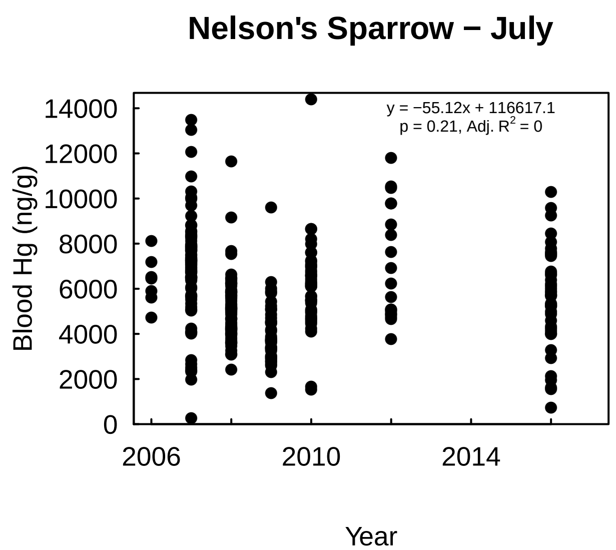


**Figure 4−26a**
**Nelson's Sparrow Mercury Concentrations in each Month**



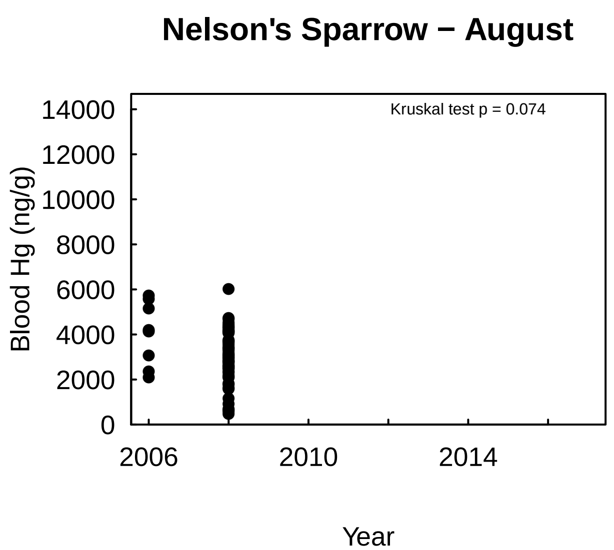
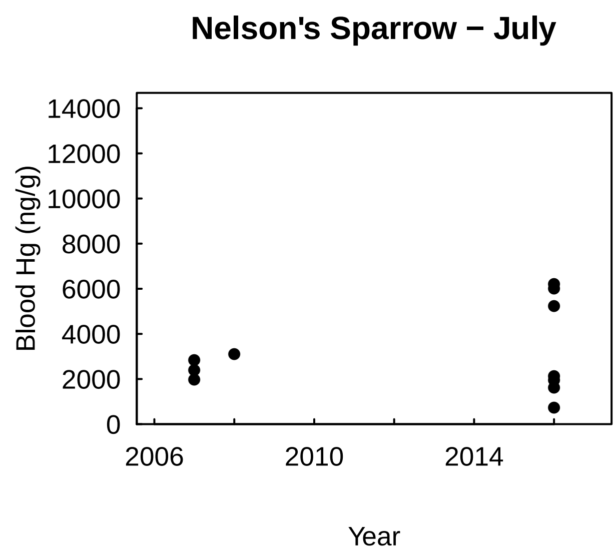



**Figure 4−26b**
**Nelson's Sparrow (Hatch Year) Mercury Concentrations in each Month**

No hatch year birds collected in June



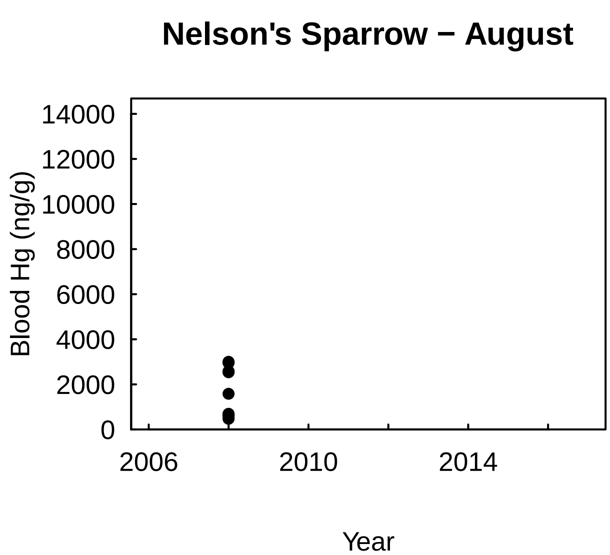



**Figure 4−26c**
**Nelson's Sparrow (Adult) Mercury Concentrations in each Month**

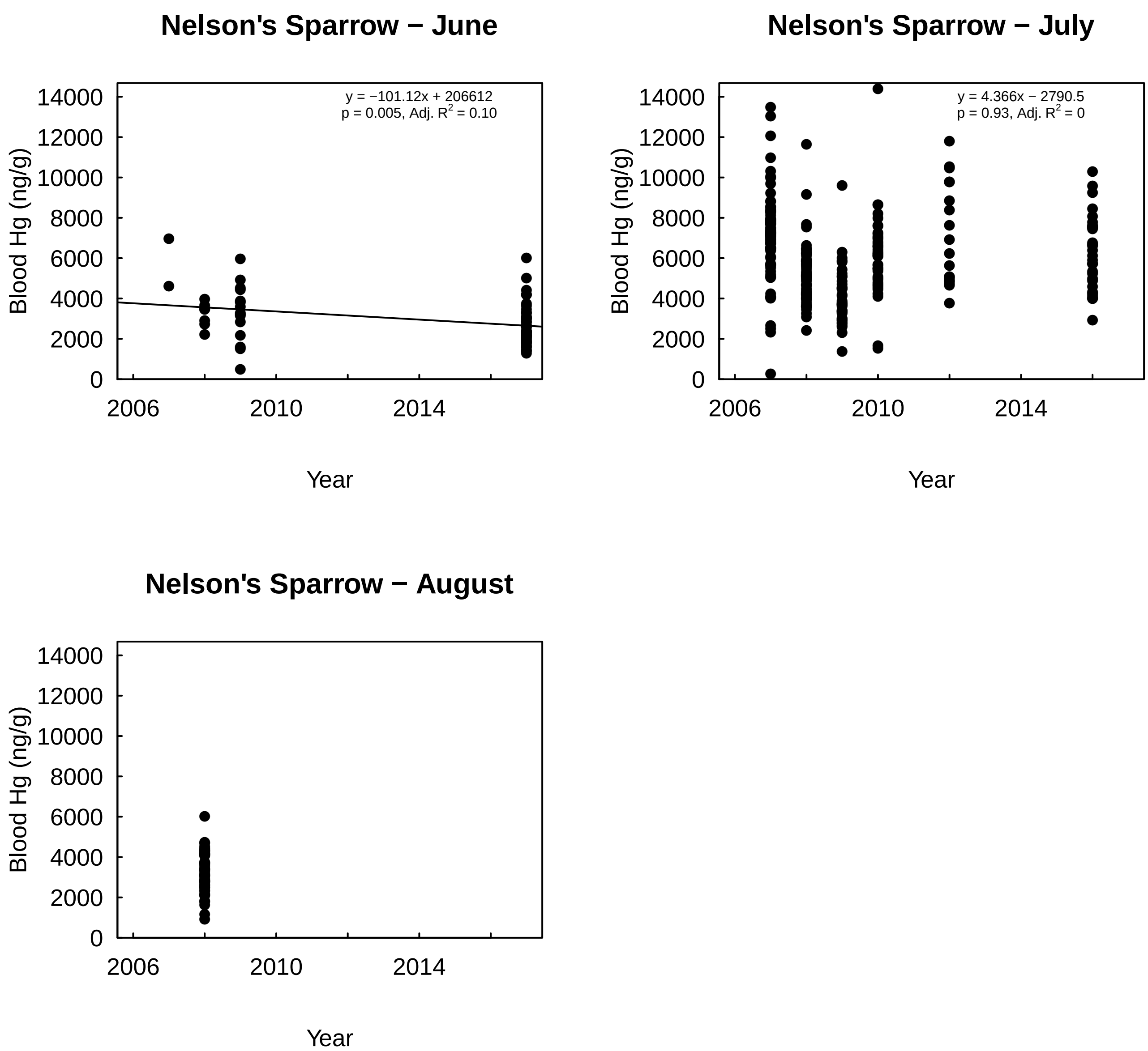
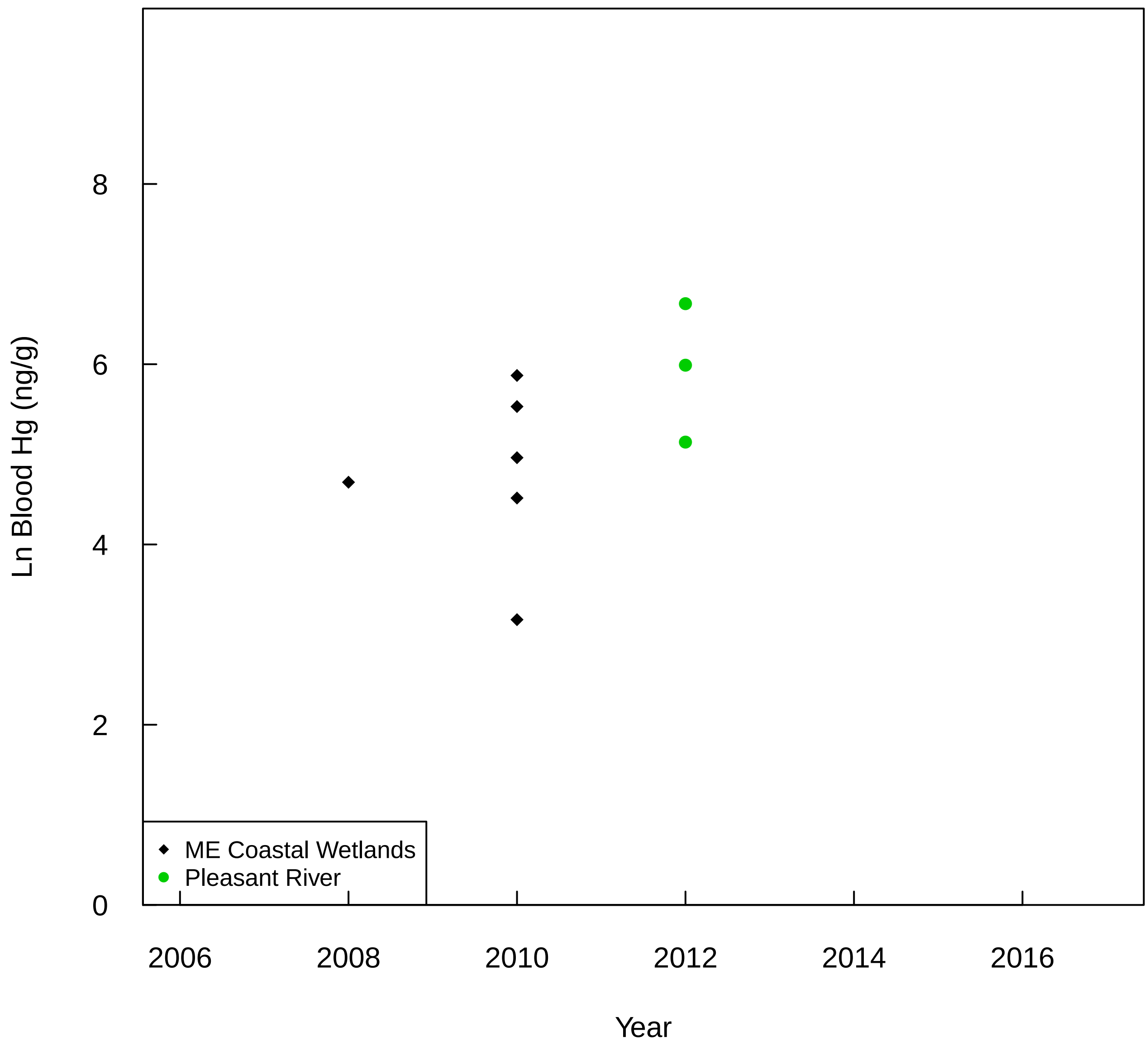
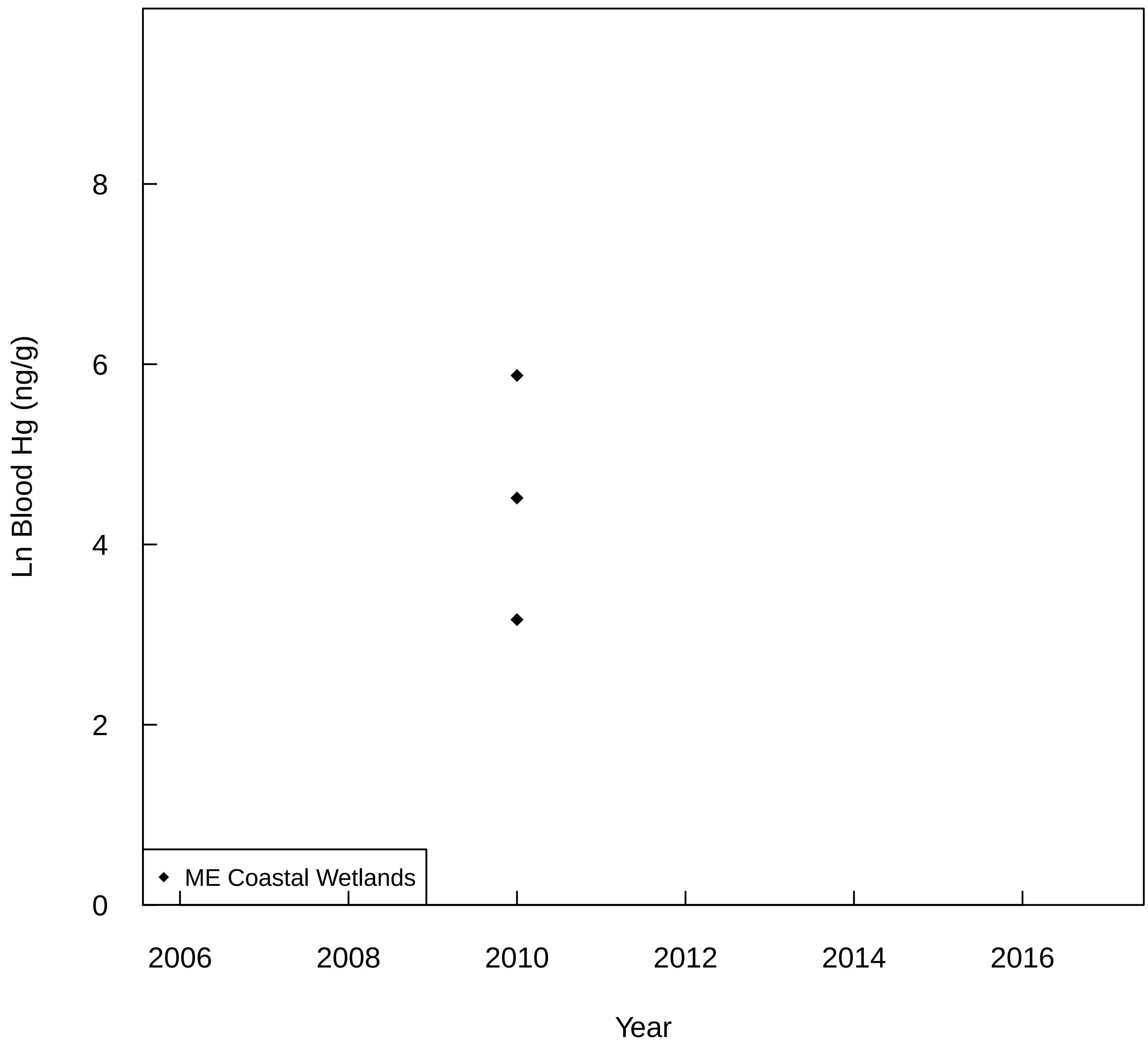


**Figure 4−27a**
**Red−winged Blackbird Blood − Reference Locations**
**Ln Mercury Concentrations**



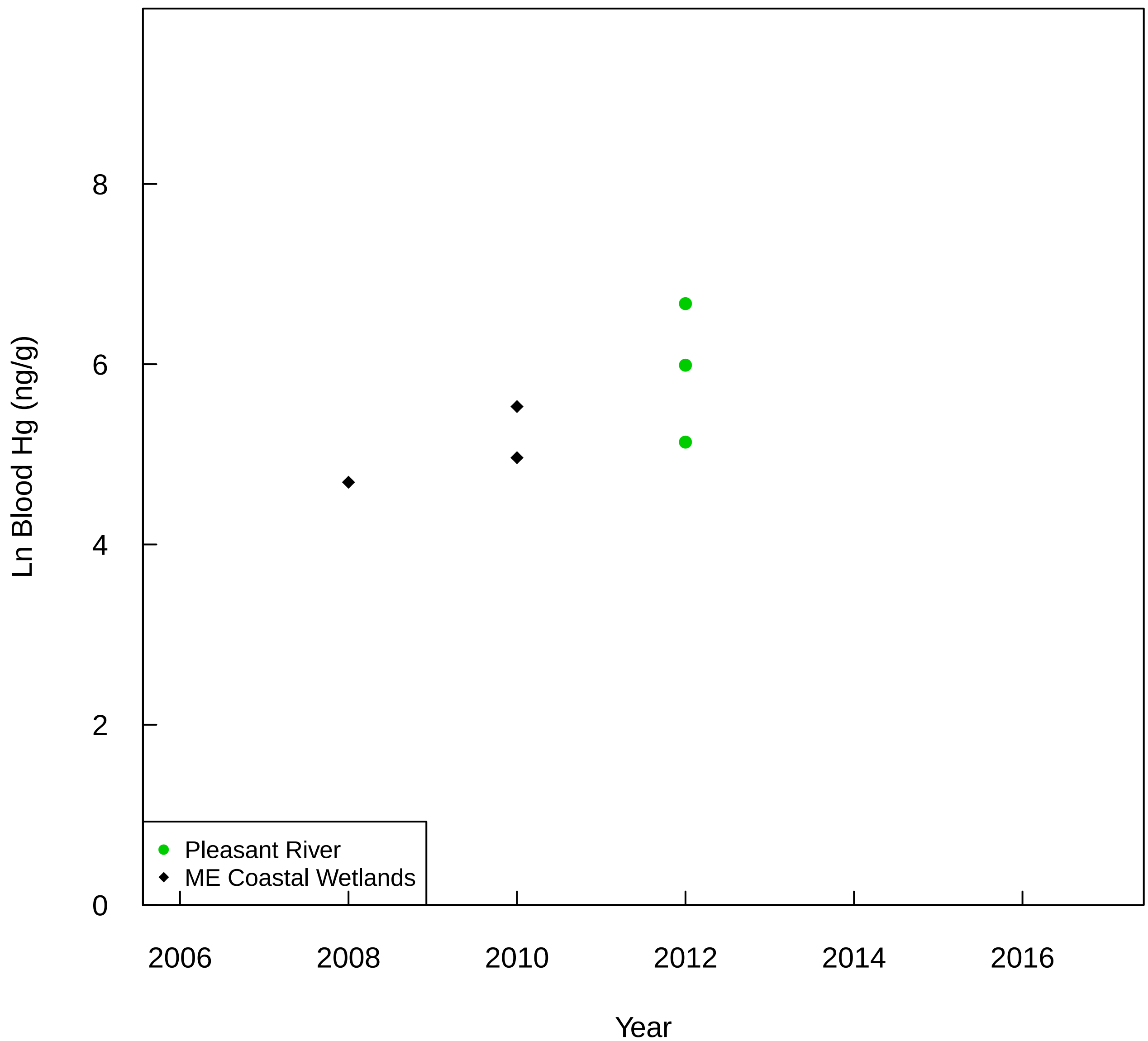

ME Coastal Wetlands includes: Spurwink River and Scarborough River areas

**Figure 4−27b**
**Red−winged Blackbird (Hatch Year) Blood − Reference Locations**
**Ln Mercury Concentrations**



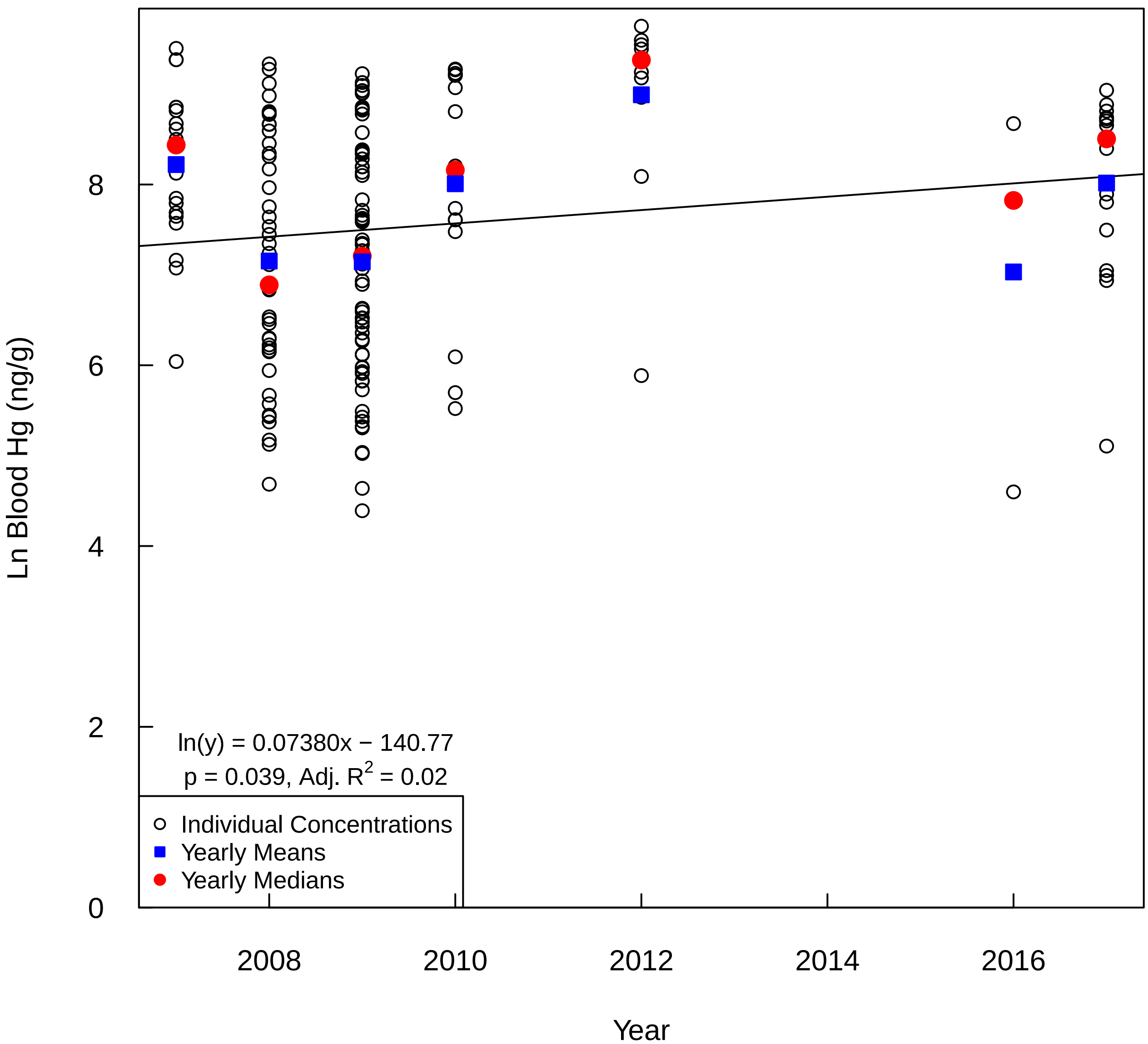

ME Coastal Wetlands includes: Spurwink River and Scarborough River areas

Figure 4−27c
Red−winged Blackbird (Adult) Blood − Reference Locations
Ln Mercury Concentrations




ME Coastal Wetlands includes: Spurwink River and Scarborough River areas

**Figure 4−28a**
**Red−winged Blackbird Blood − Whole River**
**Loglinear Regression**



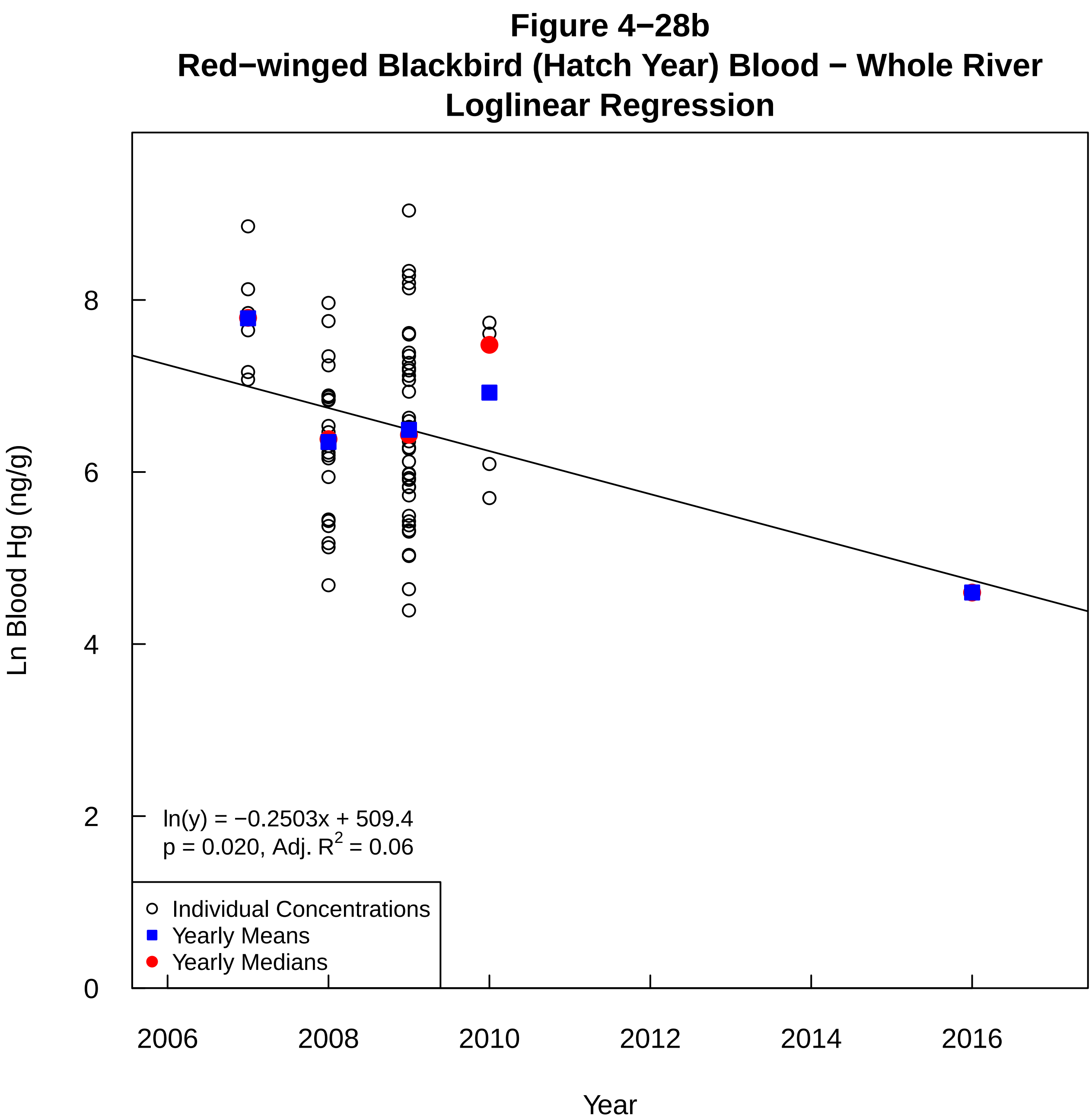


Figure 4−28b
Red−winged Blackbird (Hatch Year) Blood − Whole River
Loglinear Regression
Ln Blood Hg (ng/g)
0
2
4
6
8
2006
2008
2010
2012
2014
2016
Year
ln(y) = −0.2503x + 509.4
p = 0.020, Adj. R2 = 0.06
Individual Concentrations
Yearly Means
Yearly Medians

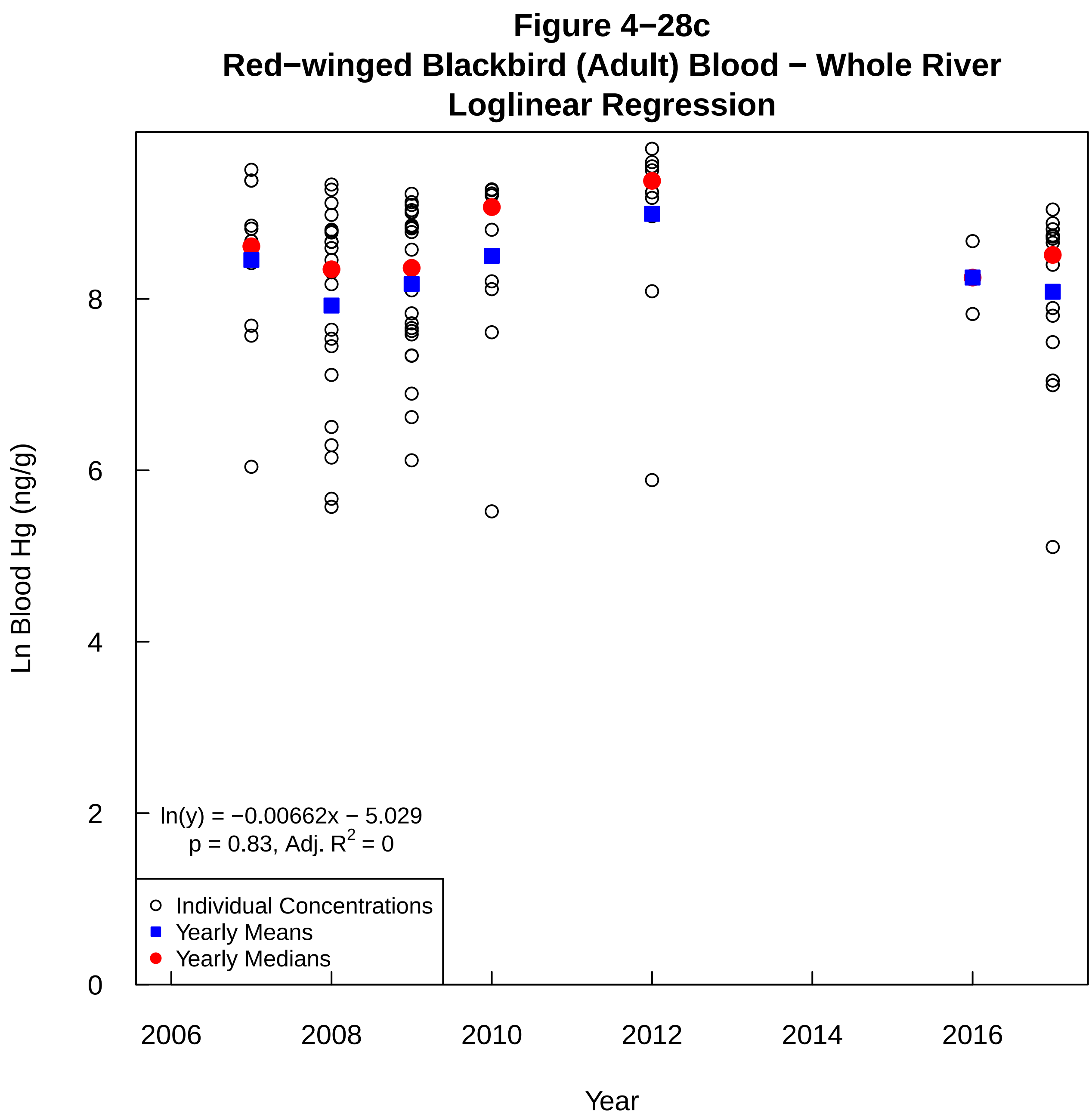


Figure 4−28c
Red−winged Blackbird (Adult) Blood − Whole River
Loglinear Regression
Ln Blood Hg (ng/g)
0
2
4
6
8
2006
2008
2010
2012
2014
2016
Year
ln(y) = −0.00662x − 5.029
p = 0.83, Adj. R2 = 0
Individual Concentrations
Yearly Means
Yearly Medians

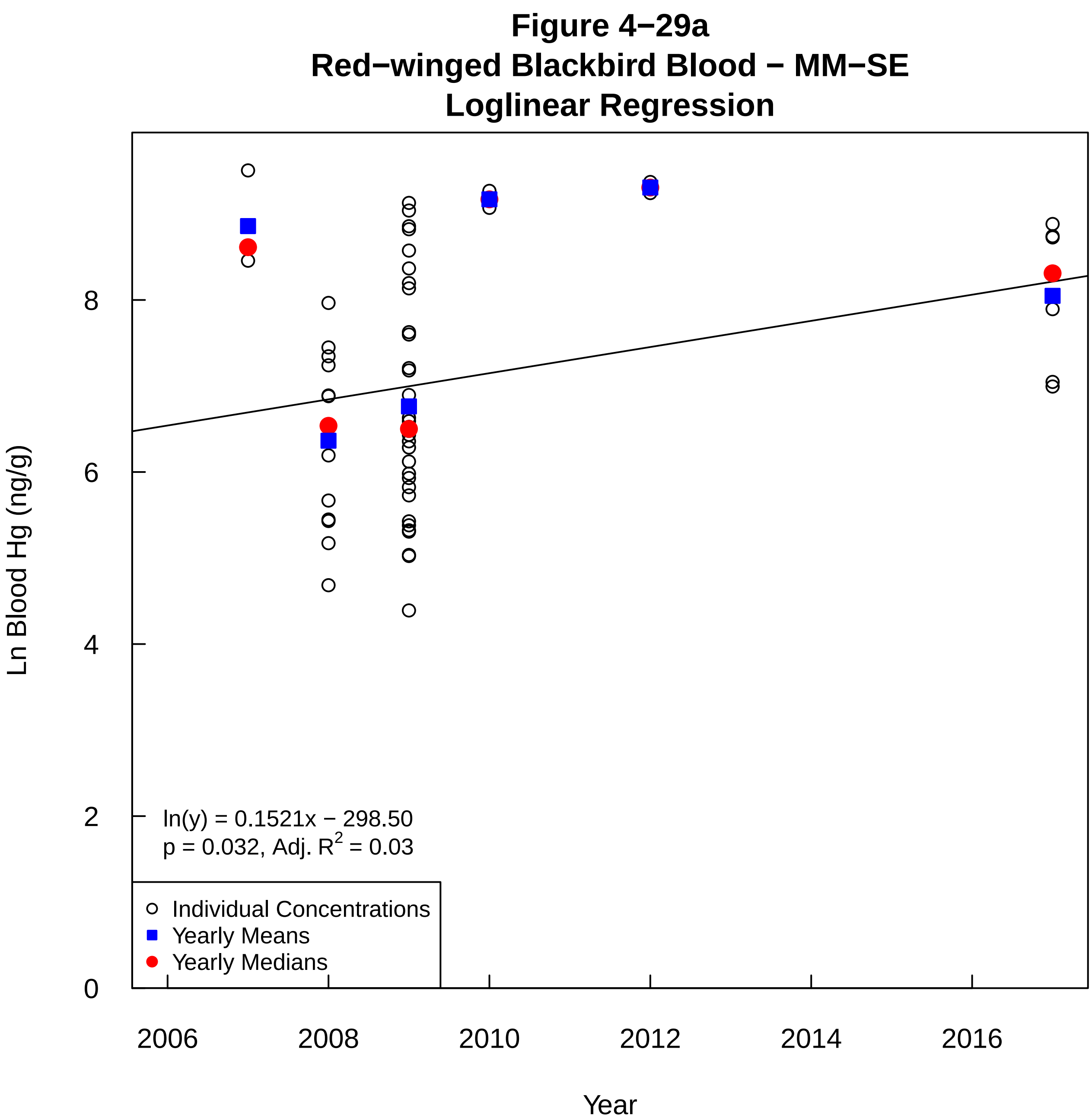


Figure 4−29a
Red−winged Blackbird Blood − MM−SE
Loglinear Regression
Ln Blood Hg (ng/g)
0
2
4
6
8
2006
2008
2010
2012
2014
2016
Year
ln(y) = 0.1521x − 298.50
p = 0.032, Adj. R2 = 0.03
Individual Concentrations
Yearly Means
Yearly Medians

Figure 4−29b
Red−winged Blackbird (Hatch Year) Blood − MM−SE
Loglinear Regression

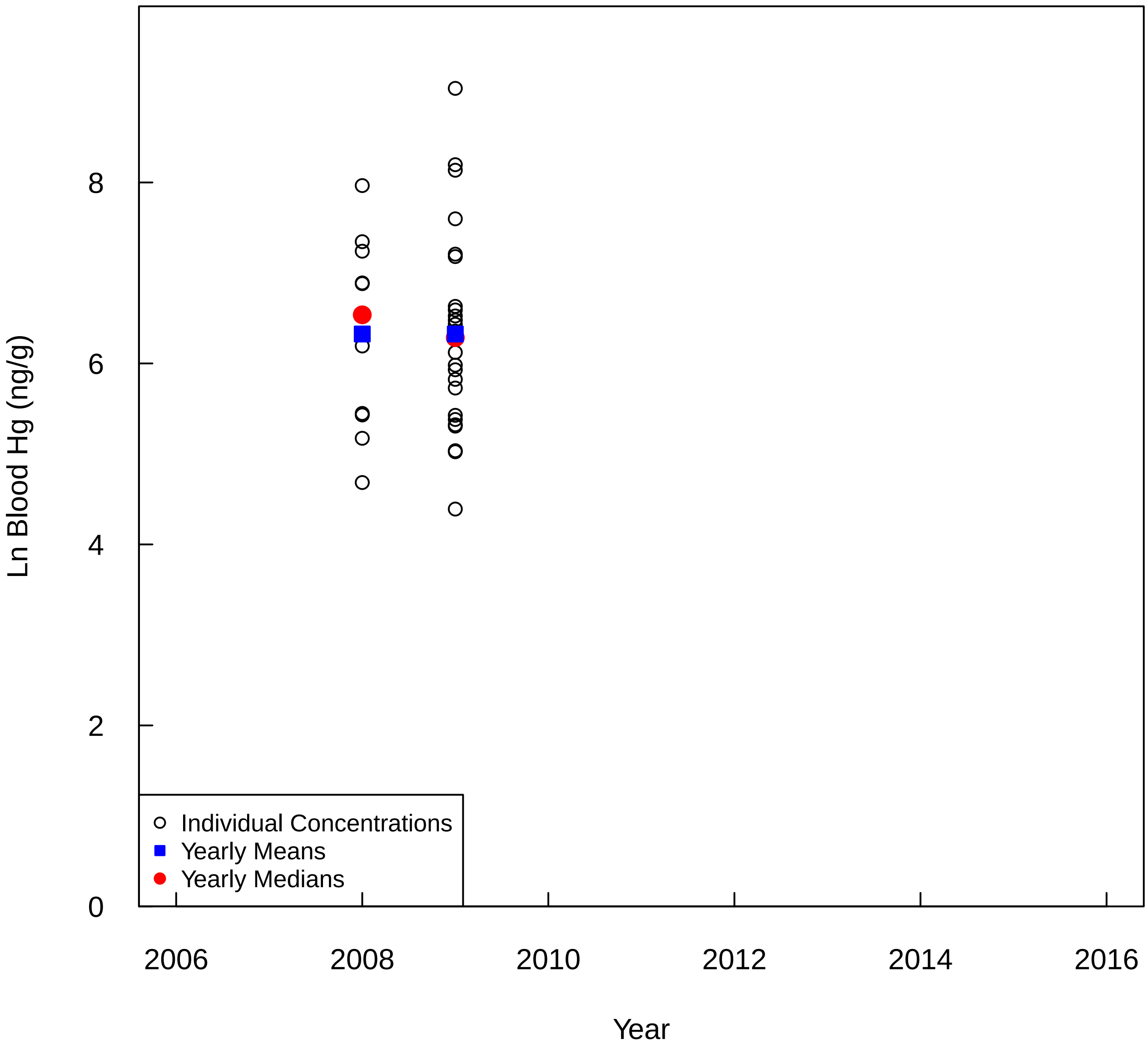
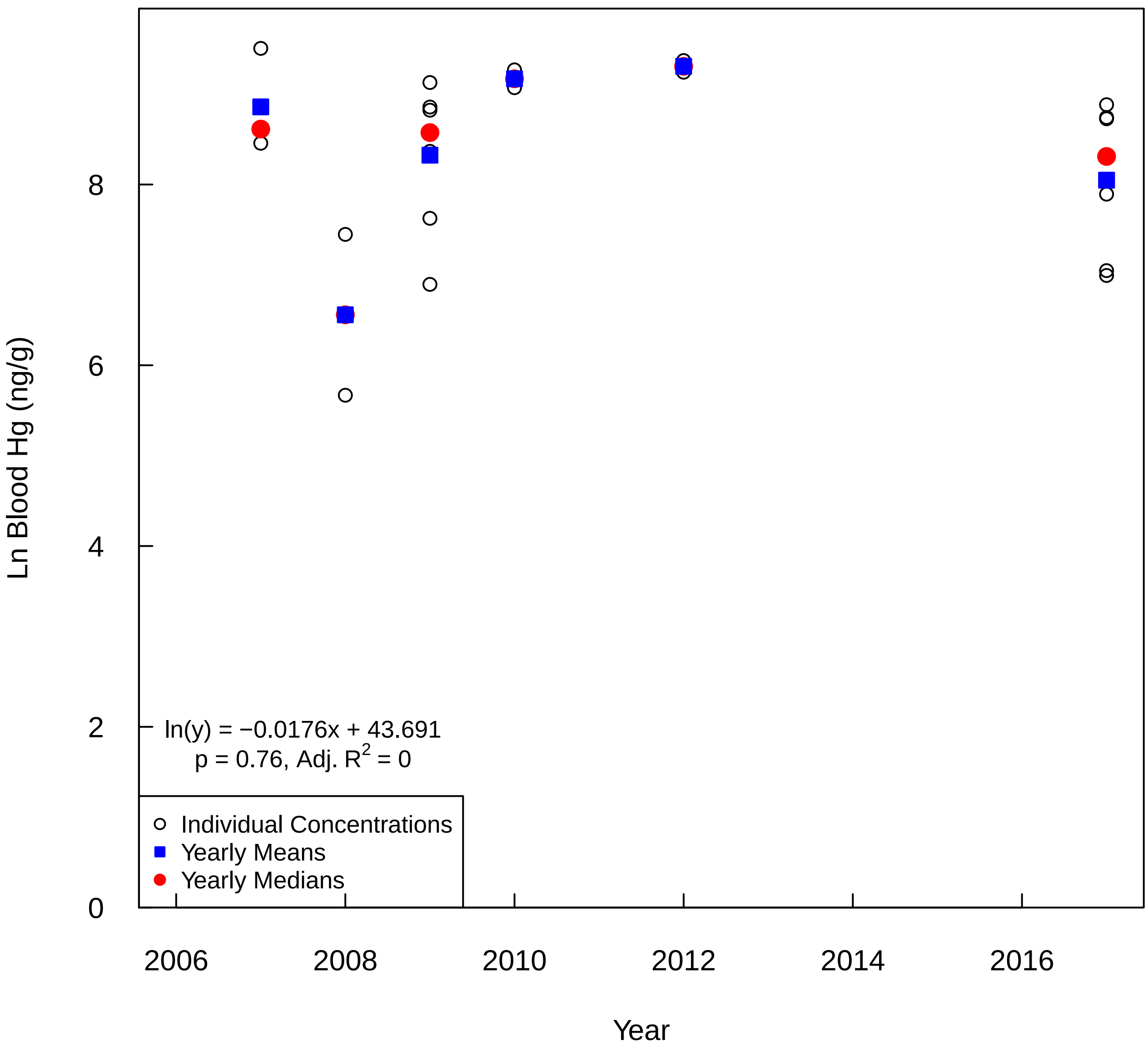


Figure 4−29c
Red−winged Blackbird (Adult) Blood − MM−SE
Loglinear Regression



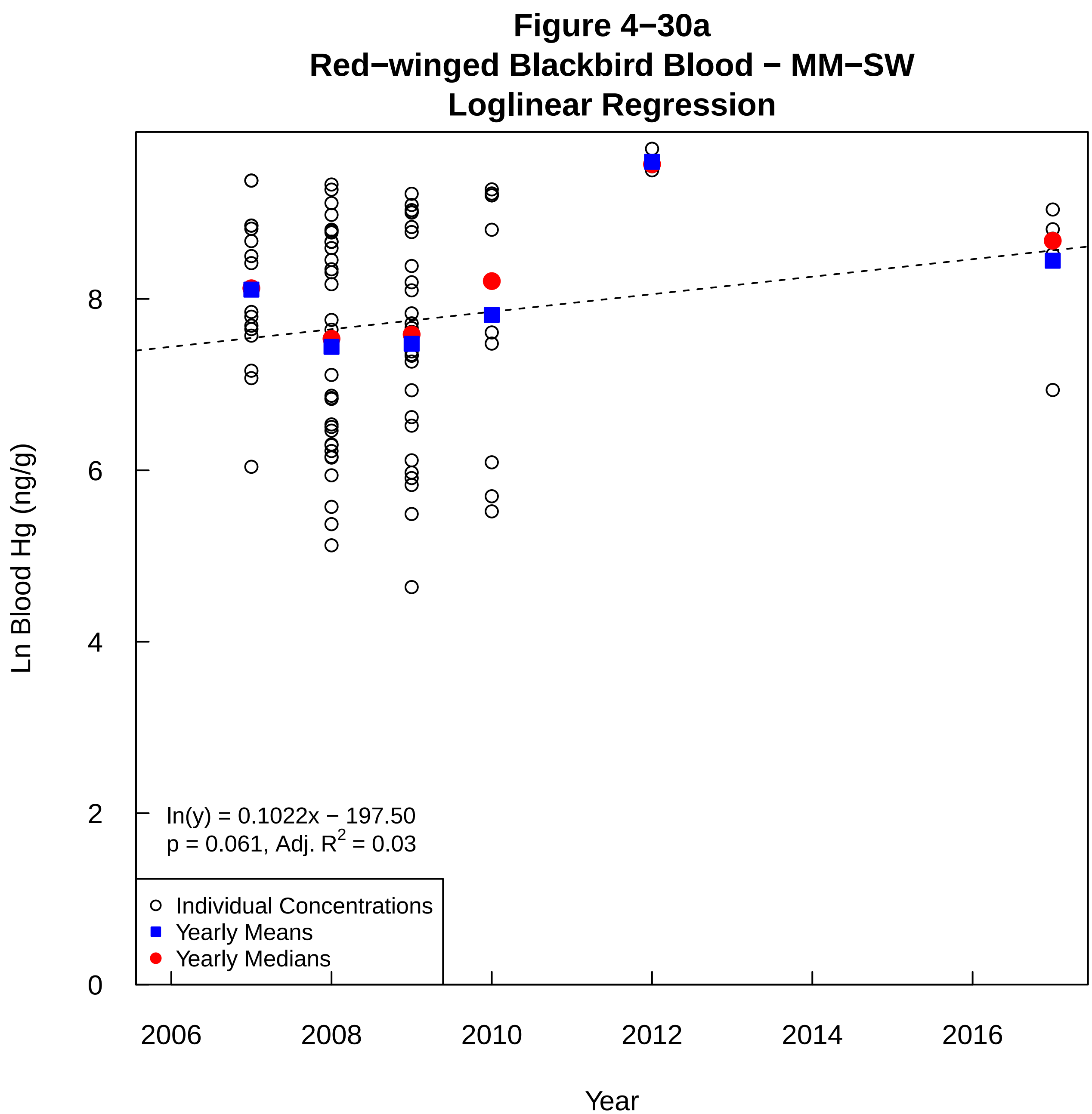
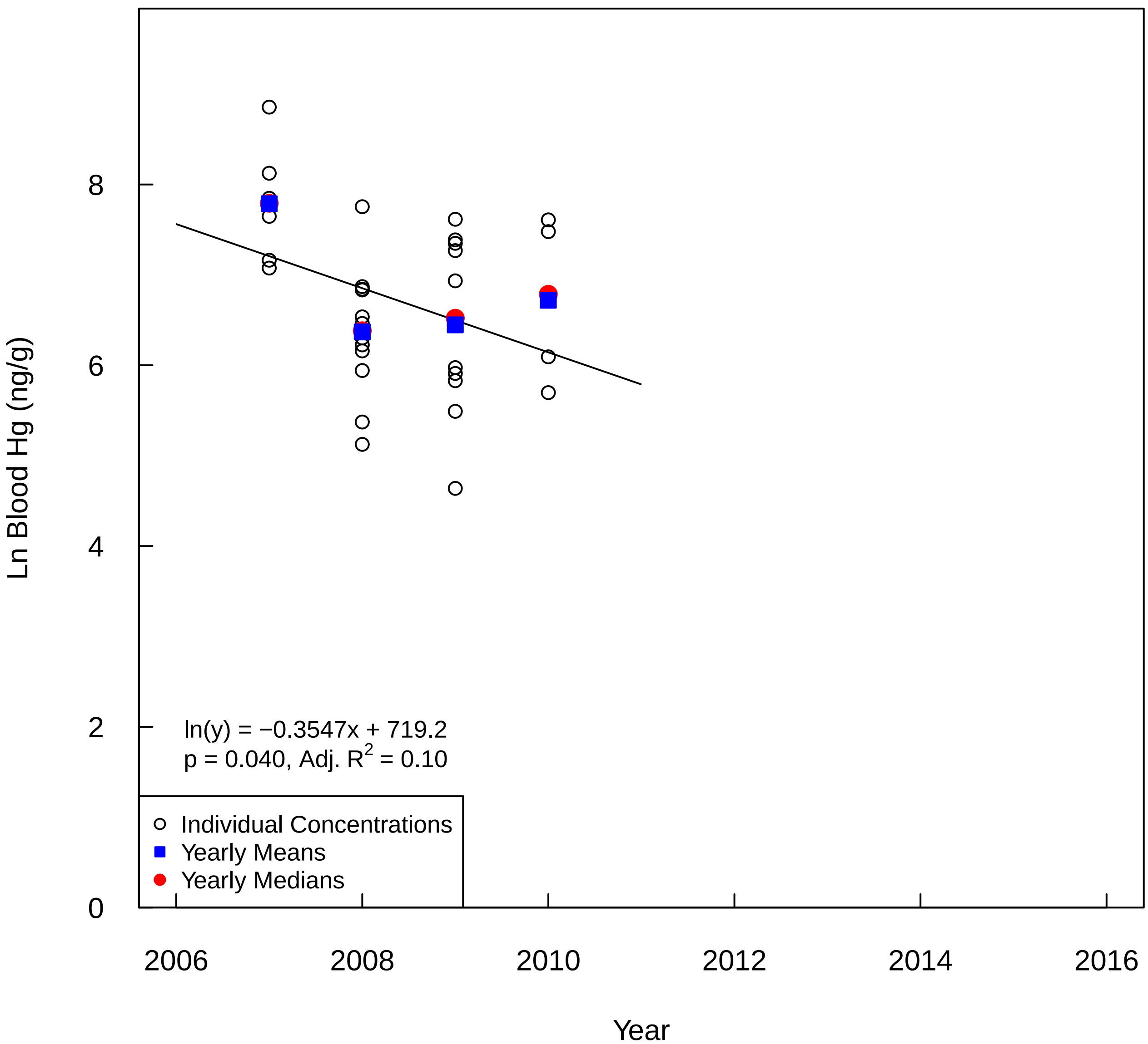


Figure 4−30a
Red−winged Blackbird Blood − MM−SW
Loglinear Regression
Ln Blood Hg (ng/g)
0
2
4
6
8
2006
2008
2010
2012
2014
2016
Year
ln(y) = 0.1022x − 197.50
p = 0.061, Adj. R2 = 0.03
Individual Concentrations
Yearly Means
Yearly Medians

**Figure 4−30b**
**Red−winged Blackbird (Hatch Year) Blood − MM−SW**
**Loglinear Regression**



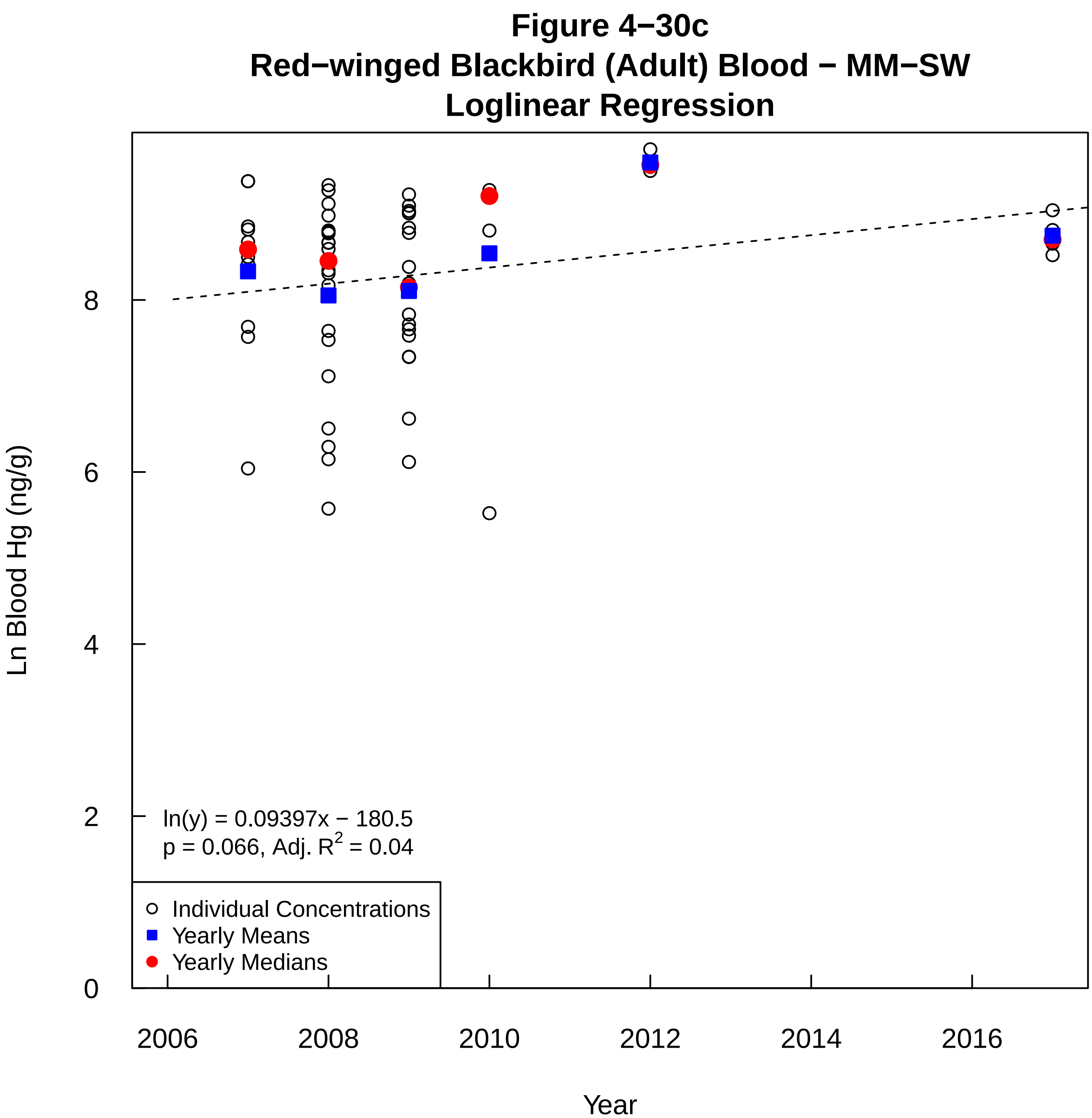


Figure 4−30c
Red−winged Blackbird (Adult) Blood − MM−SW
Loglinear Regression
Ln Blood Hg (ng/g)
0
2
4
6
8
2006
2008
2010
2012
2014
2016
Year
ln(y) = 0.09397x − 180.5
p = 0.066, Adj. R2 = 0.04
Individual Concentrations
Yearly Means
Yearly Medians

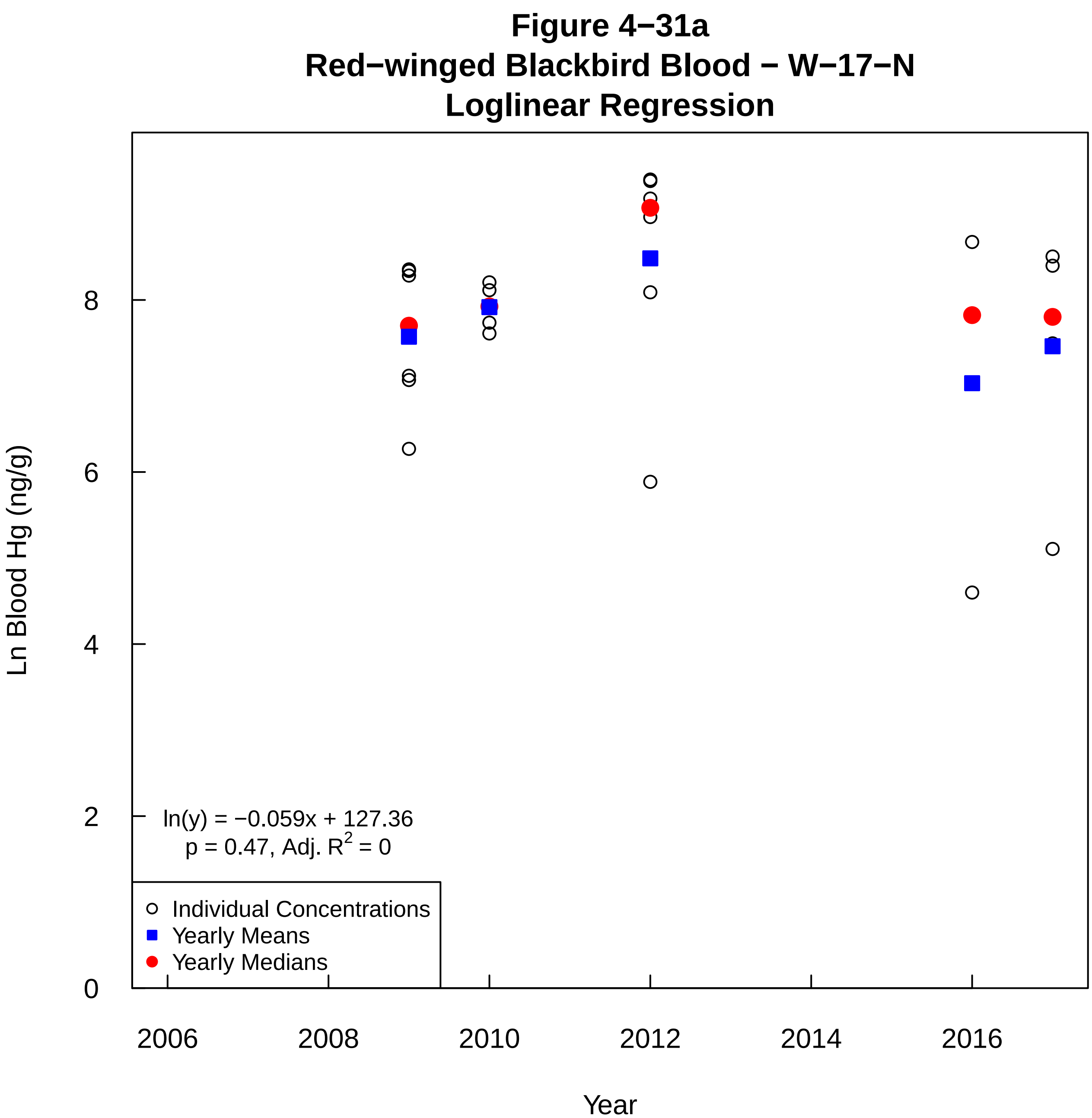


Figure 4−31a
Red−winged Blackbird Blood − W−17−N
Loglinear Regression
Ln Blood Hg (ng/g)
Year
0
2
4
6
8
2006
2008
2010
2012
2014
2016
ln(y) = −0.059x + 127.36
p = 0.47, Adj. R2 = 0
Individual Concentrations
Yearly Means
Yearly Medians

**Figure 4−31b**
**Red−winged Blackbird (Hatch Year) Blood − W−17−N**
**Loglinear Regression**

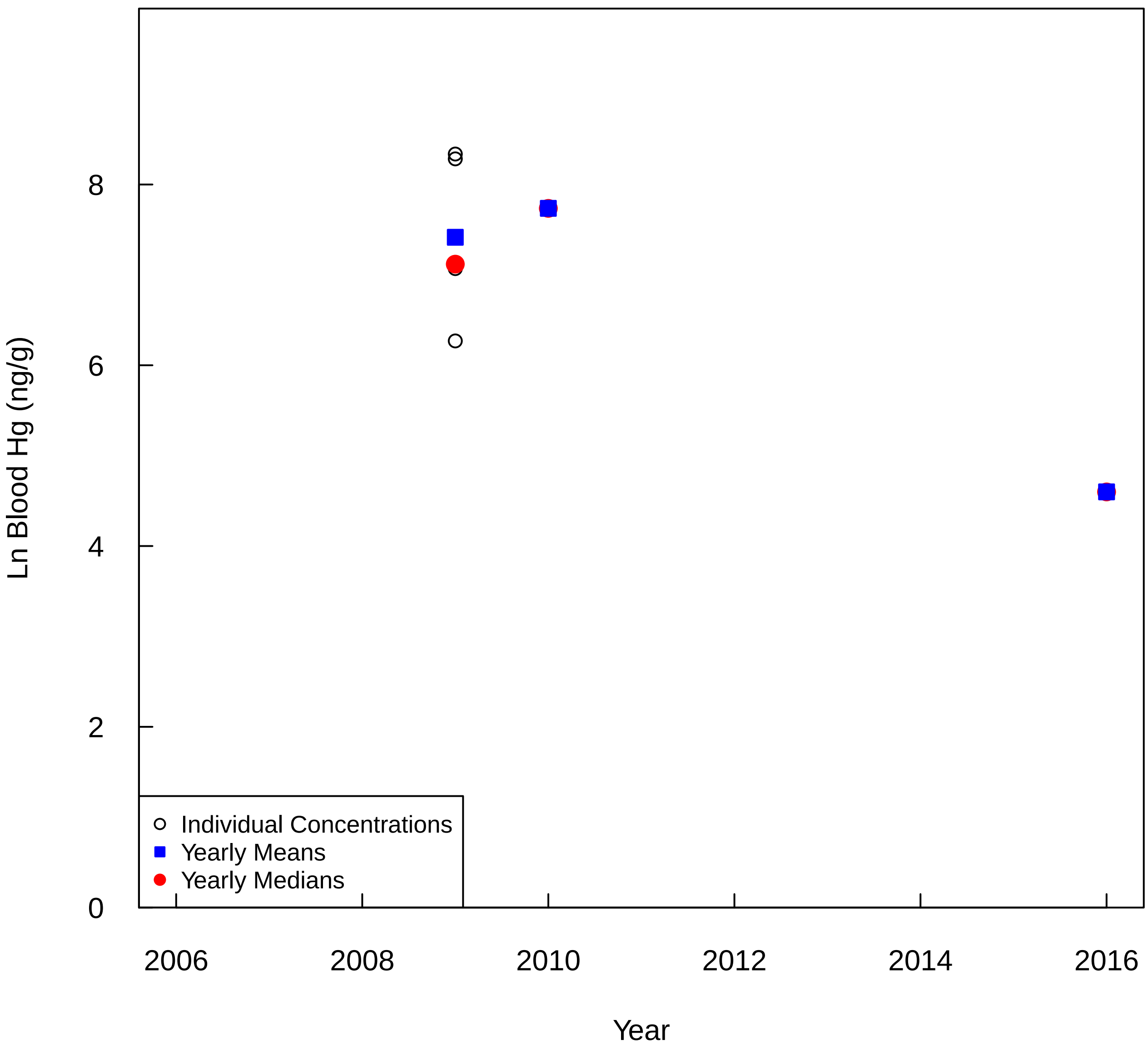


Figure 4−31c
Red−winged Blackbird (Adult) Blood − W−17−N
Loglinear Regression

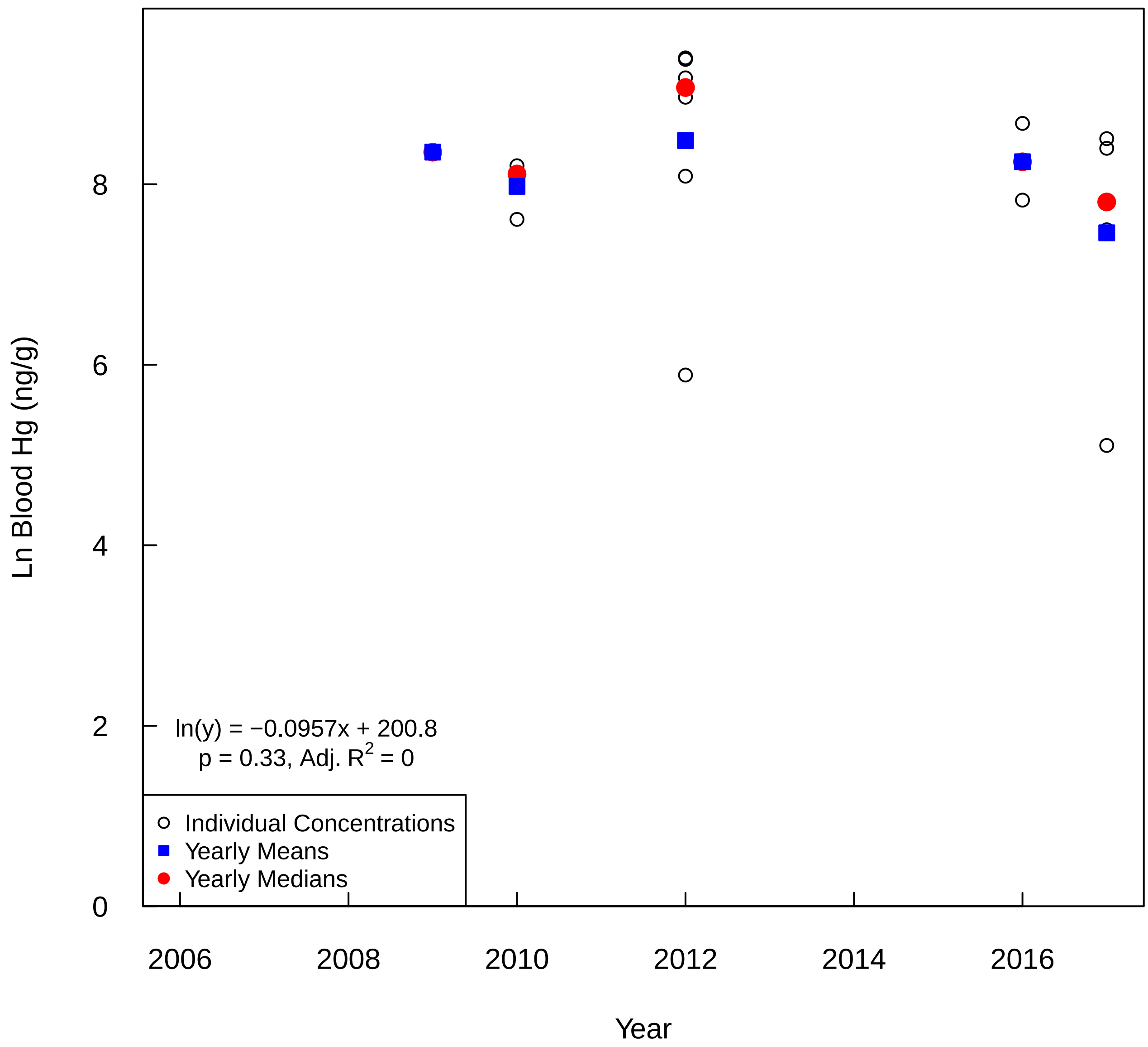


**Figure 4−32a**
**Red−winged Blackbird Mercury Concentrations in each Month**

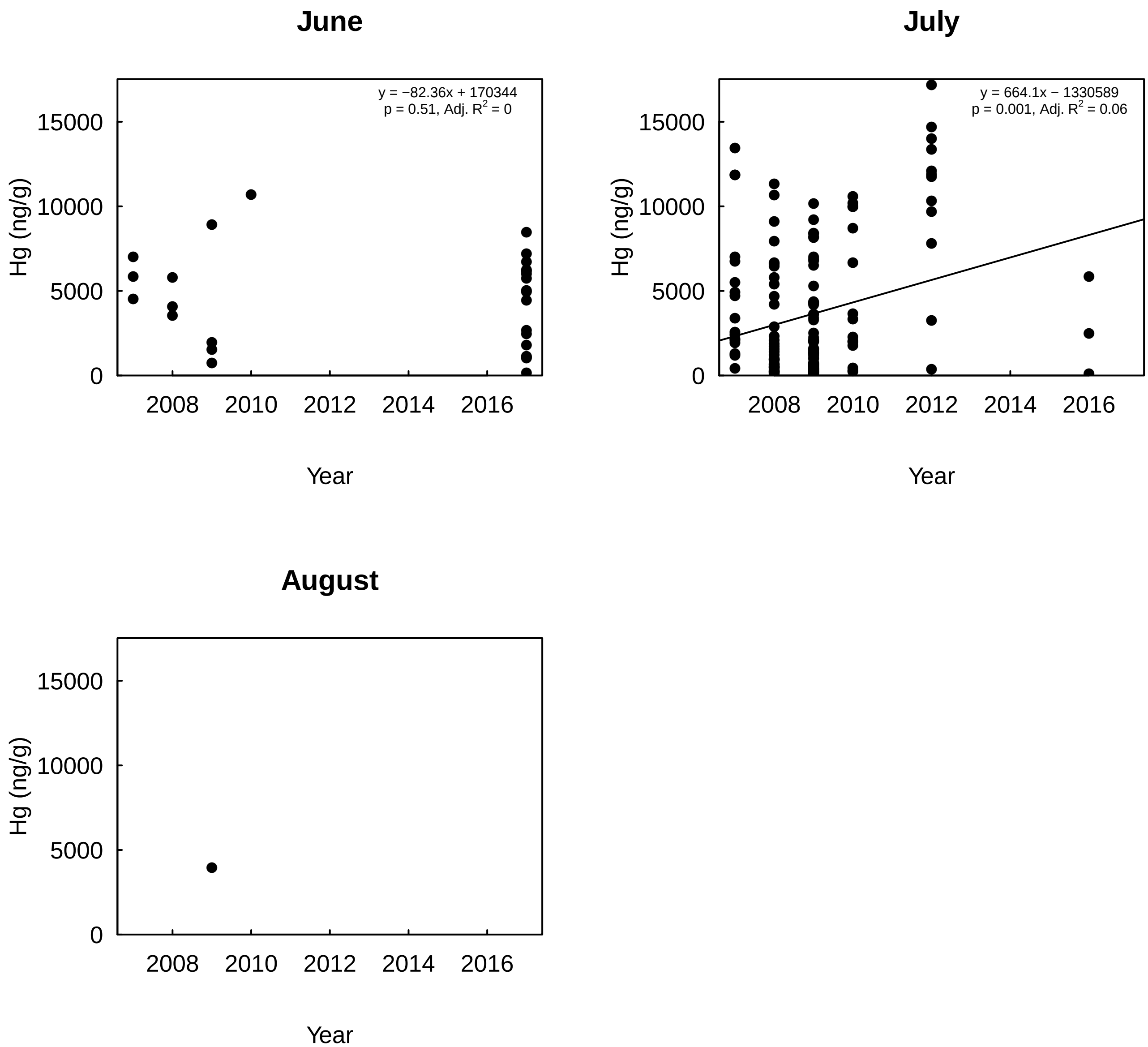
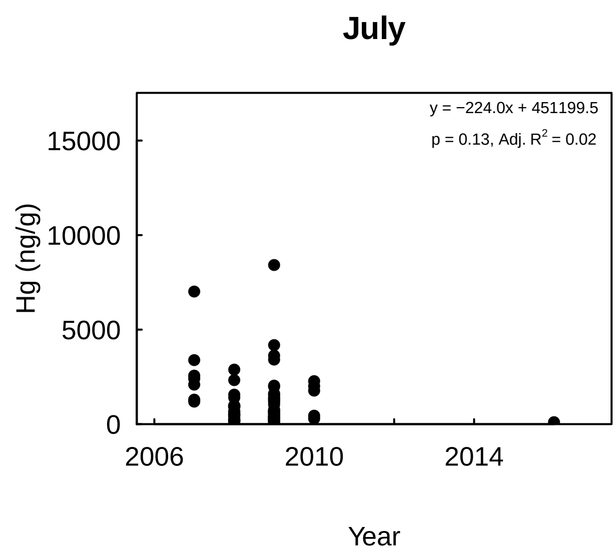


**Figure 4−32b**
**Red−winged Blackbird (Hatch Year) Mercury Concentrations in each Month**

No hatch year birds collected in June



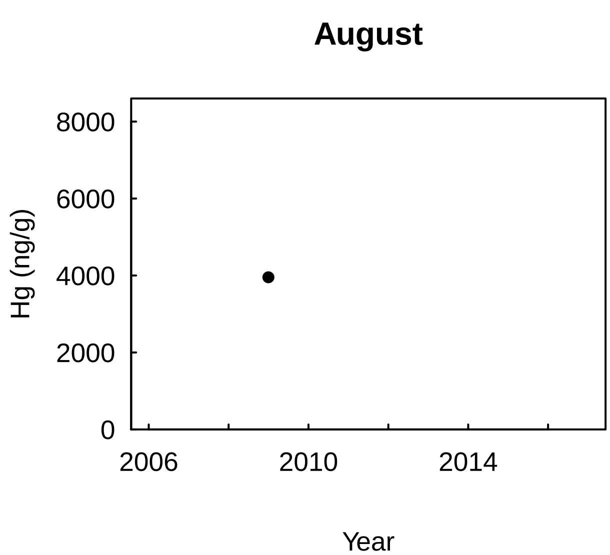
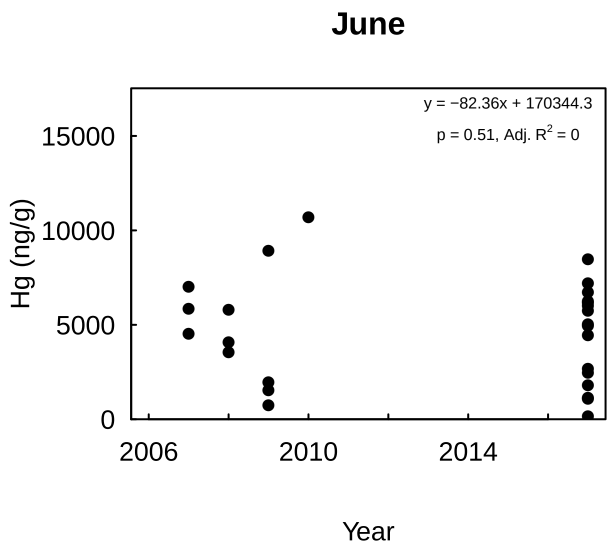
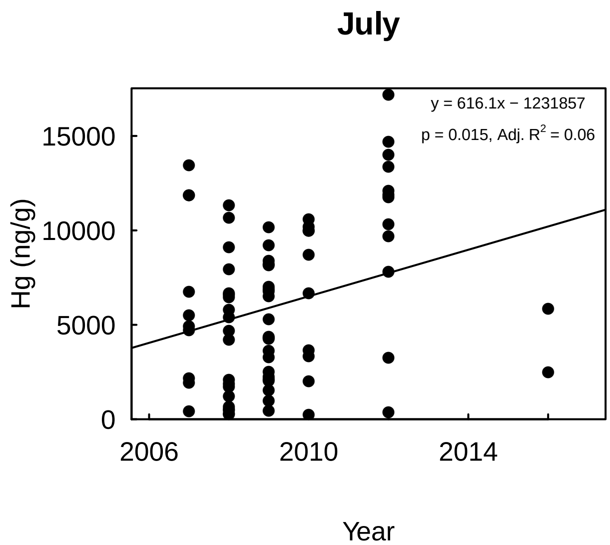



**Figure 4−32c**
**Red−winged Blackbird (Adult) Mercury Concentrations in each Month**




No hatch year birds collected in August

**Figure 4−33**
**American Black Duck Blood − Frenchman Bay (Reference)**
**Loglinear Regression**

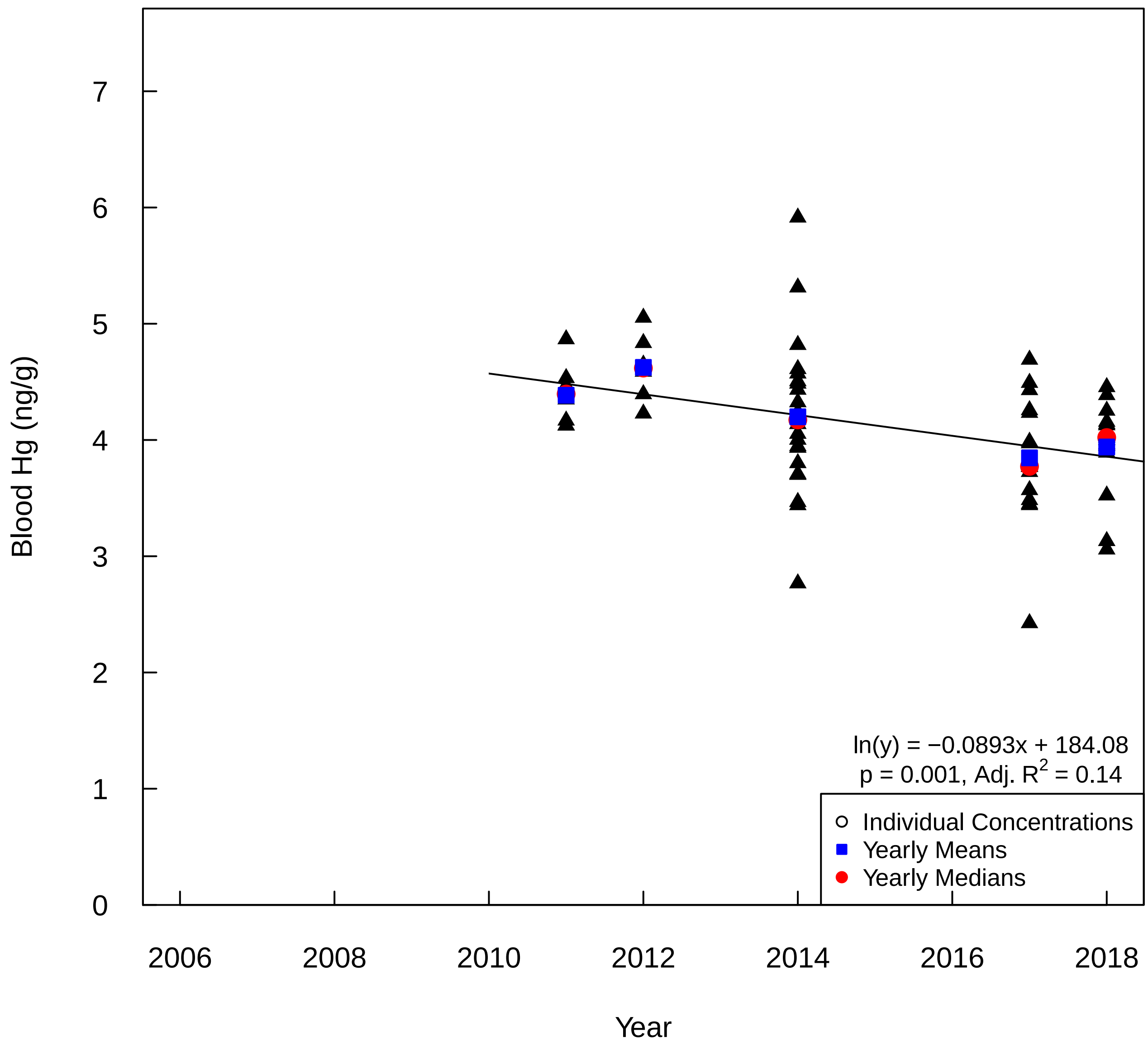
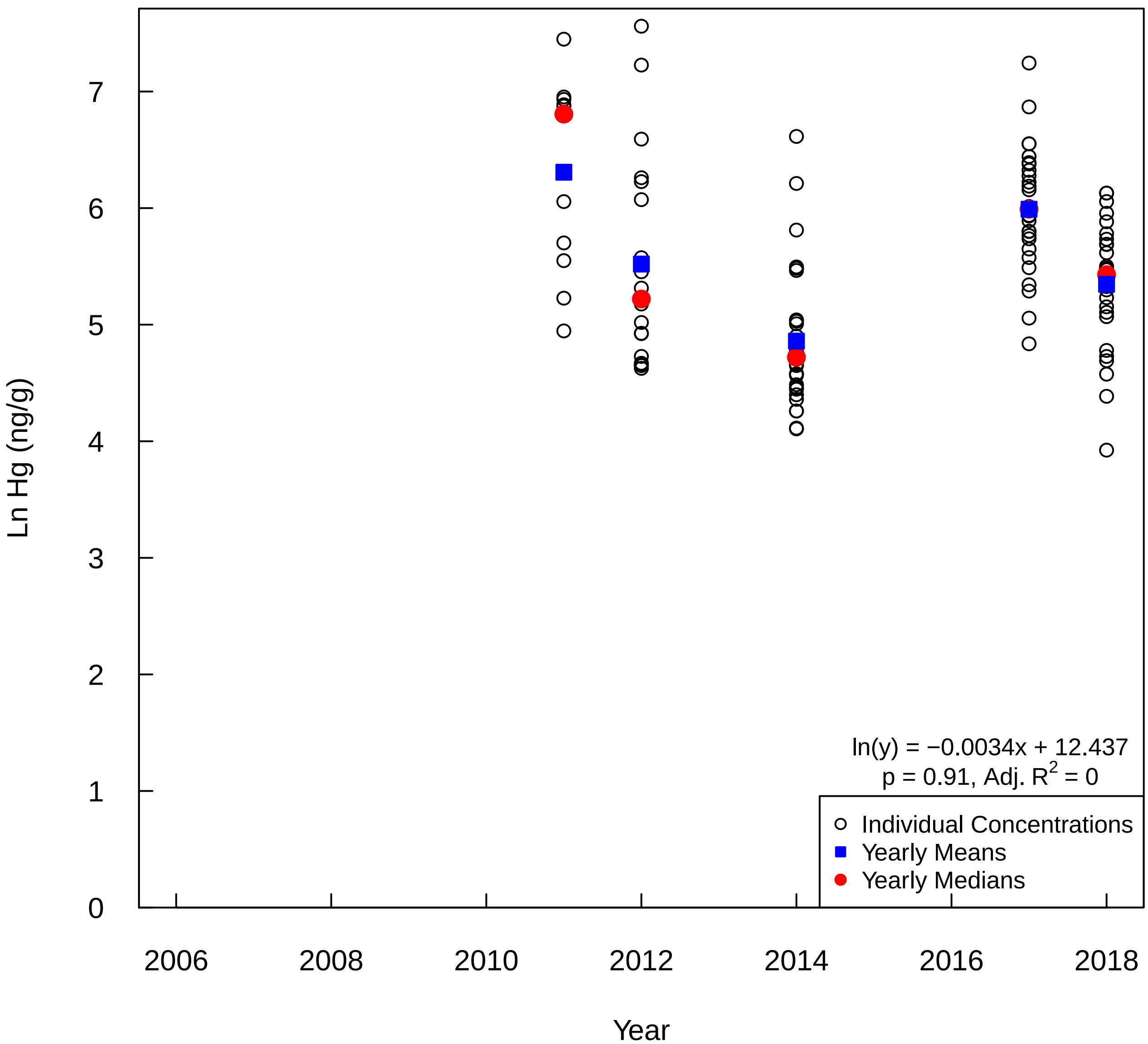


**Figure 4−34**
**American Black Duck Blood − Whole River**
**Loglinear Regression**




Includes American Black Ducks sampled at Mendall Marsh and South Verona

**Figure 4−35**
**American Black Duck Blood − Mendall Marsh**
**Loglinear Regression**

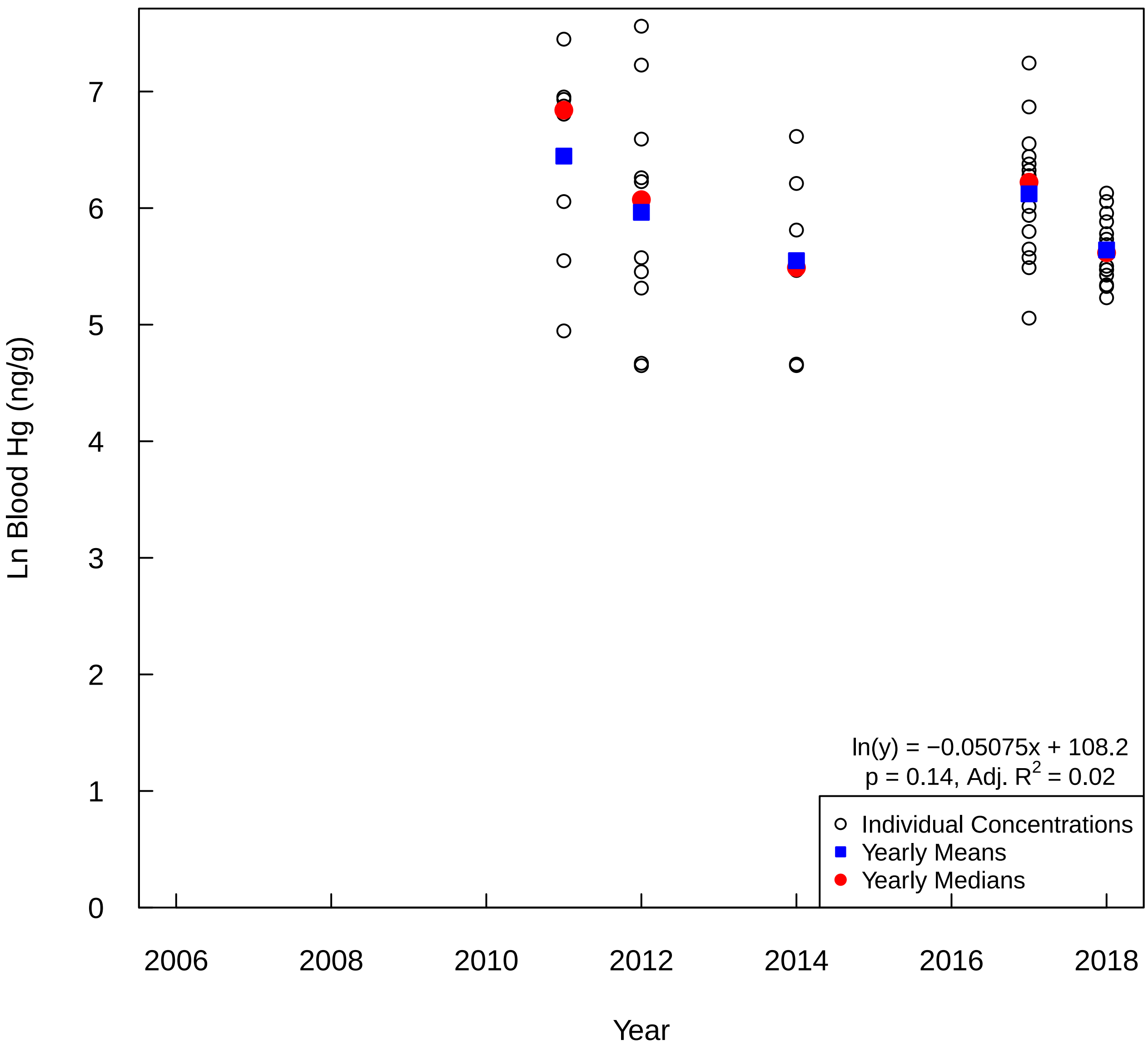
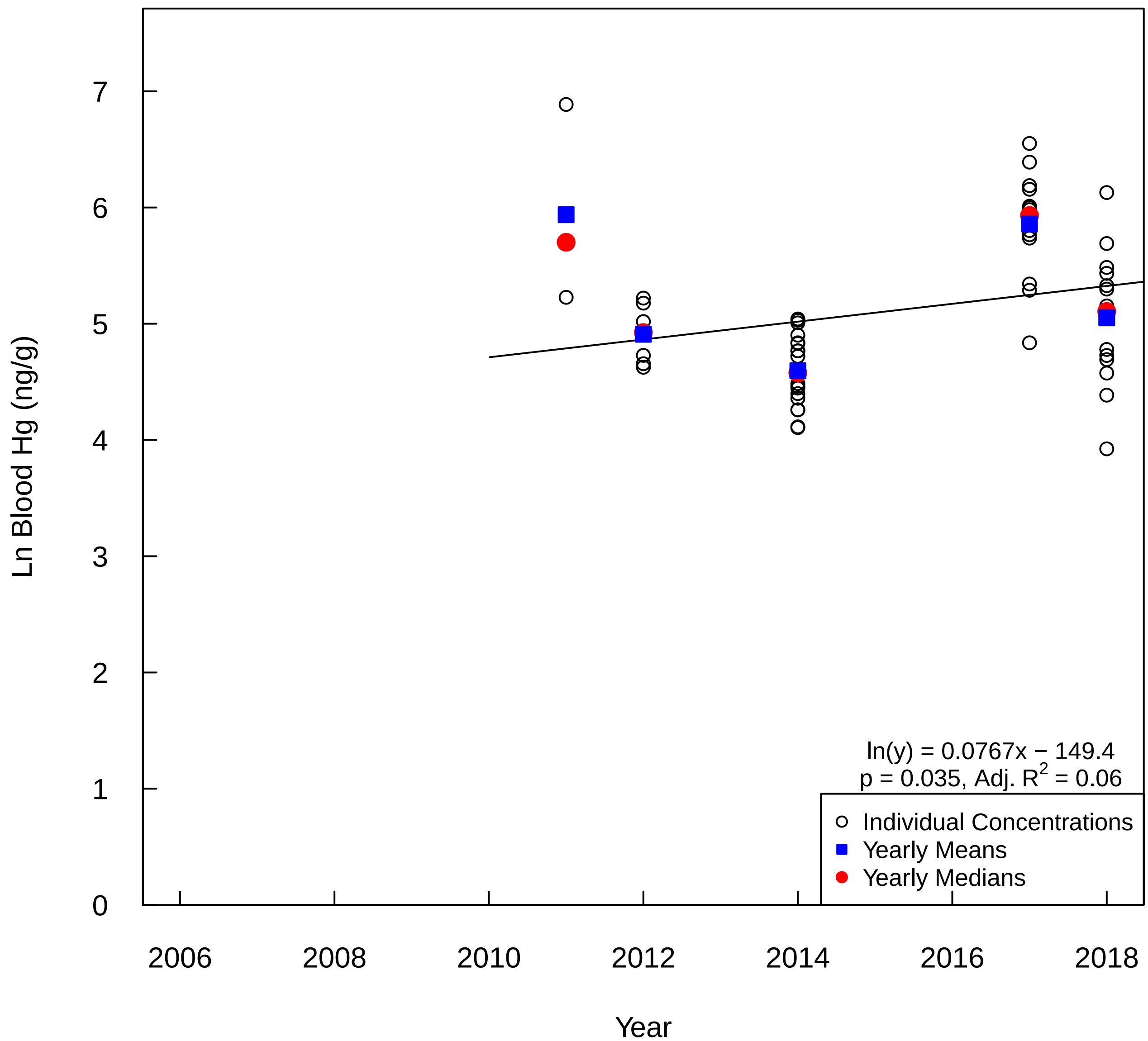
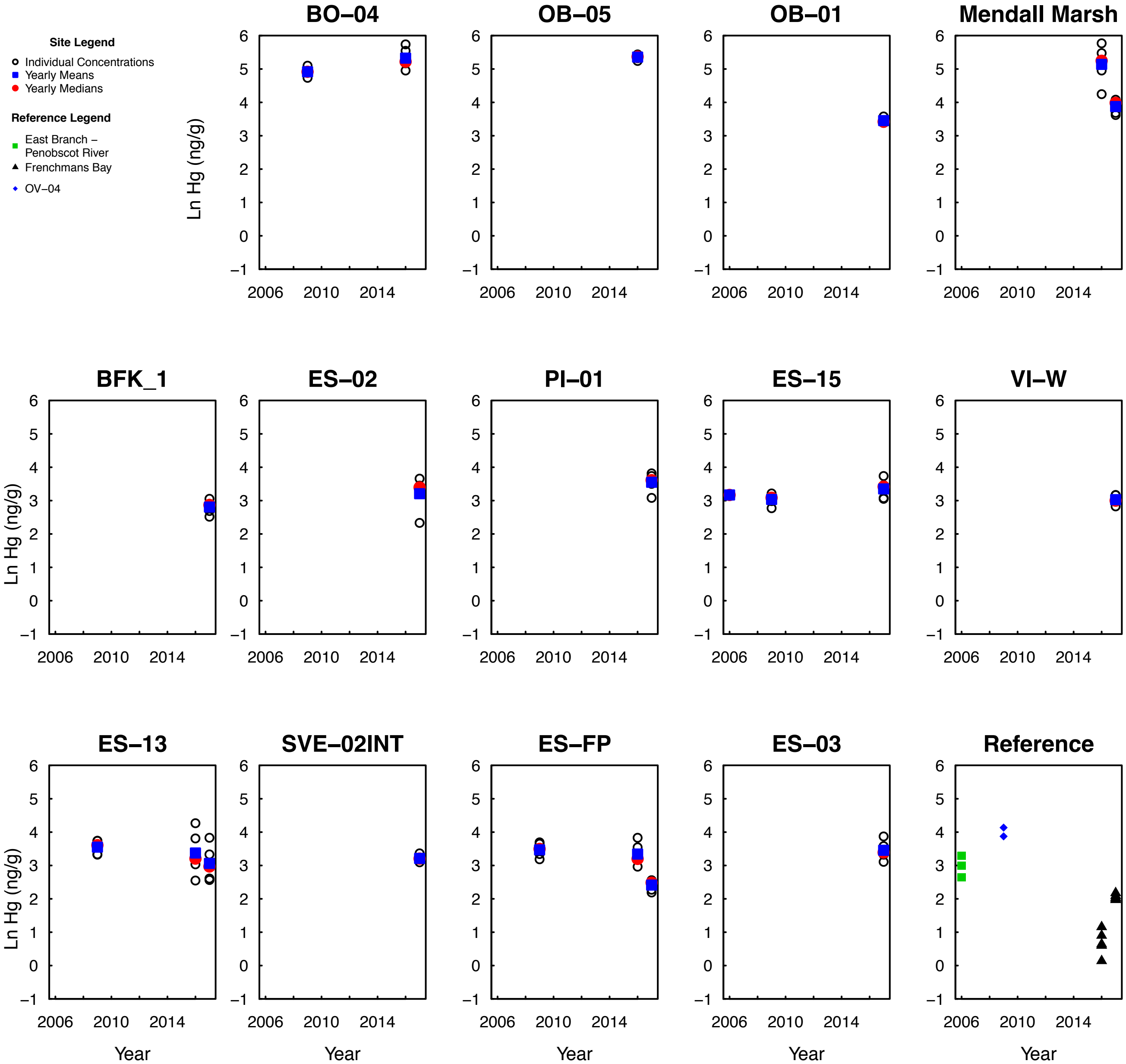


**Figure 4−36**
**American Black Duck Blood − South Verona**
**Loglinear Regression**



## Figure 4–37
## Polychaete Ln Mercury Concentrations



## Figure 4–38
## Polychaete Ln Methyl Mercury Concentrations

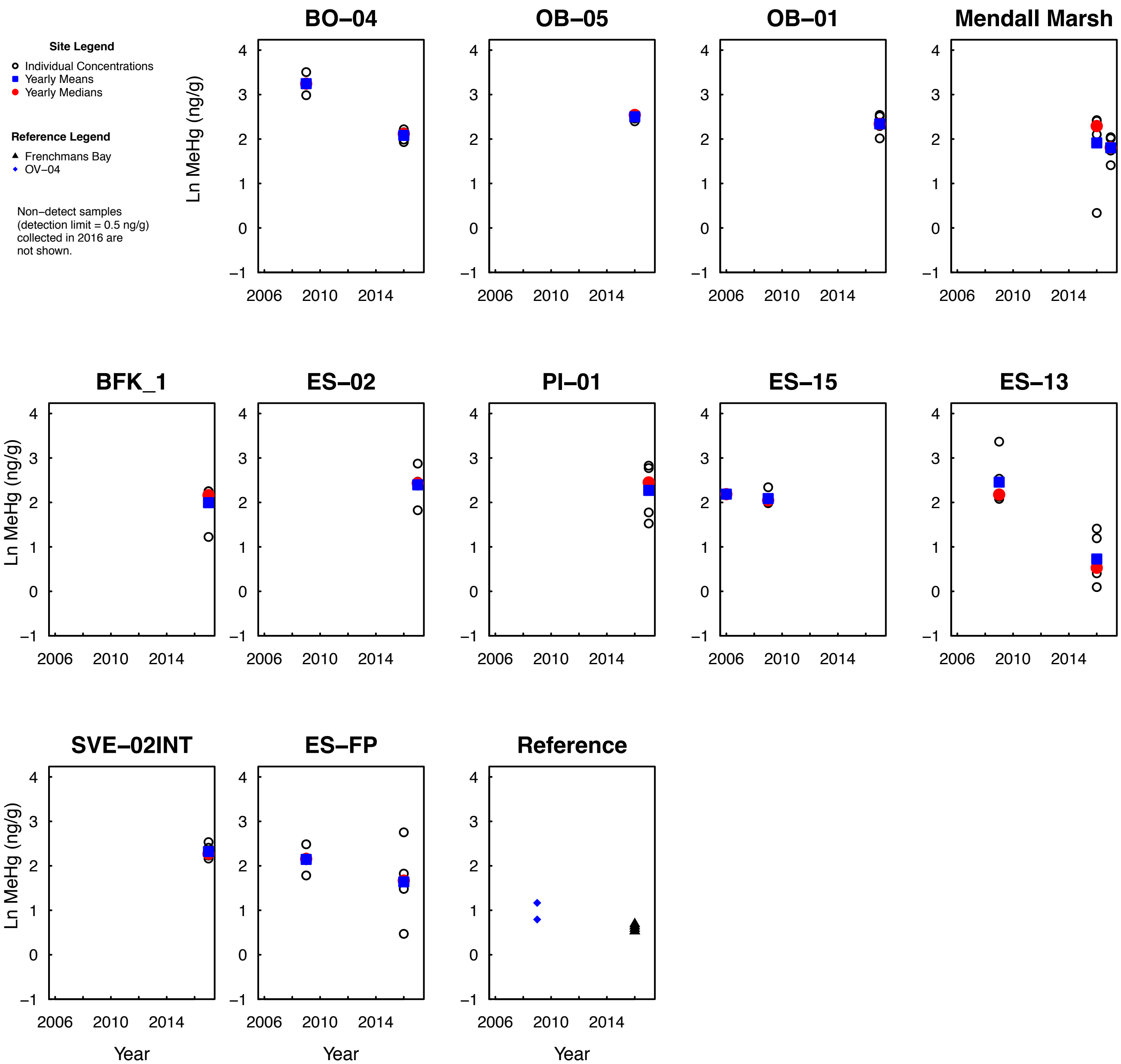


**Figure 4–39**
**Blue Mussel – Reference Locations**
**Ln Mercury Concentrations**

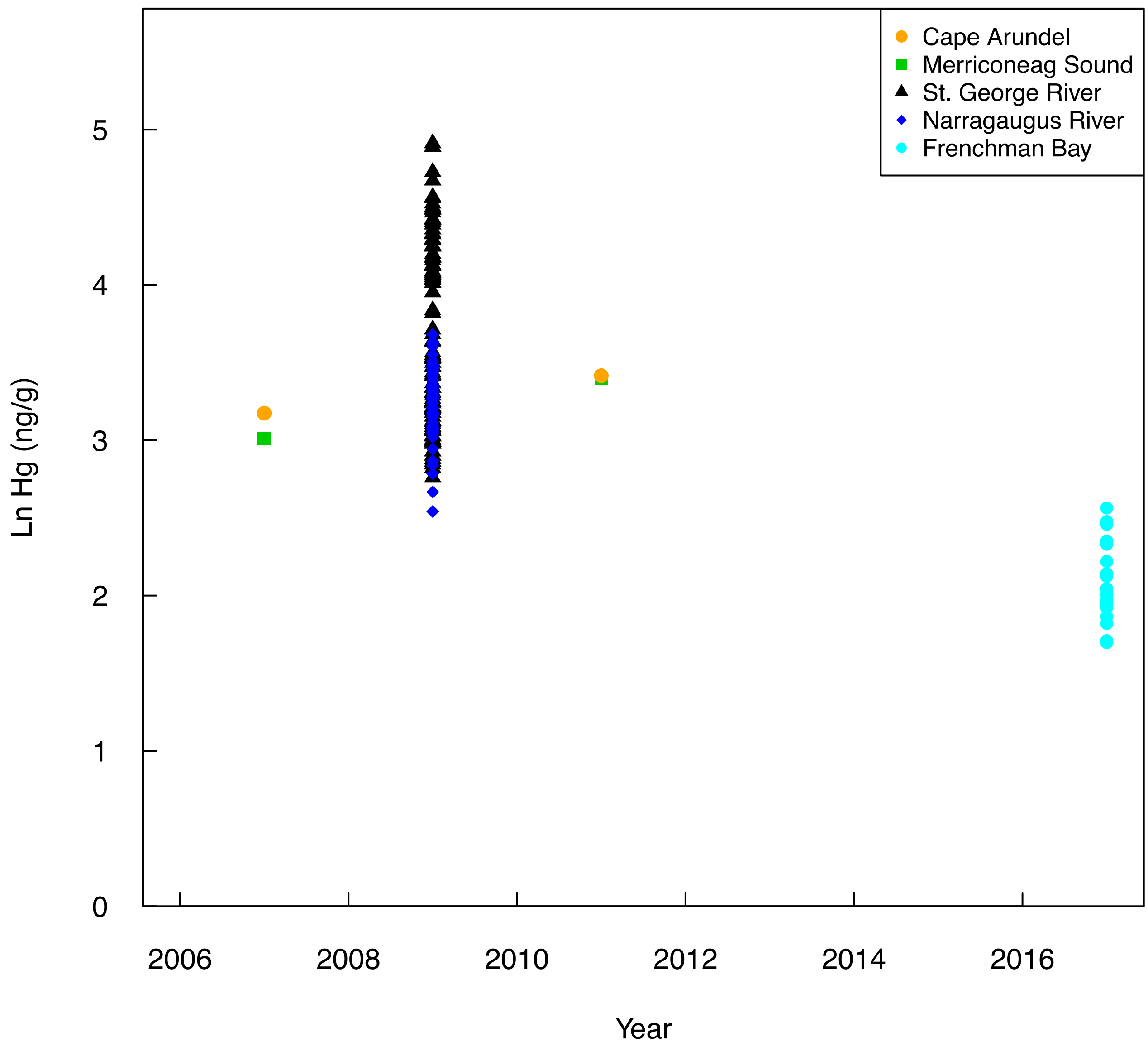
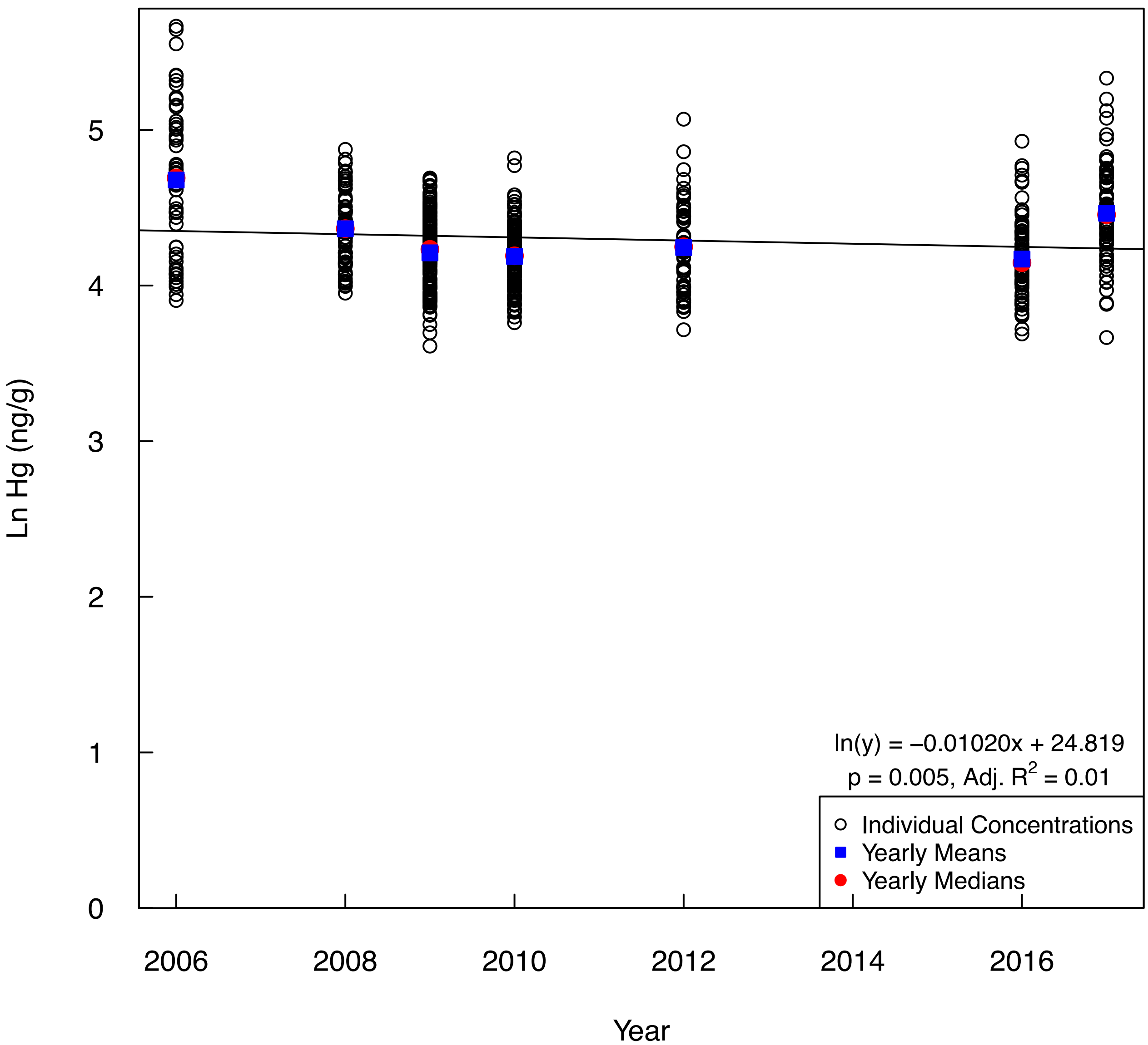


**Figure 4–40**
**Blue Mussel – Whole River**
**Loglinear Regression**




Includes Blue Mussel sampled at ES−13, ES−15, ES−03, and ES−FP

**Figure 4–41**
**Blue Mussel – ES–15**
**Loglinear Regression**

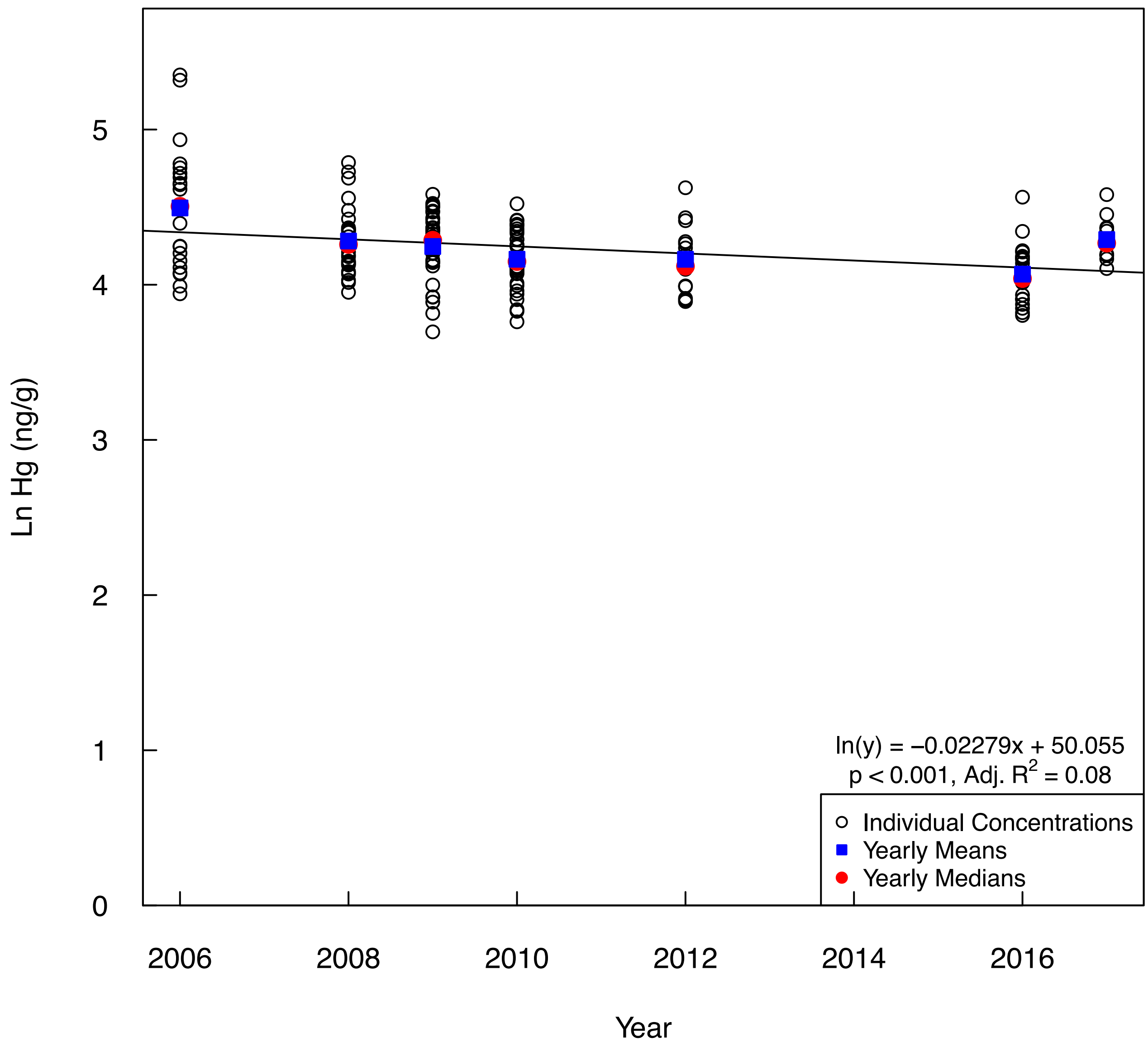
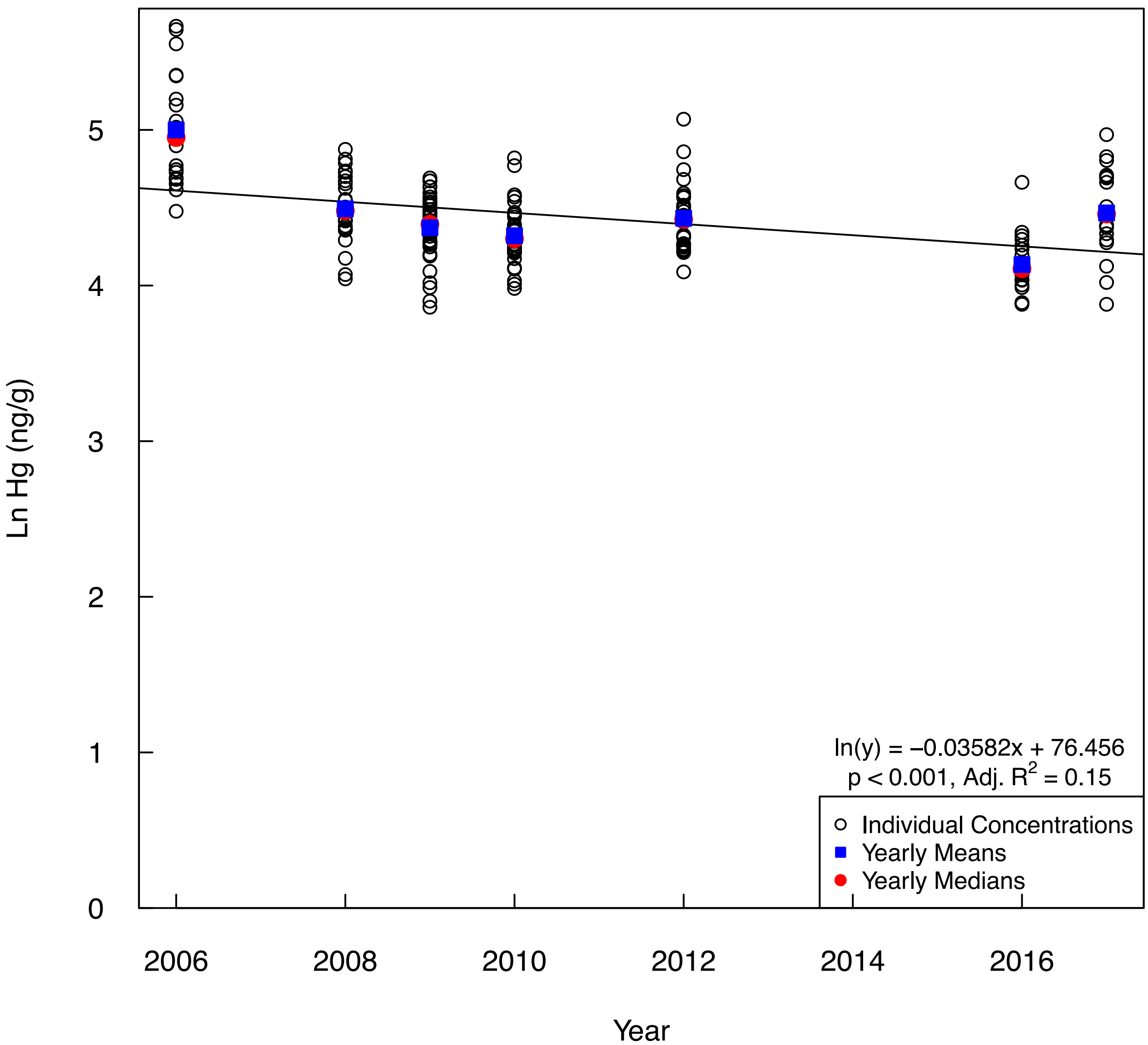


**Figure 4–42**
**Blue Mussel – ES–13**
**Loglinear Regression**



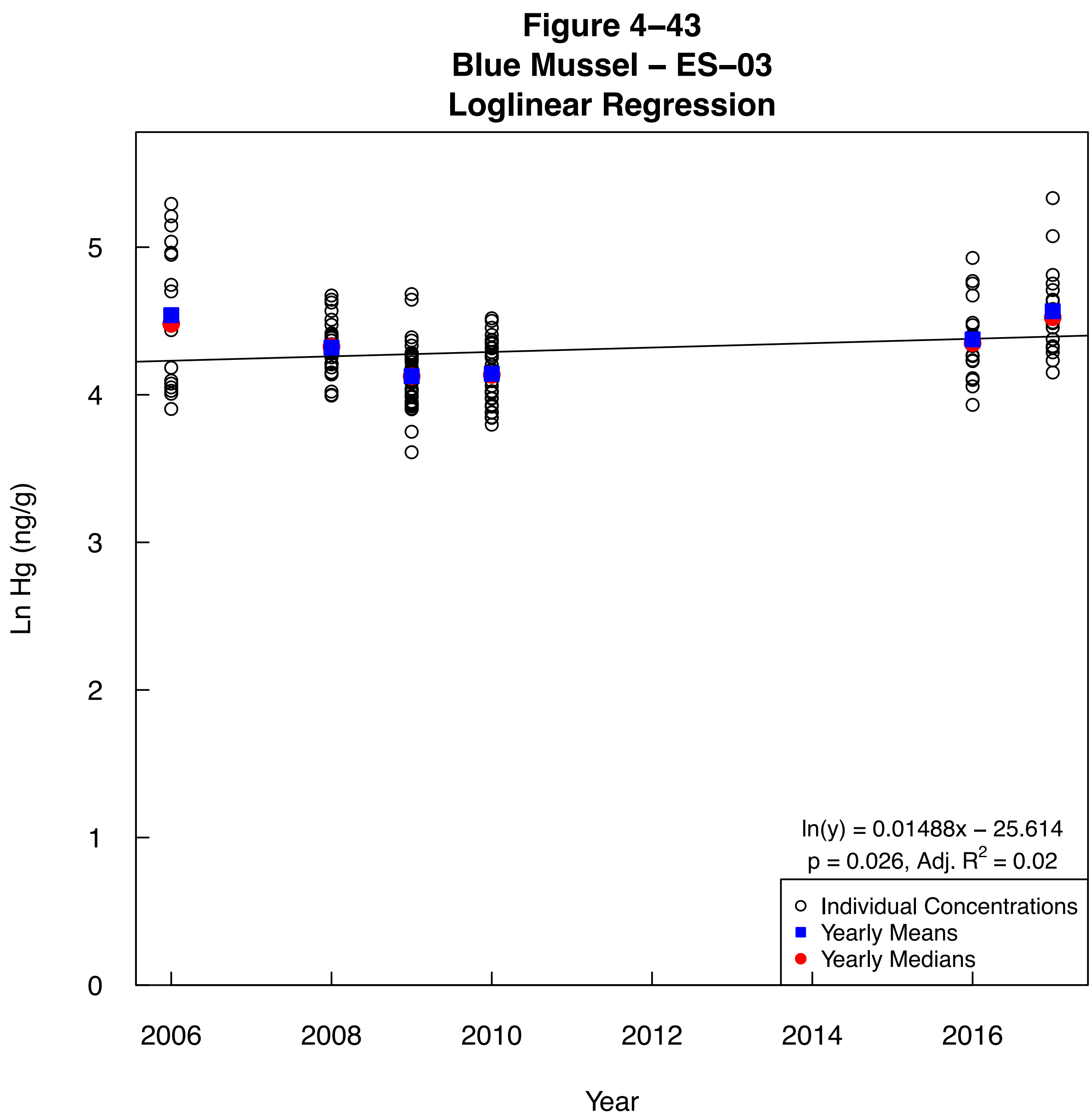


Figure 4–43
Blue Mussel – ES–03
Loglinear Regression
Ln Hg (ng/g)
0
1
2
3
4
5
2006
2008
2010
2012
2014
2016
Year
ln(y) = 0.01488x – 25.614
p = 0.026, Adj. R2 = 0.02
Individual Concentrations
Yearly Means
Yearly Medians

**Figure 4–44**
**Blue Mussel – ES–FP**
**Loglinear Regression**

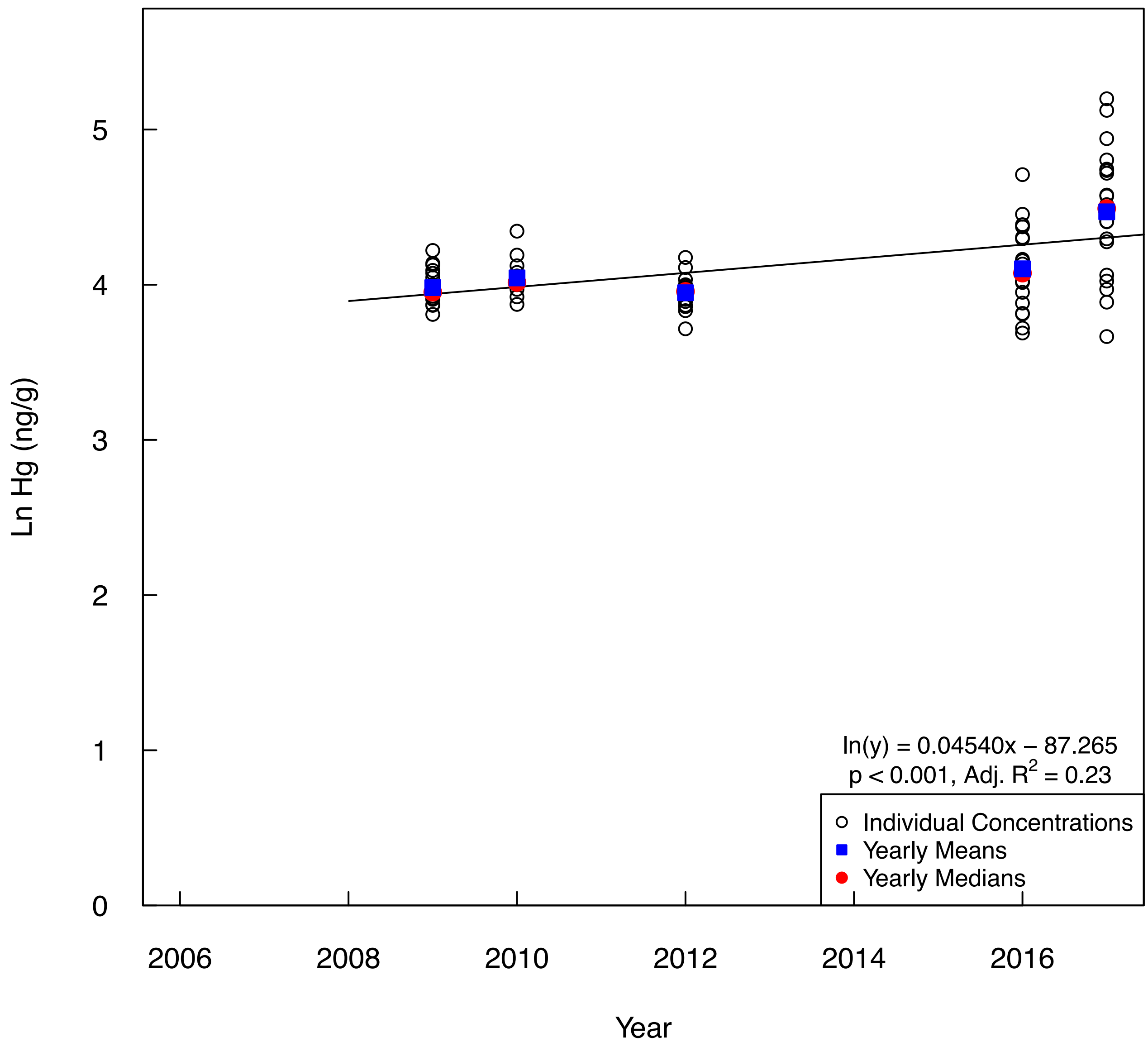


**Figure 4–45**
**Lobster Tail – Frenchman Bay**
**Length Adjusted Ln Mercury Concentrations**

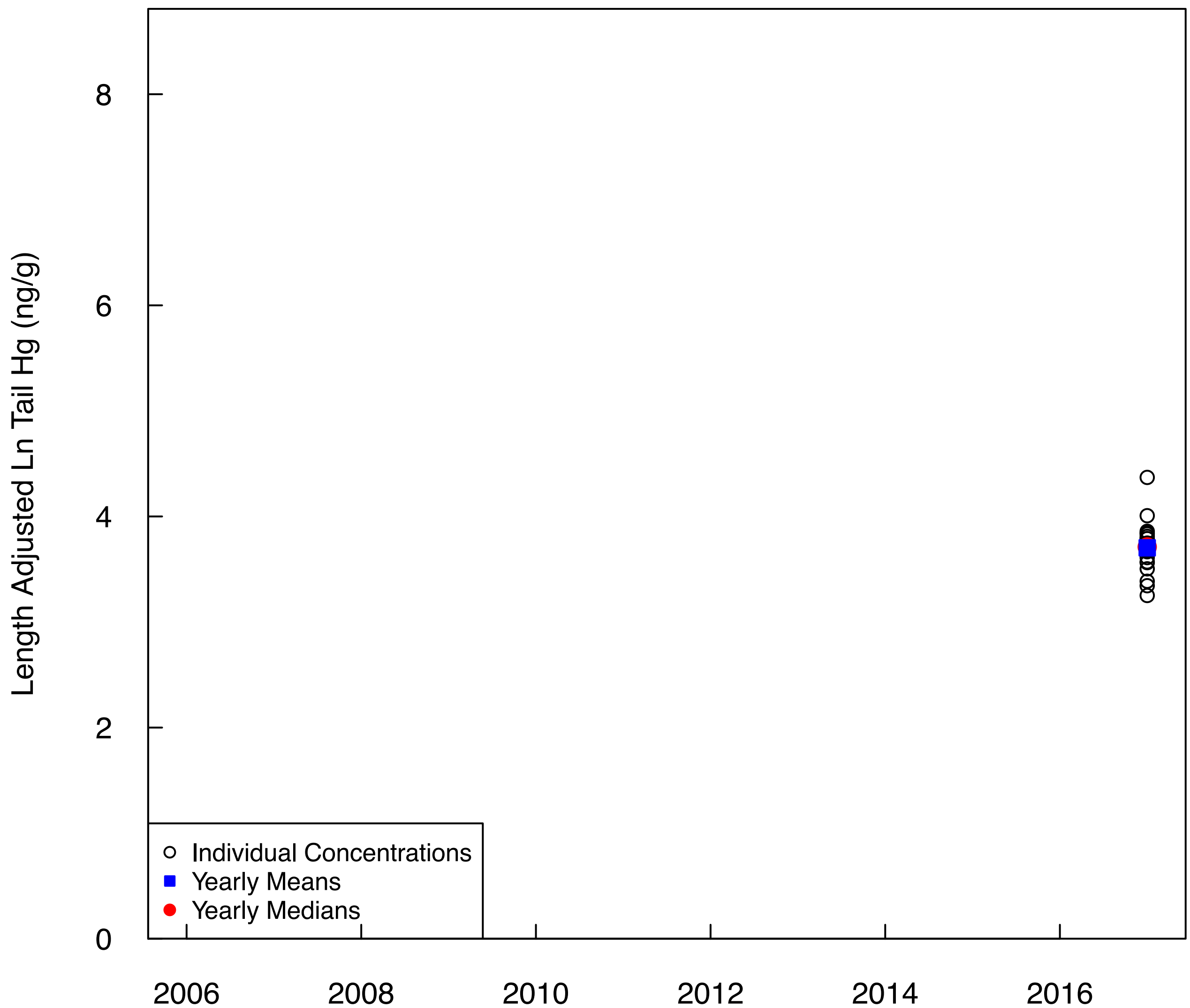
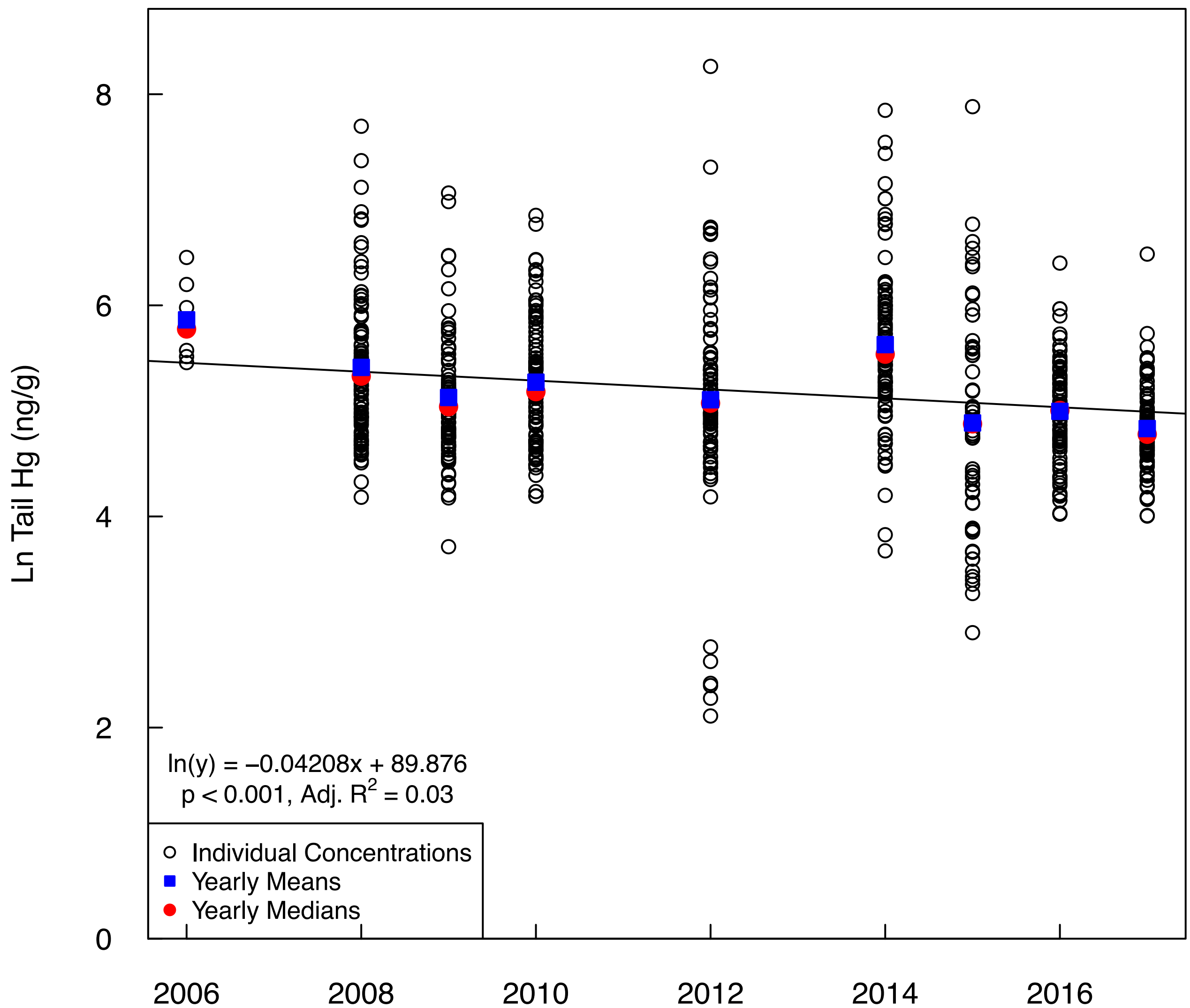


**Figure 4–46**
**Lobster Tail – Penobscot Bay**
**Length Adjusted Loglinear Regression**




Includes lobster data from Odom Ledge, South Verona, Turner Point, and Harborside

**Figure 4–47**
**Lobster Tail – Odom Ledge**
**Length Adjusted Loglinear Regression**

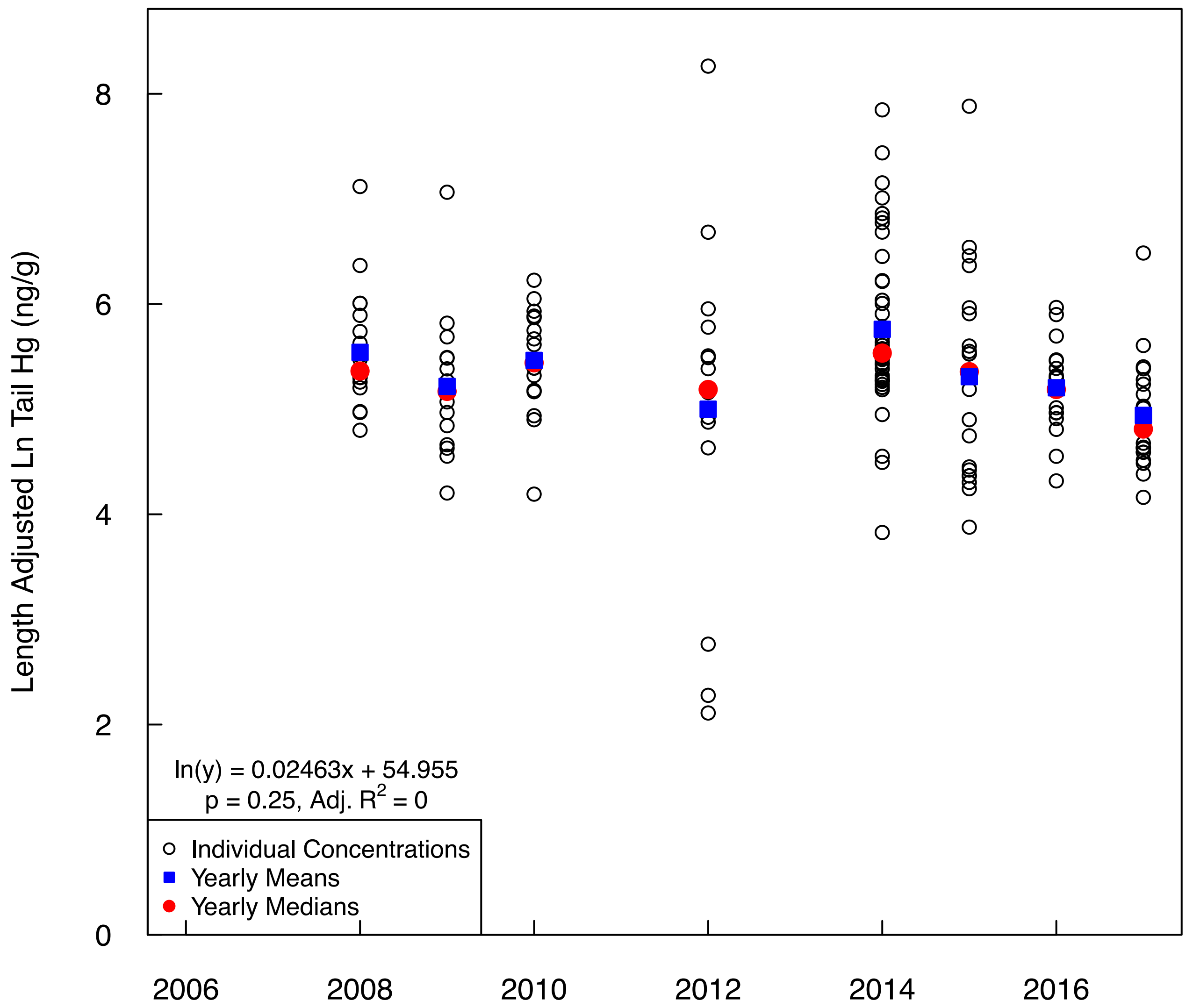


**Figure 4–48**
**Lobster Tail – South Verona**
**Length Adjusted Loglinear Regression**

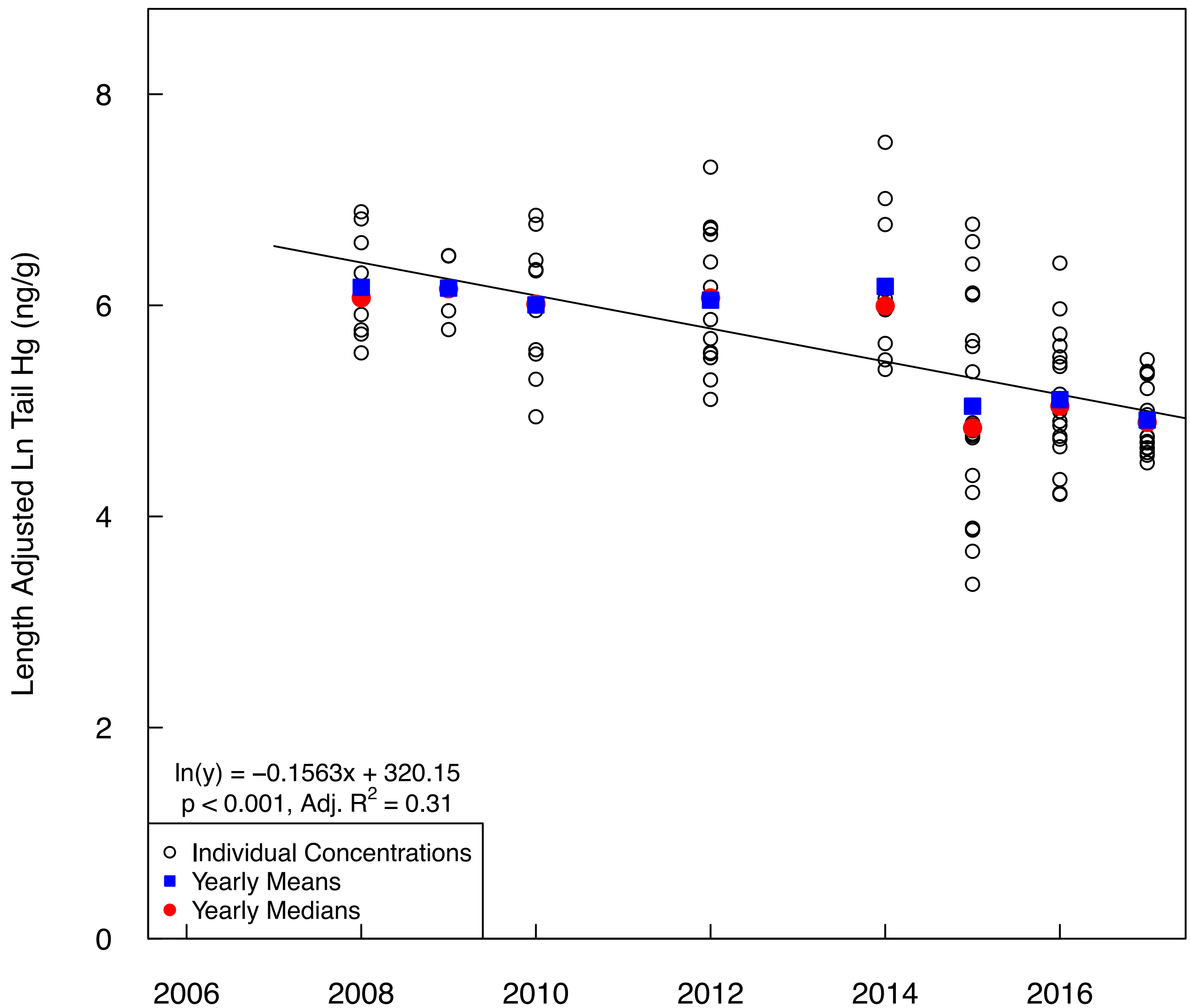


**Figure 4–49**
**Lobster Tail – Cape Jellison**
**Length Adjusted Loglinear Regression**

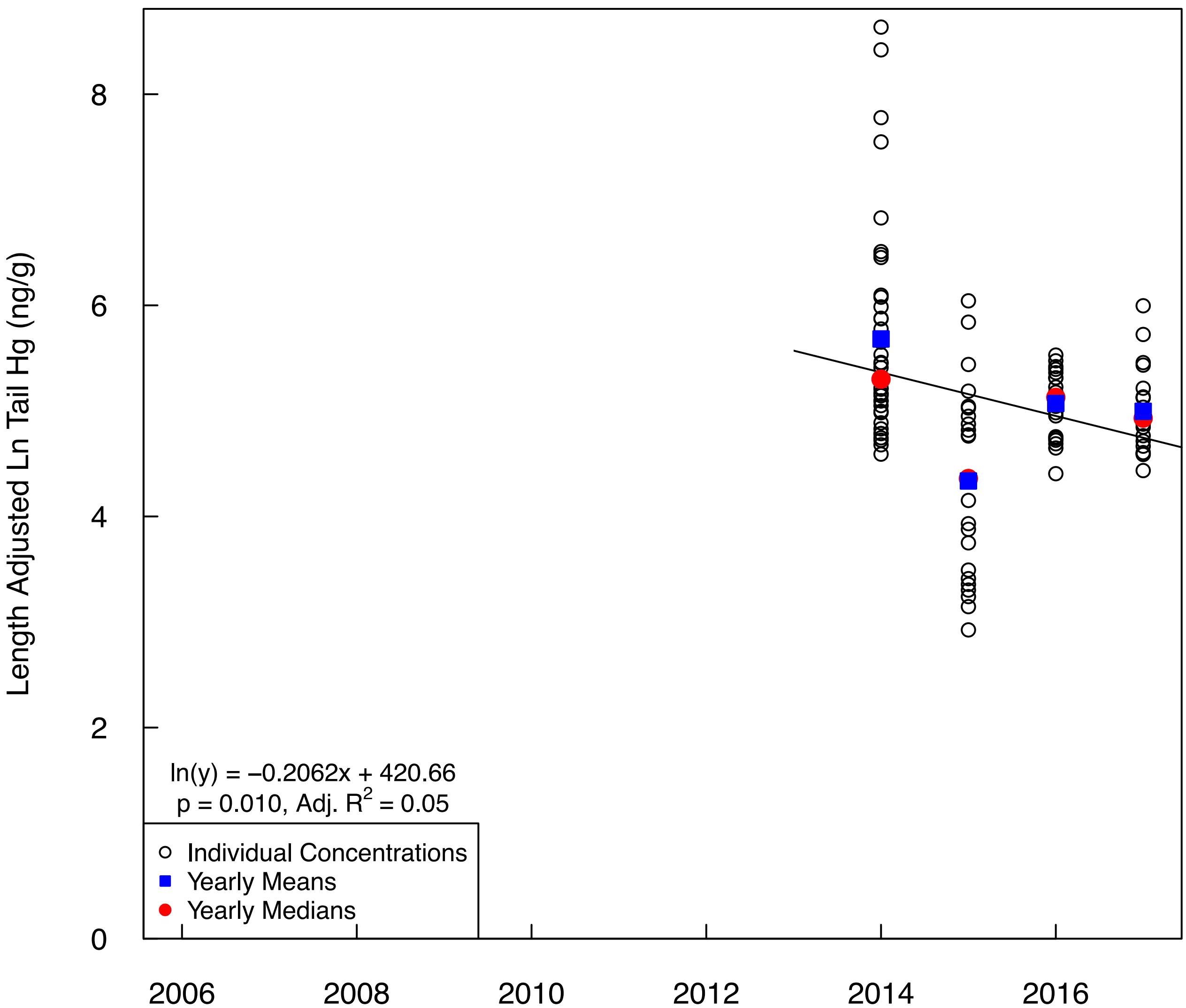


**Figure 4–50**
**Lobster Tail – Turner Point**
**Length Adjusted Loglinear Regression**

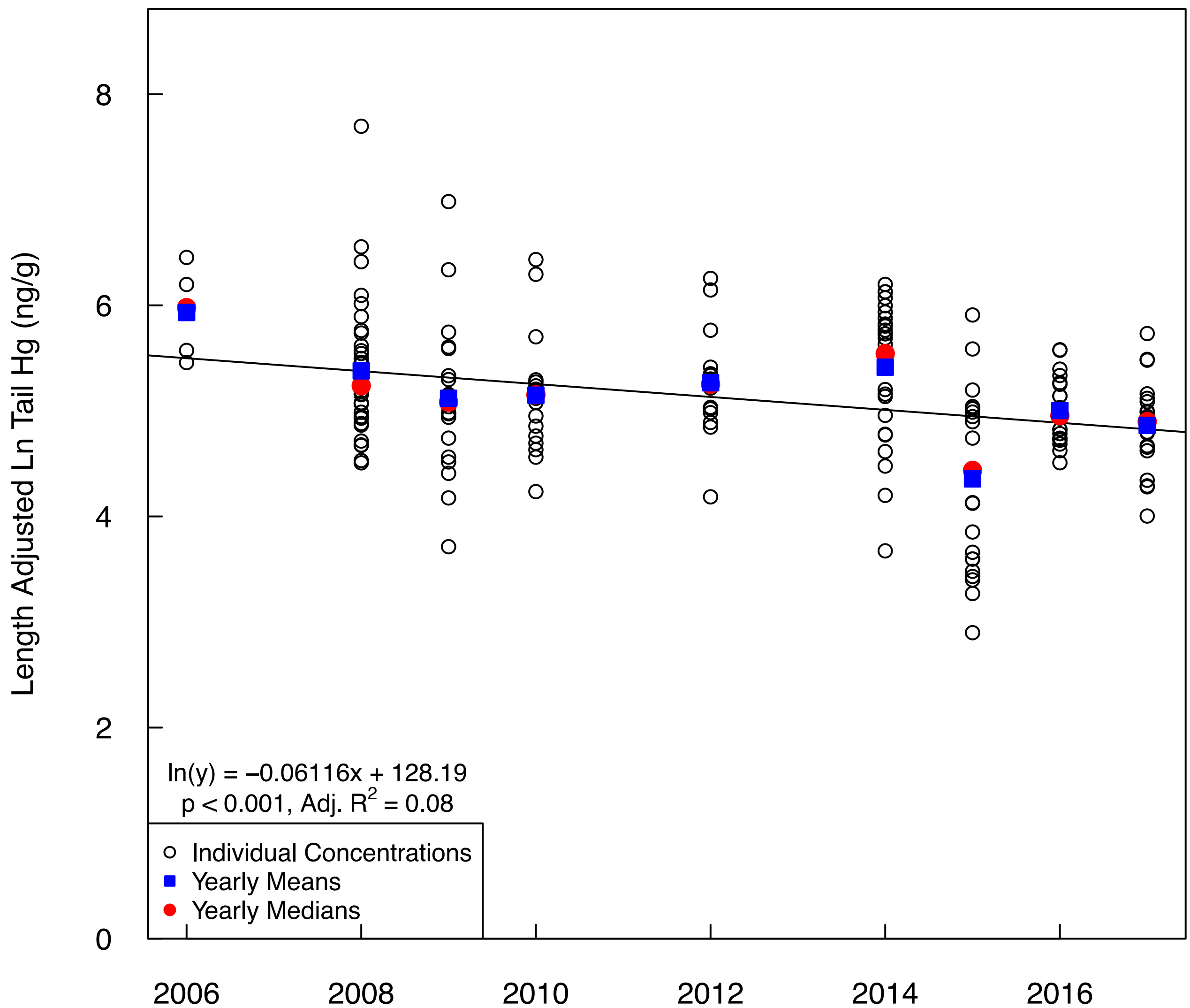


**Figure 4–51**
**Lobster Tail – Harborside**
**Length Adjusted Loglinear Regression**

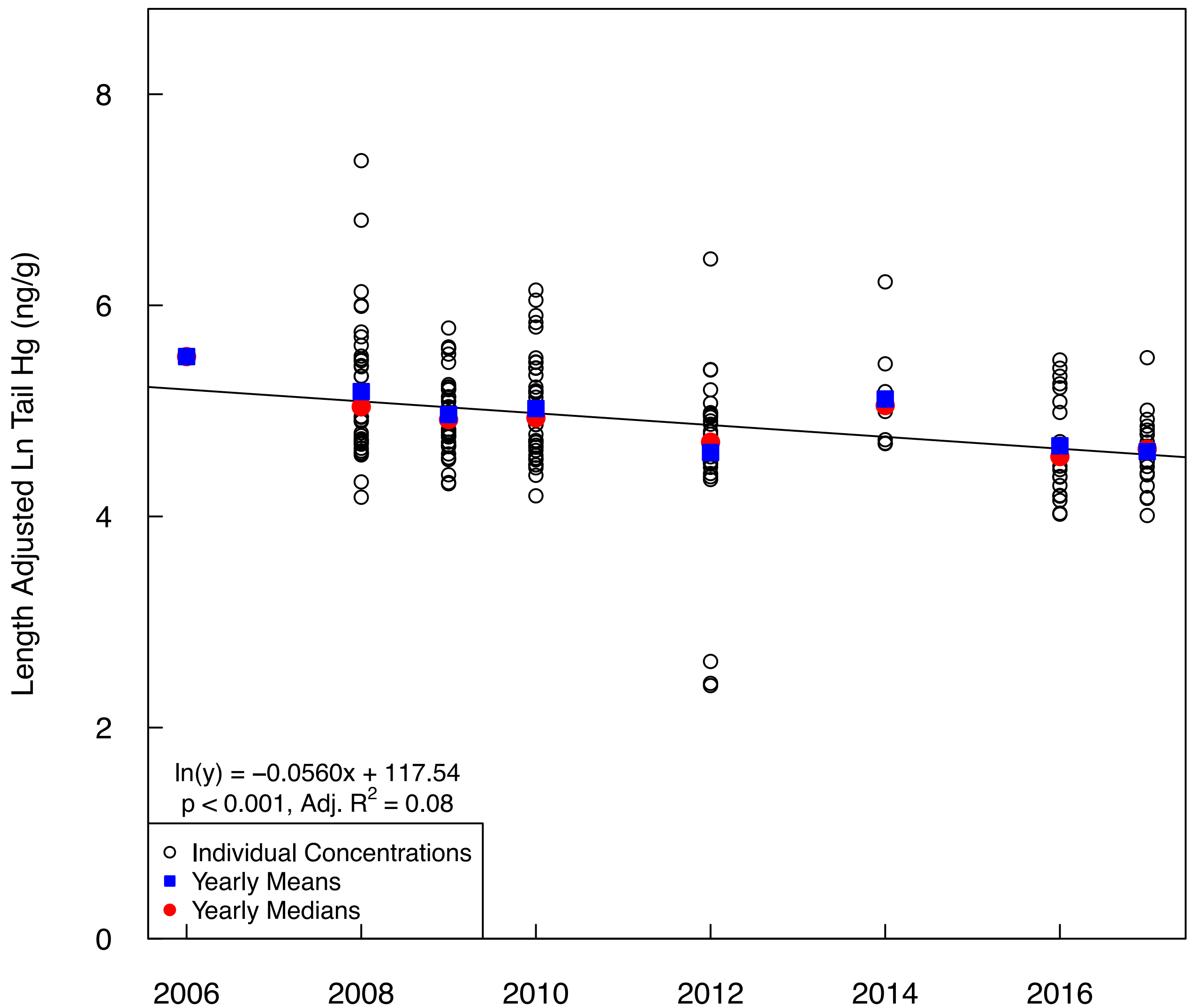


**Figure 4–52**
**Mummichog – Frenchman Bay (Reference)**
**Length Adjusted Loglinear Regression**

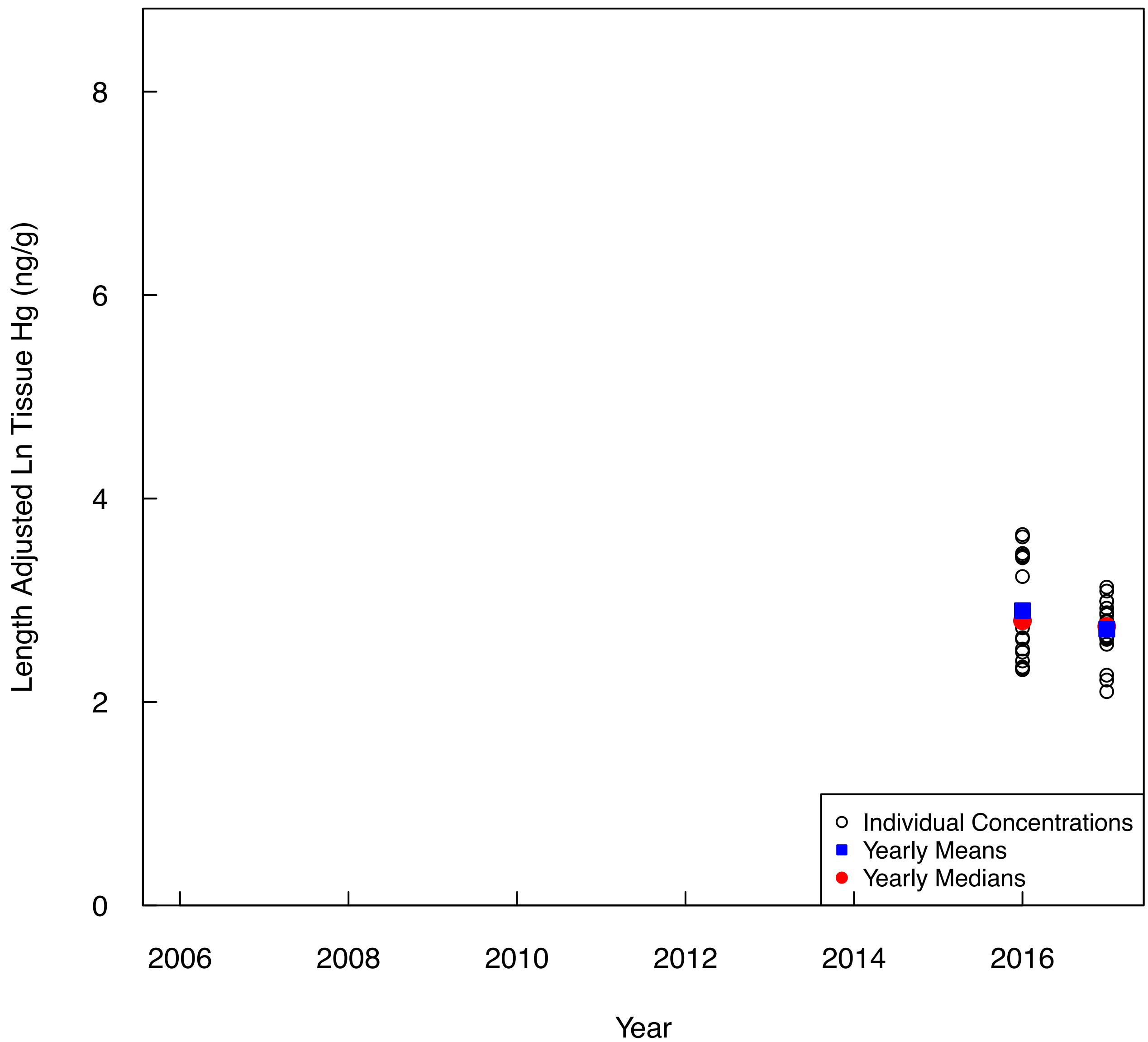
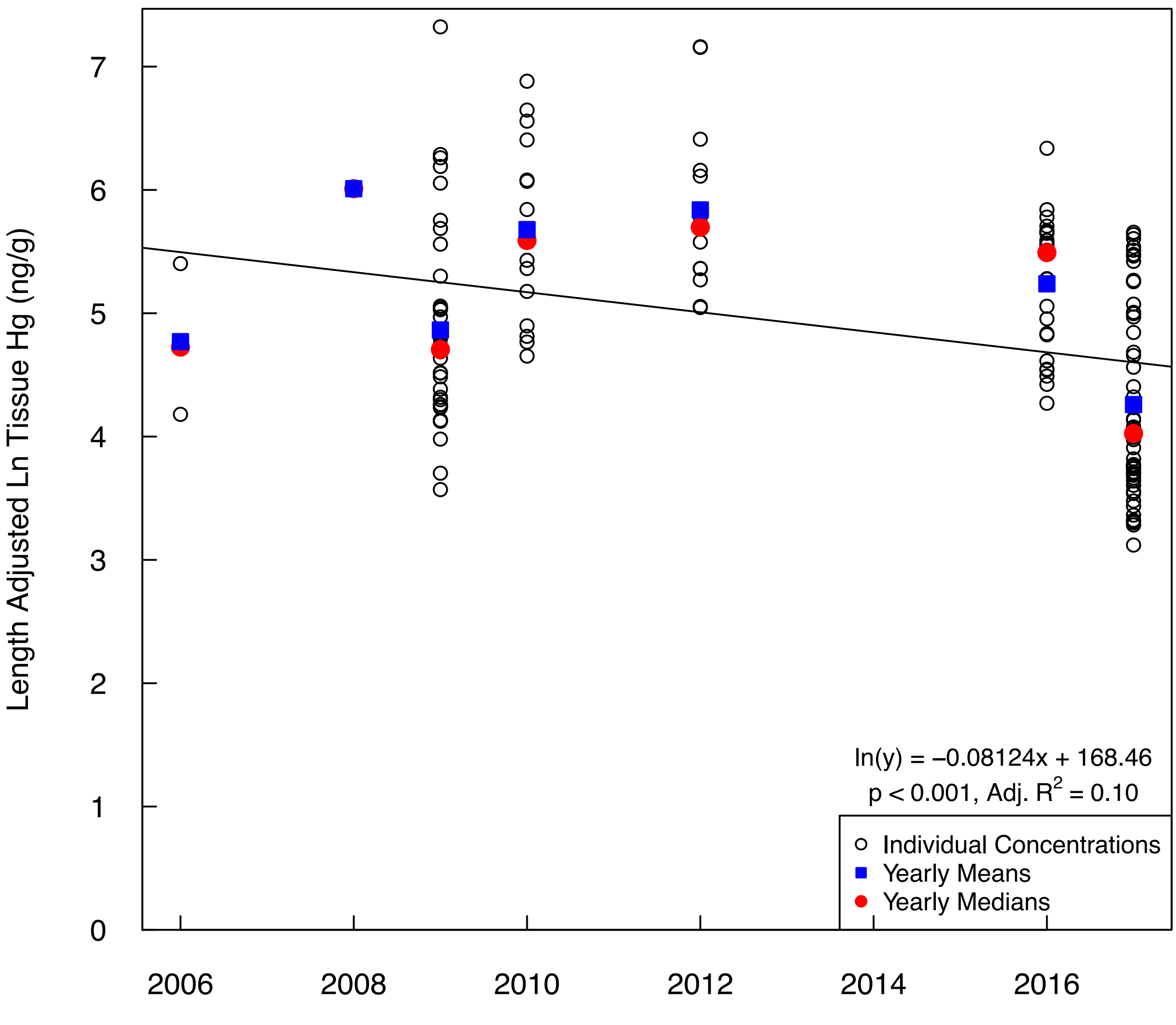


**Figure 4–53**
**Mummichog – Whole River**
**Length Adjusted Loglinear Regression**




Includes Mummichog sampled at OB–05, OB–01, and Mendall Marsh

**Figure 4–54**
**Mummichog – OB–05**
**Length Adjusted Loglinear Regression**

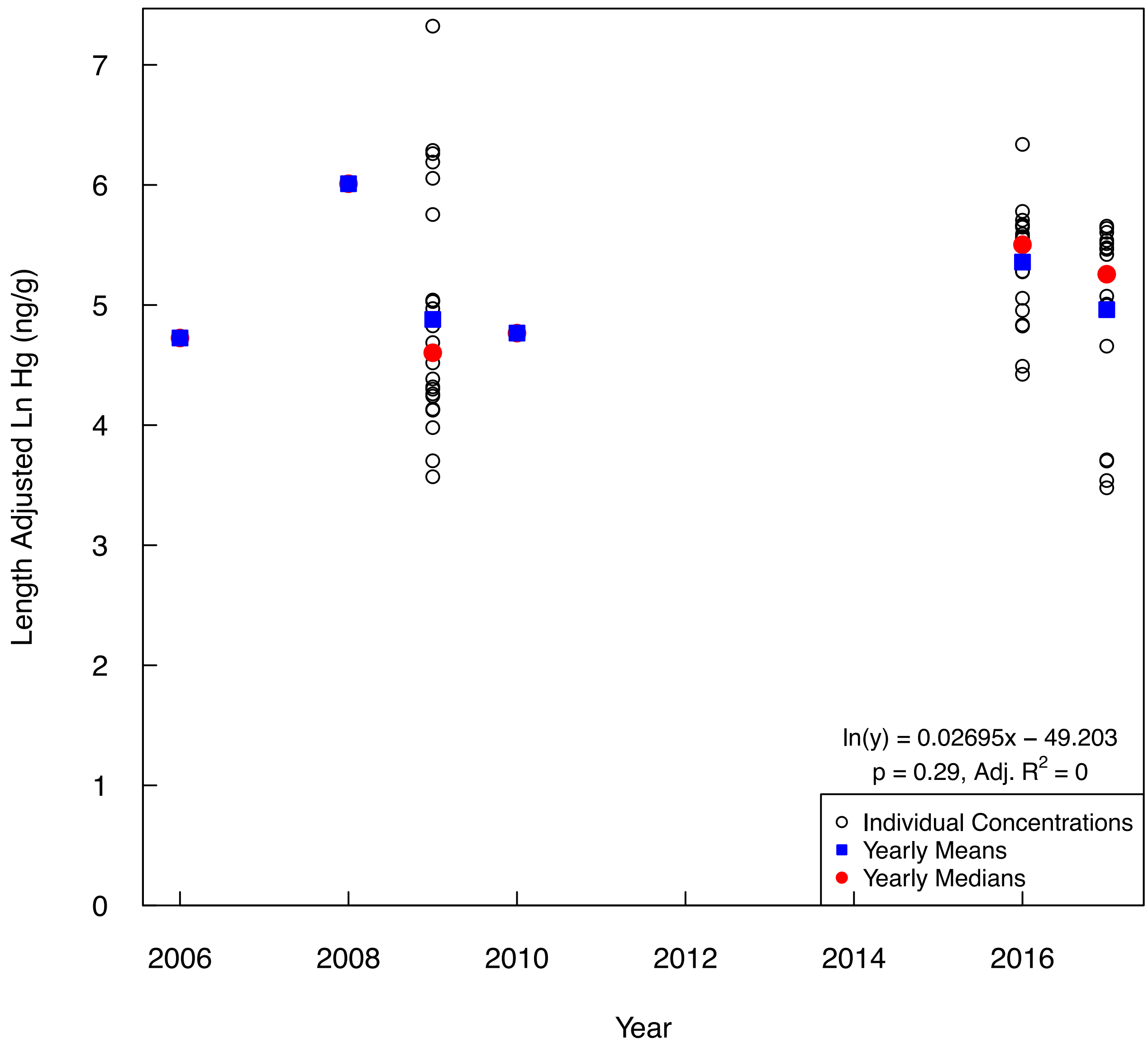
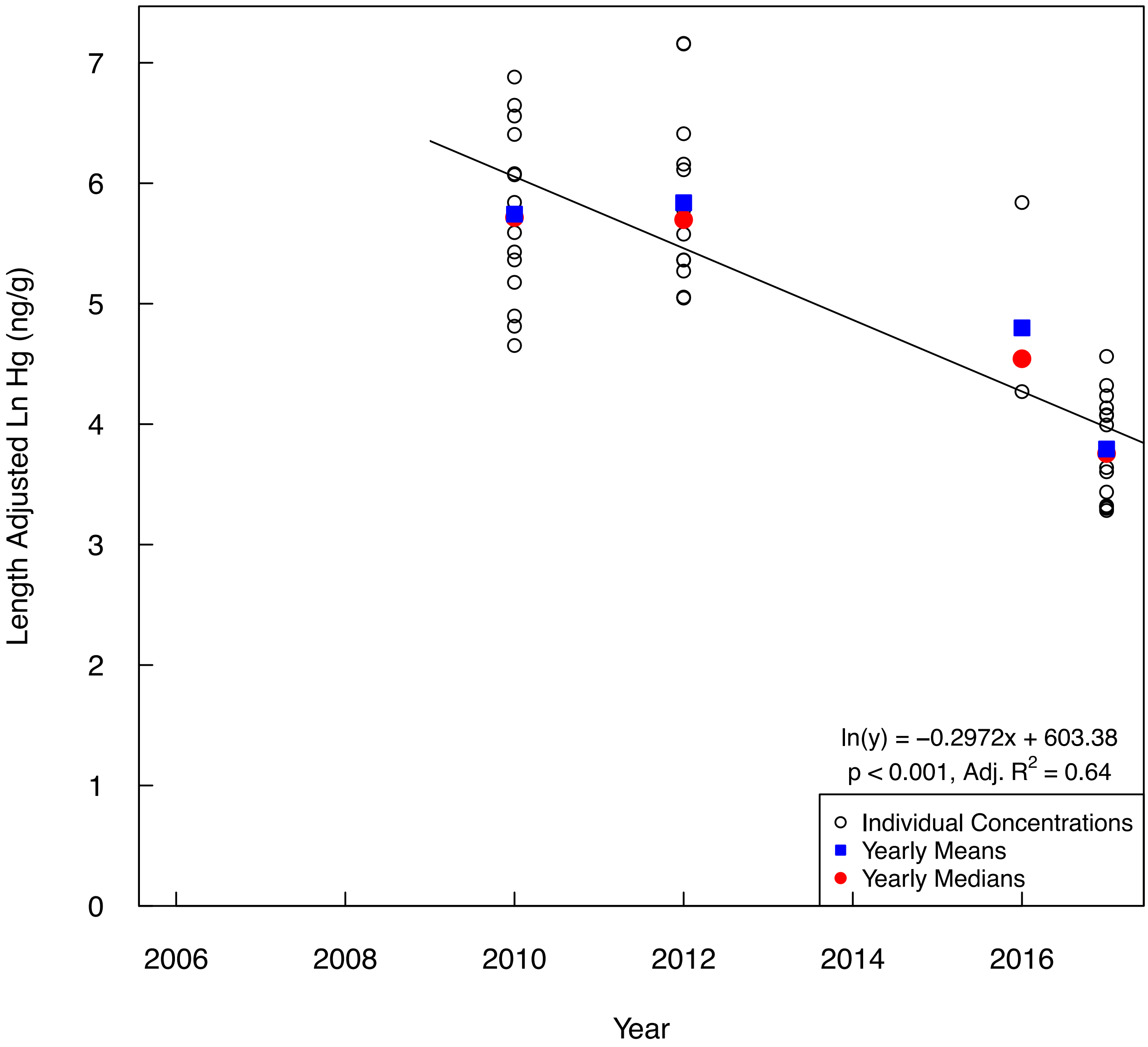


**Figure 4–55**
**Mummichog – Mendall Marsh**
**Length Adjusted Loglinear Regression**




Includes Mummichog sampled at MMMC−01 and W−21

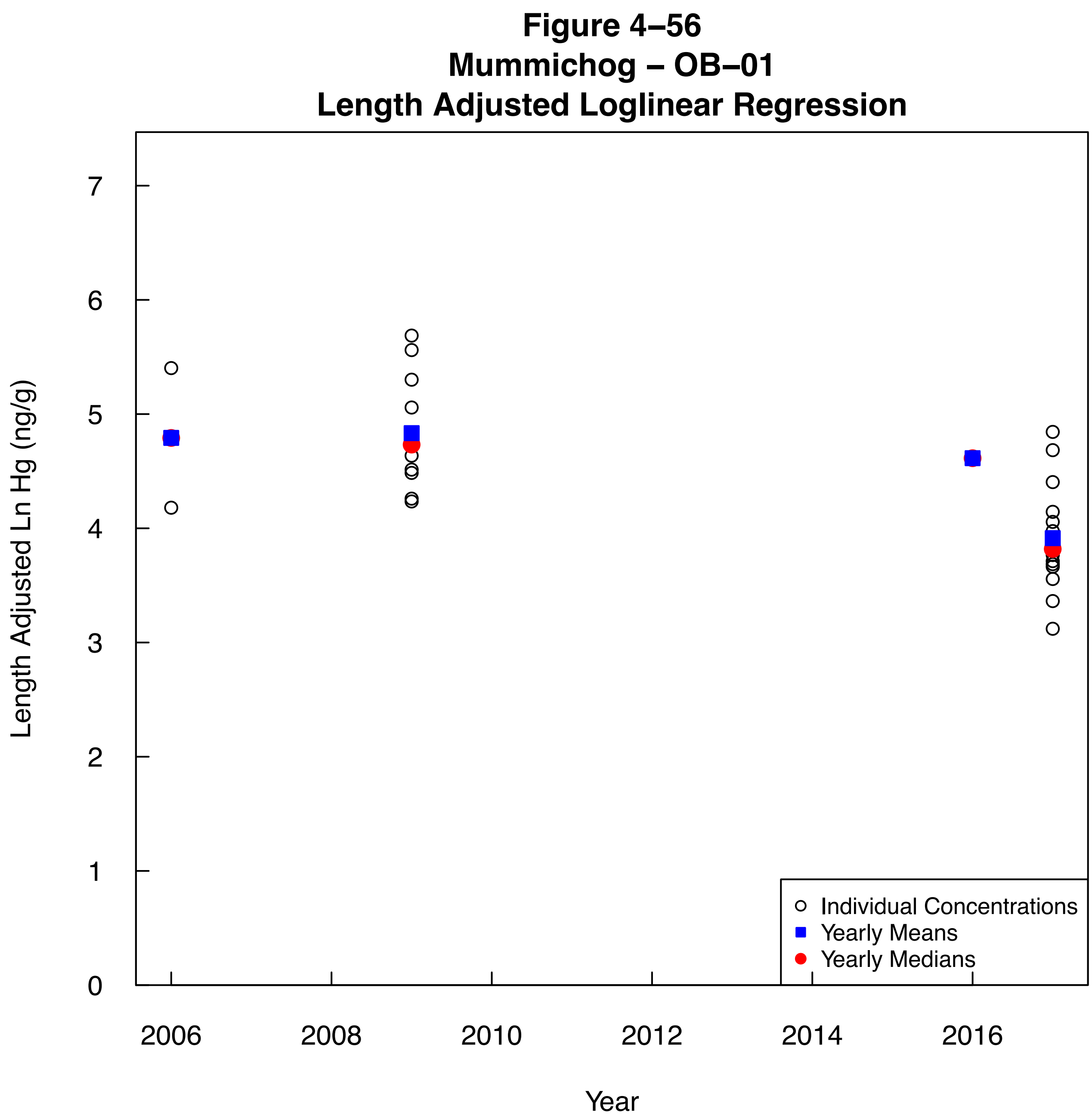


Figure 4–56
Mummichog – OB–01
Length Adjusted Loglinear Regression
Length Adjusted Ln Hg (ng/g)
0
1
2
3
4
5
6
7
2006
2008
2010
2012
2014
2016
Year
Individual Concentrations
Yearly Means
Yearly Medians

**Figure 4–57**
**Rainbow Smelt – Frenchman Bay (Reference)**
**Length Adjusted Ln Mercury Concentrations**

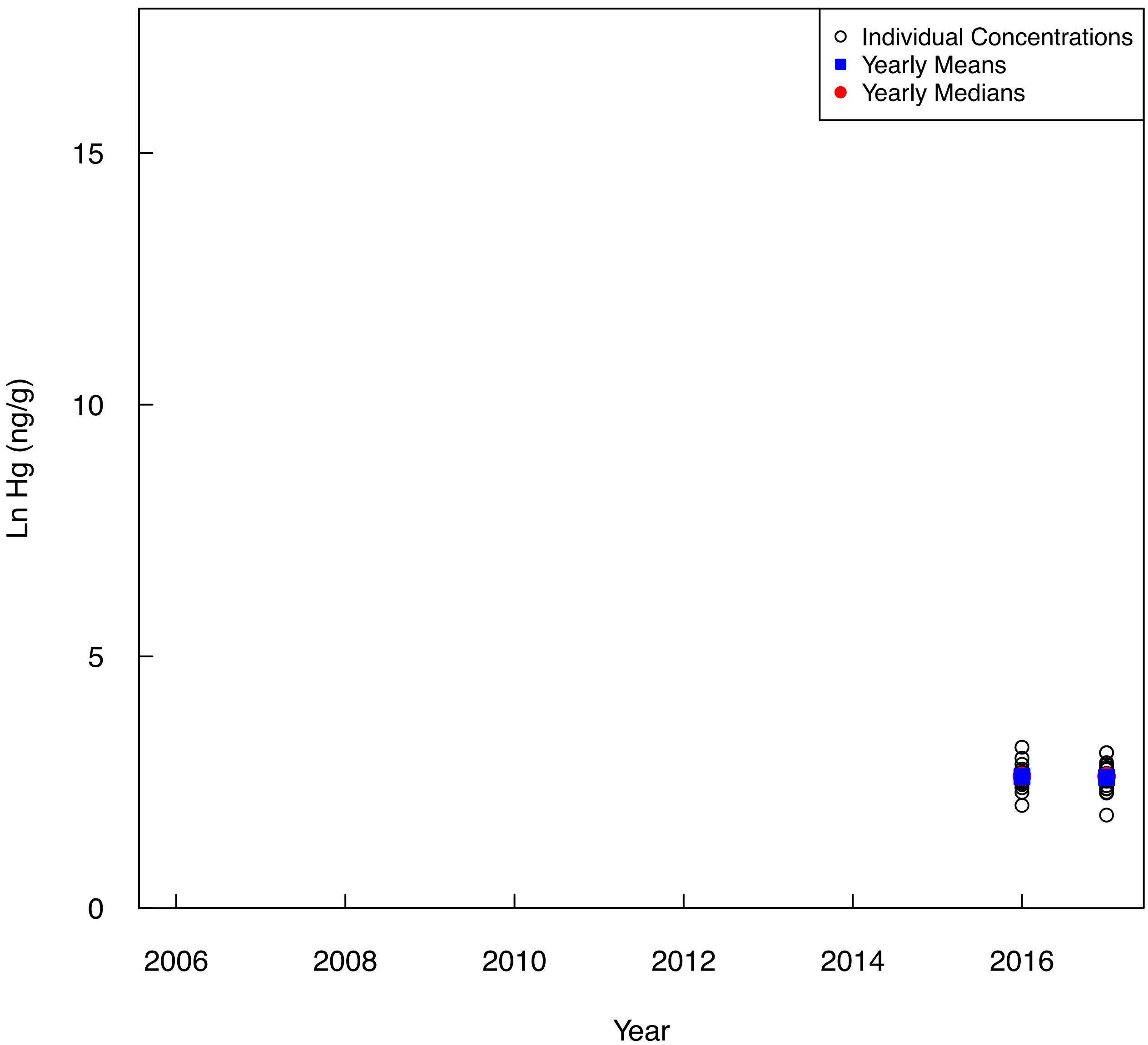
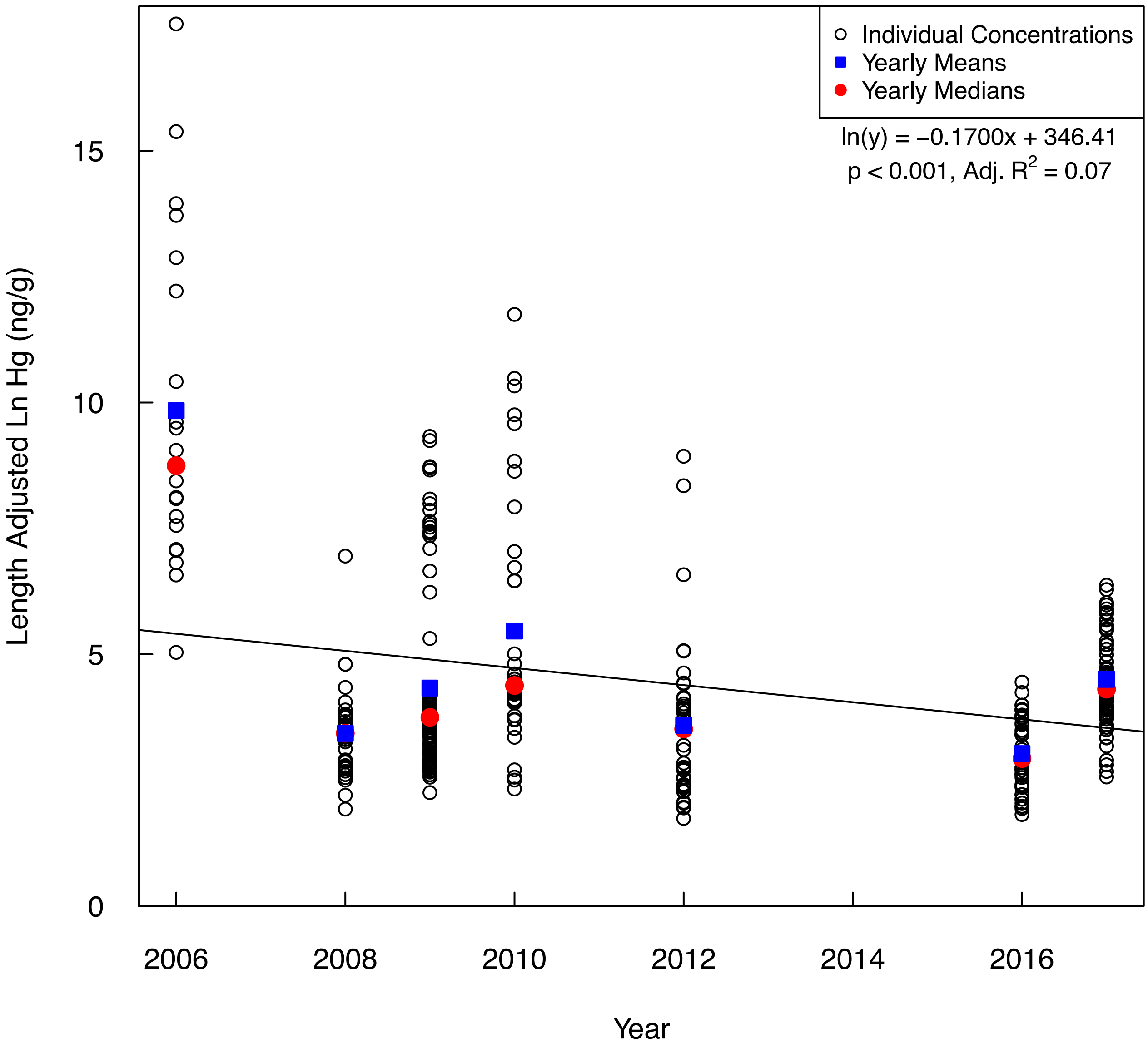
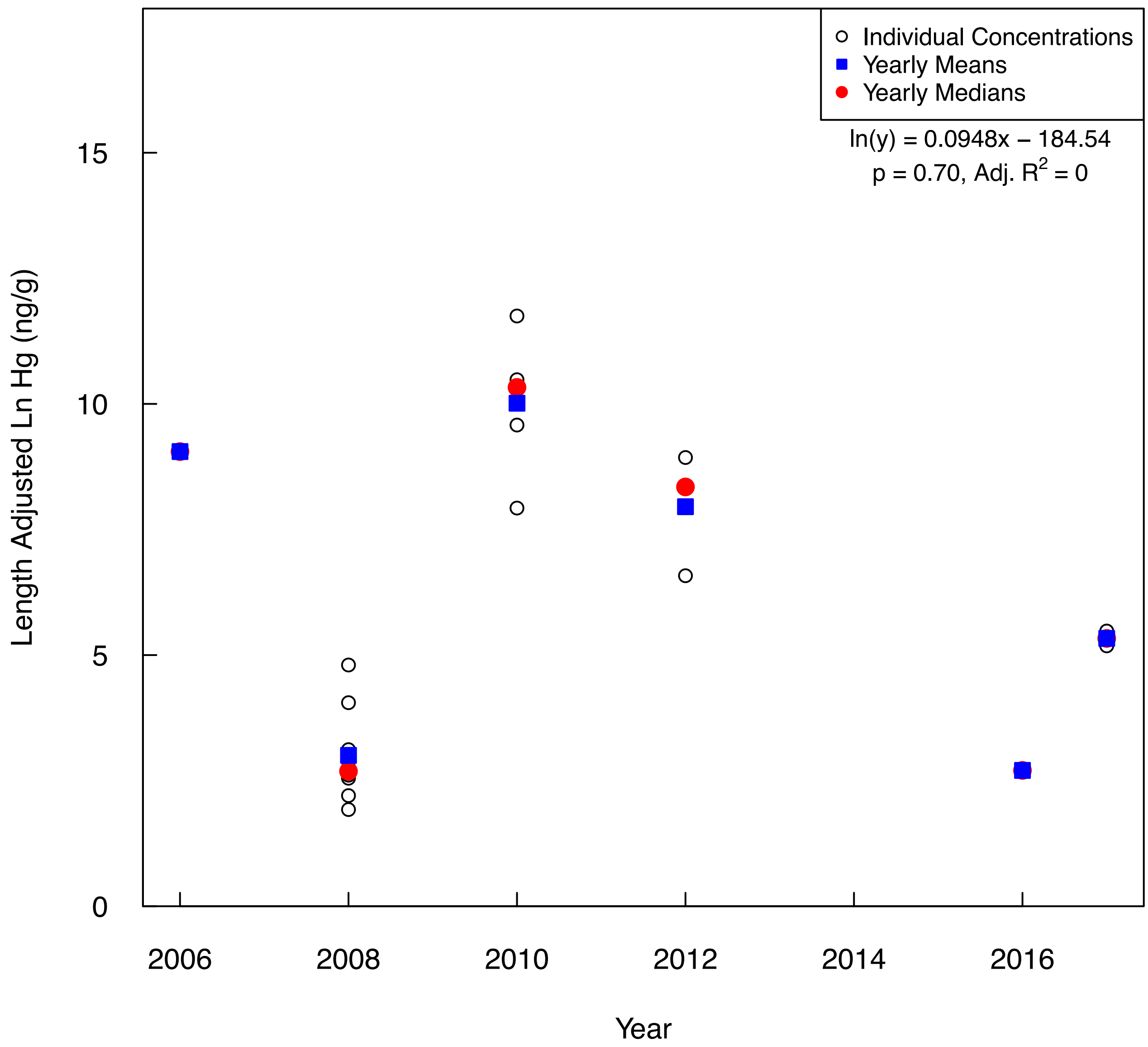


**Figure 4–58**
**Rainbow Smelt – Whole River**
**Length Adjusted Loglinear Regression**




Includes Smelt sampled at OB−05, OB−04, OB−01, ES−13, ES−15, and ES−FP

**Figure 4–59**
**Rainbow Smelt – OB–05**
**Length Adjusted Loglinear Regression**



# Figure 4–60
## Rainbow Smelt – ES–FP
## Length Adjusted Loglinear Regression

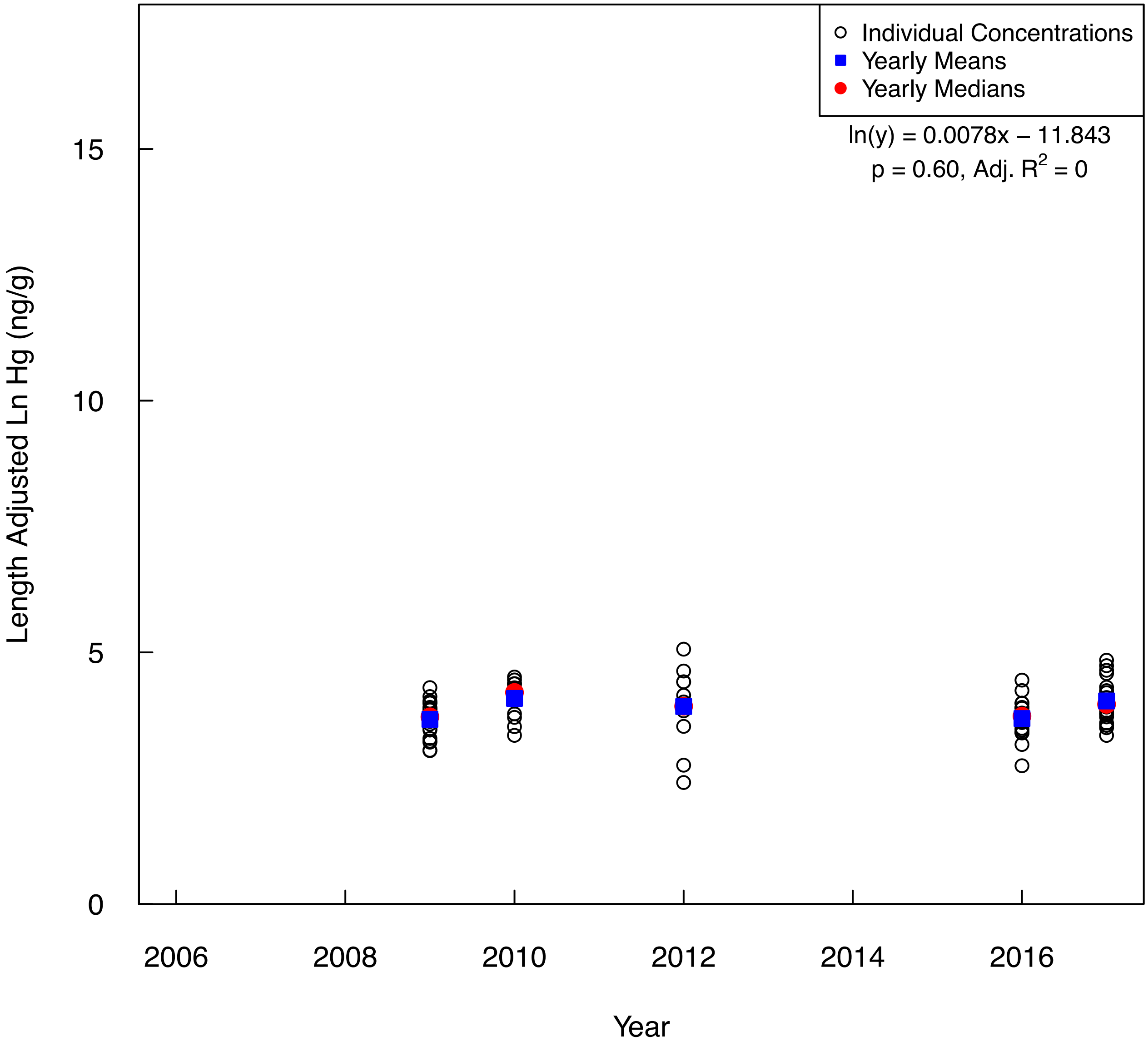
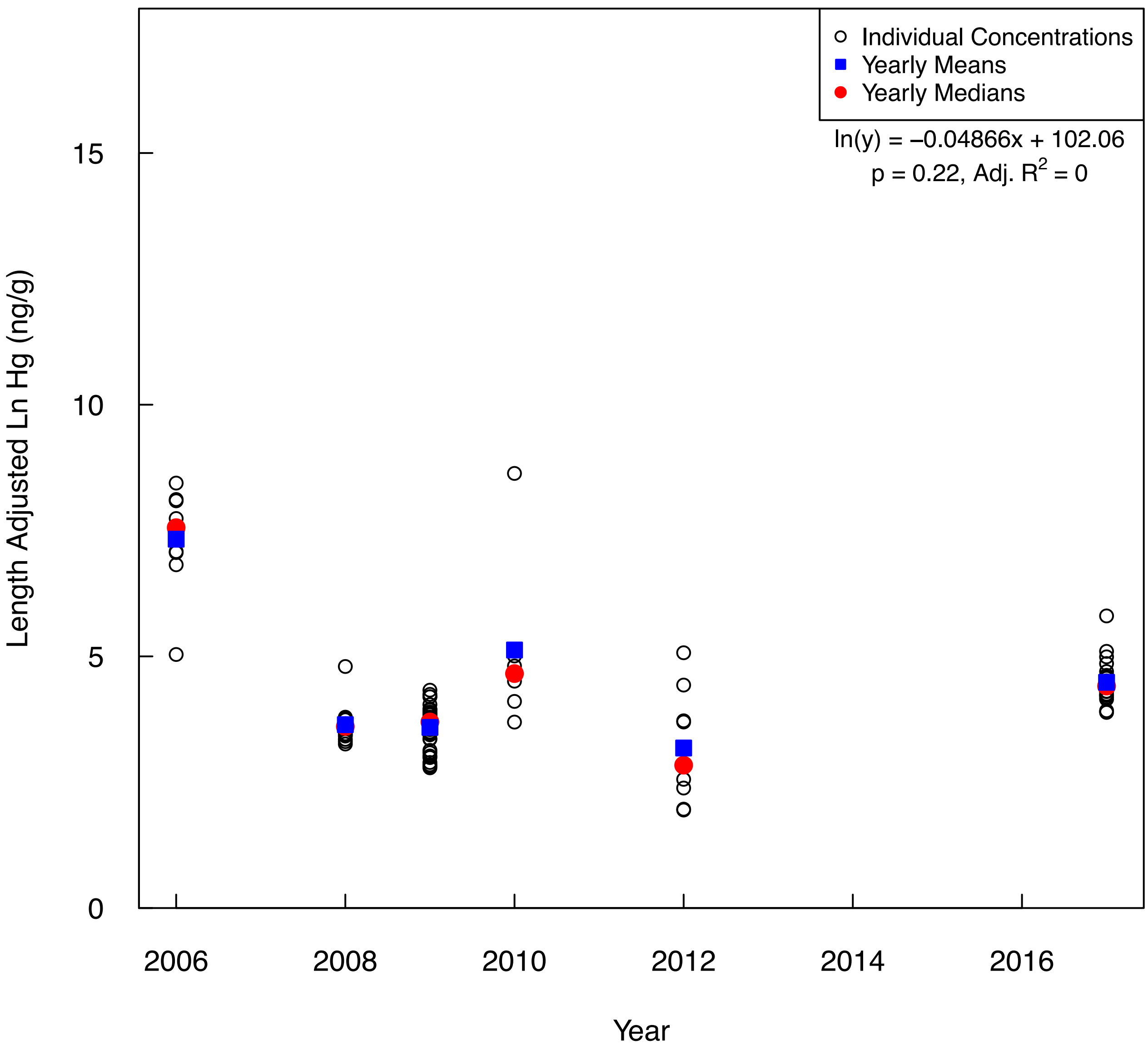


**Figure 4–61**
**Rainbow Smelt – ES–13**
**Length Adjusted Loglinear Regression**



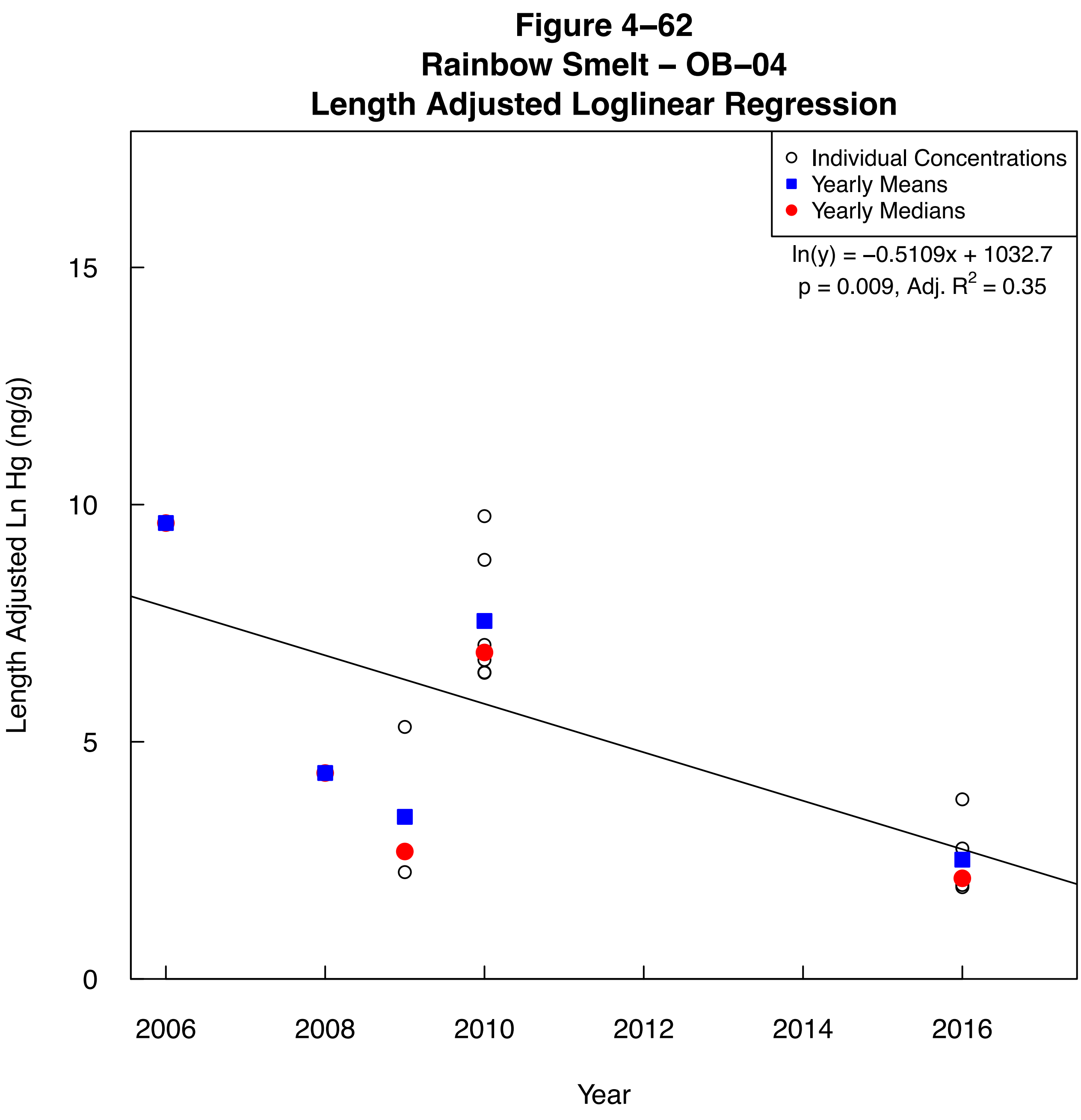


Figure 4–62
Rainbow Smelt – OB–04
Length Adjusted Loglinear Regression
Individual Concentrations
Yearly Means
Yearly Medians
ln(y) = −0.5109x + 1032.7
p = 0.009, Adj. R2 = 0.35
Length Adjusted Ln Hg (ng/g)
0
5
10
15
2006
2008
2010
2012
2014
2016
Year

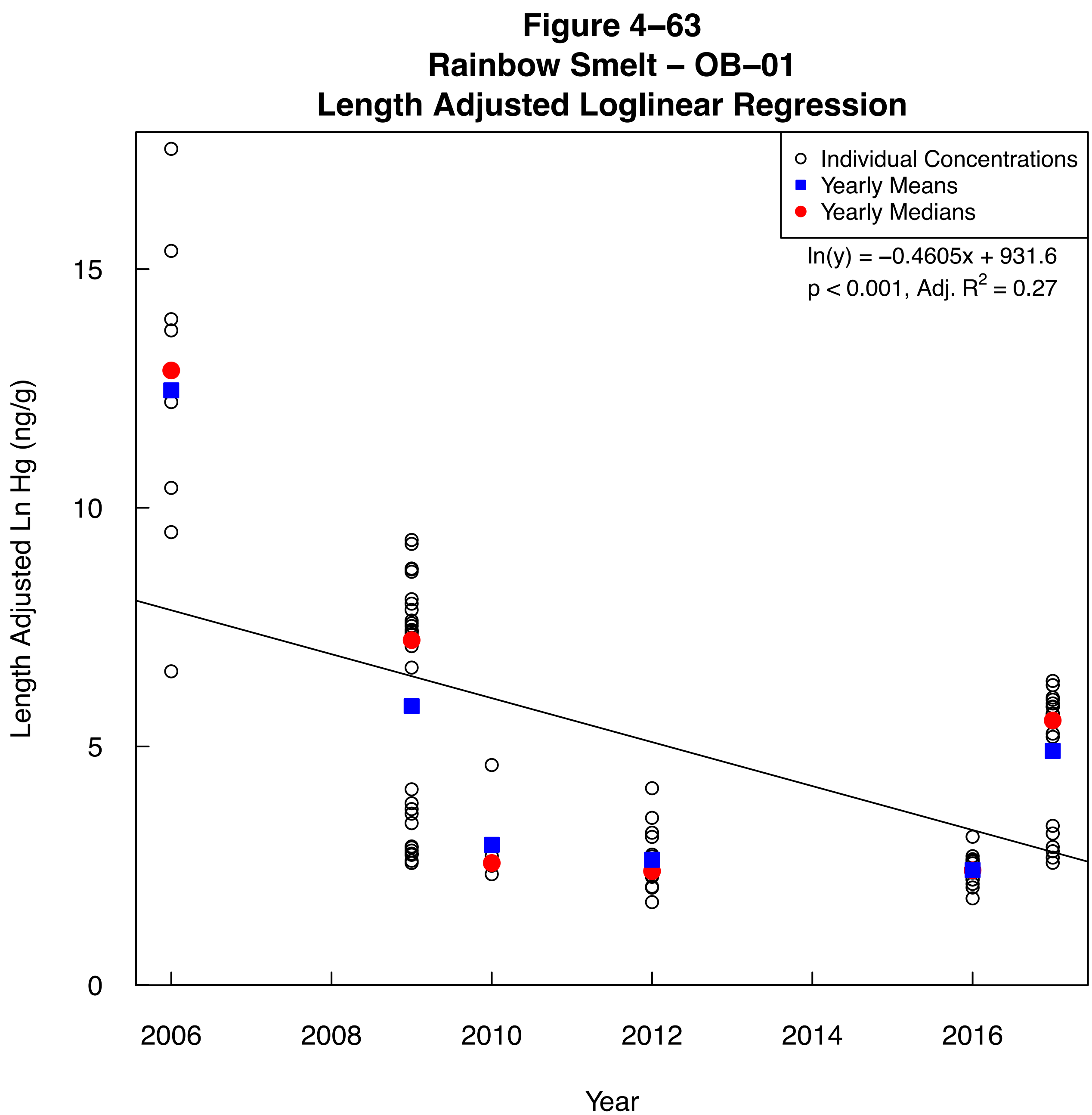


Figure 4–63
Rainbow Smelt – OB–01
Length Adjusted Loglinear Regression
Individual Concentrations
Yearly Means
Yearly Medians
ln(y) = −0.4605x + 931.6
p < 0.001, Adj. R2 = 0.27
Length Adjusted Ln Hg (ng/g)
0
5
10
15
2006
2008
2010
2012
2014
2016
Year

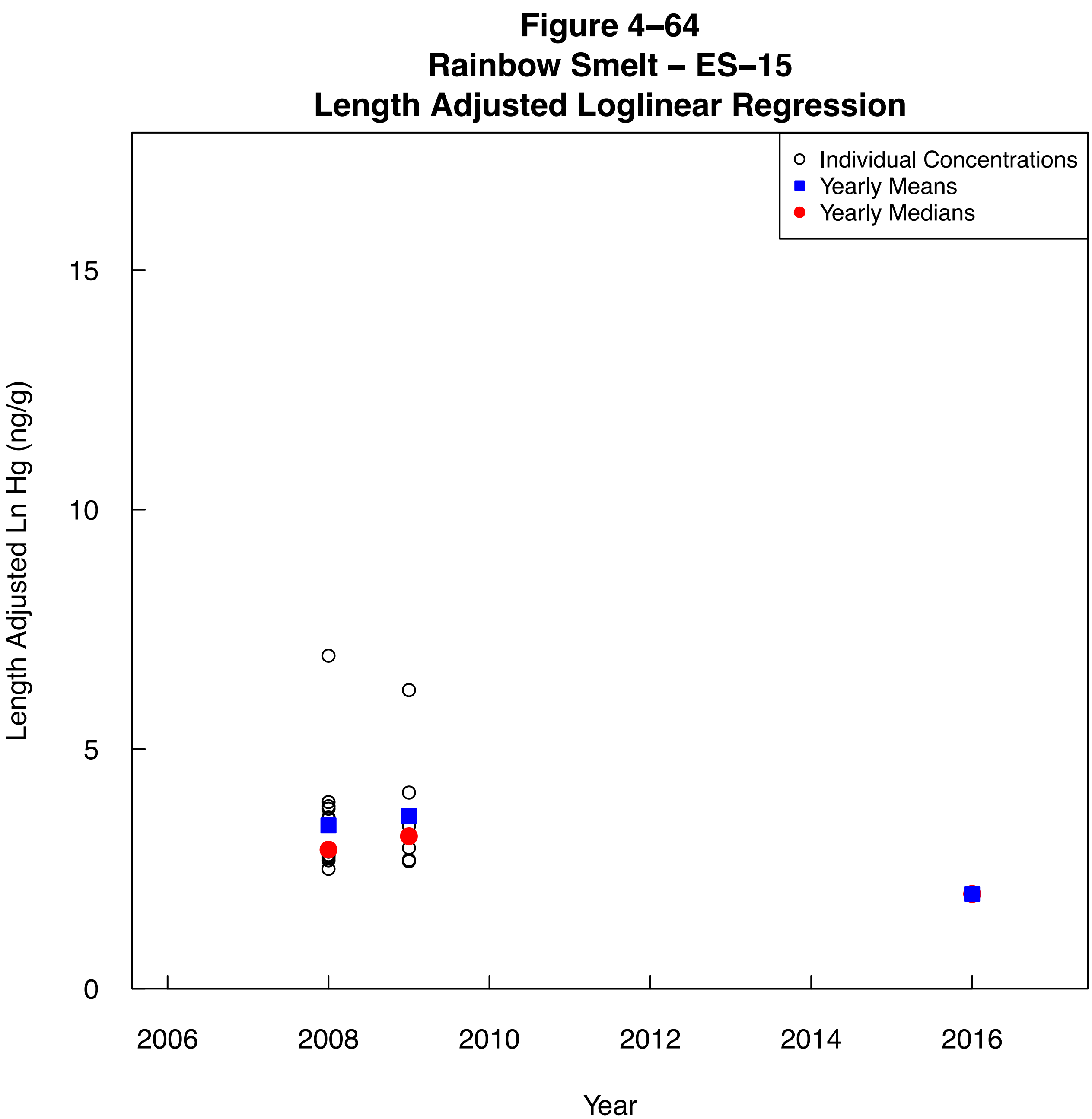


Figure 4–64
Rainbow Smelt – ES–15
Length Adjusted Loglinear Regression
Individual Concentrations
Yearly Means
Yearly Medians
Length Adjusted Ln Hg (ng/g)
0
5
10
15
2006
2008
2010
2012
2014
2016
Year

**Figure 4–65**
**American Eel – OV–04 (Reference)**
**Length Adjusted Loglinear Regression**

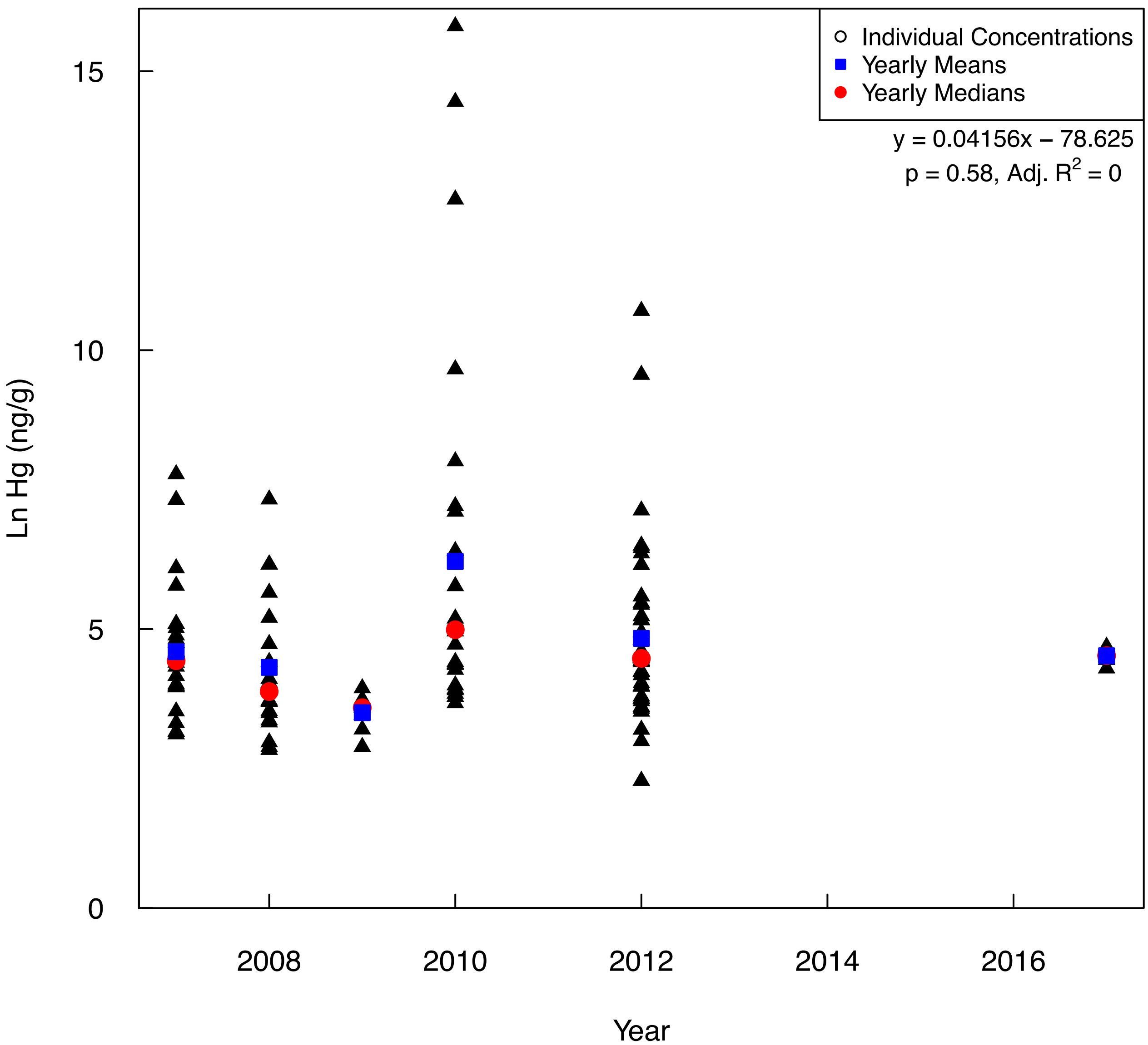
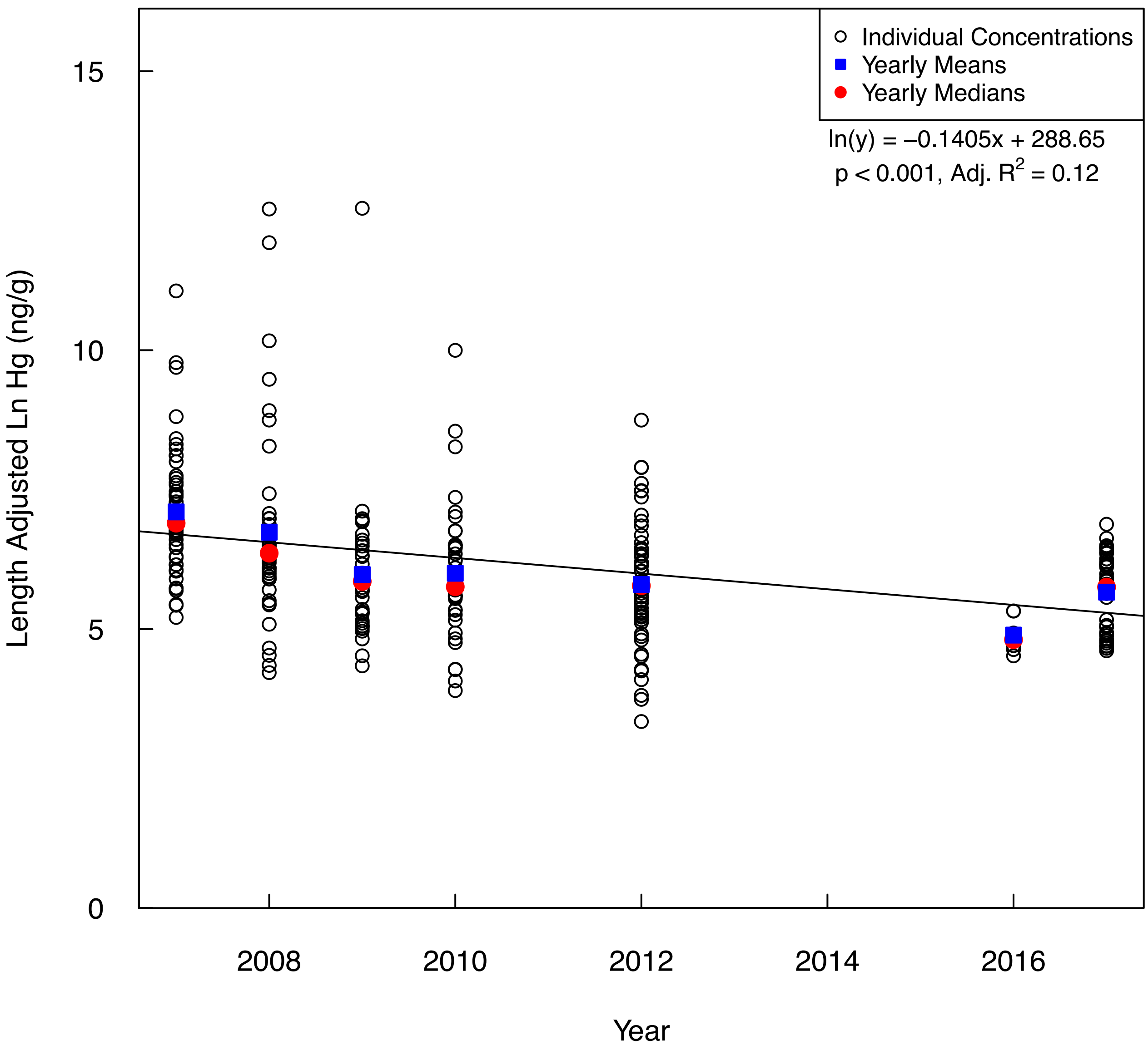


**Figure 4–66**
**American Eel – Whole River**
**Length Adjusted Loglinear Regression**




Includes Eel sampled at BO–04, OB–05, and OB–01

**Figure 4–67**
**American Eel – BO–04**
**Length Adjusted Loglinear Regression**

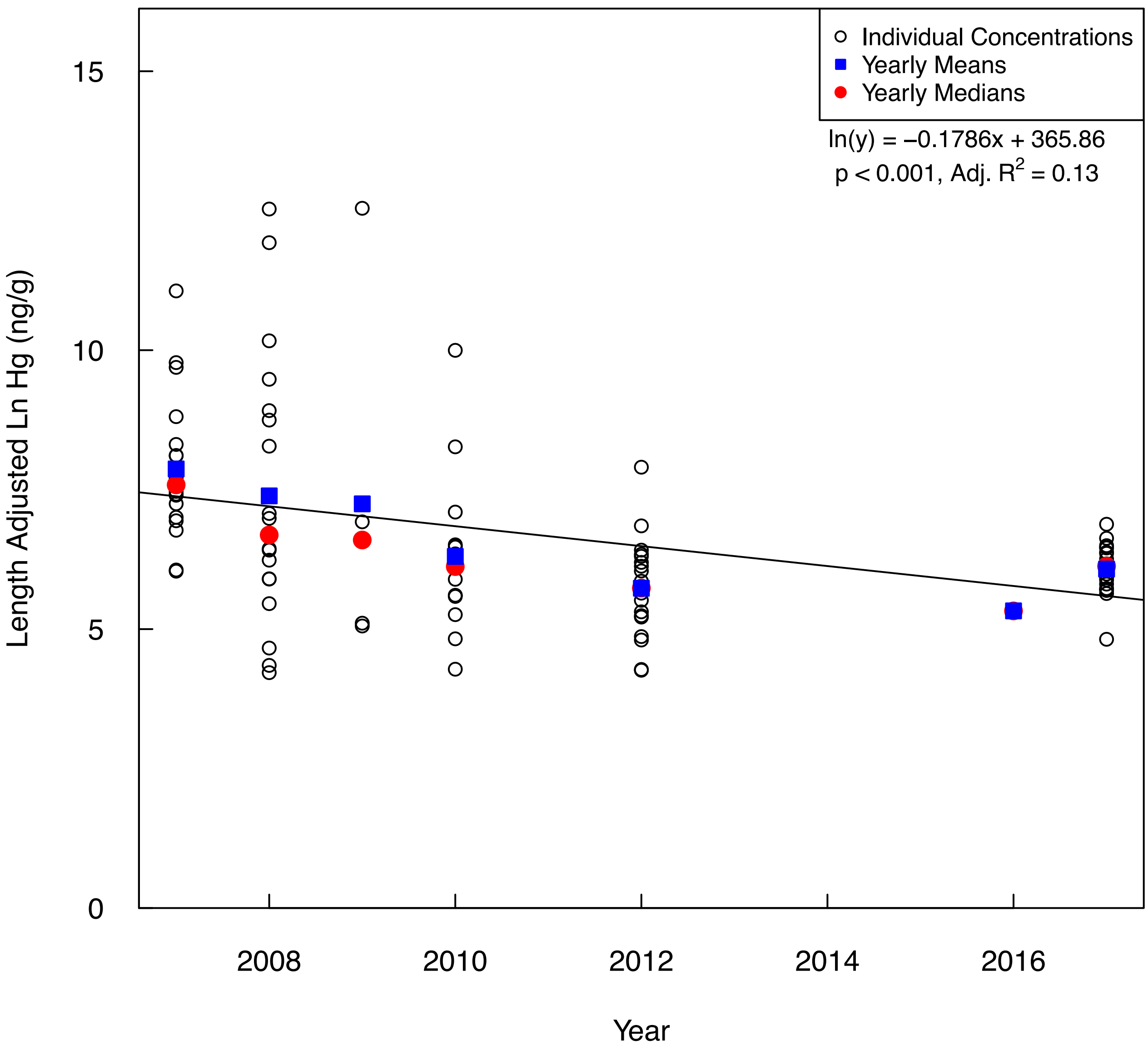


**Figure 4–68**
**American Eel – OB–05**
**Length Adjusted Loglinear Regression**

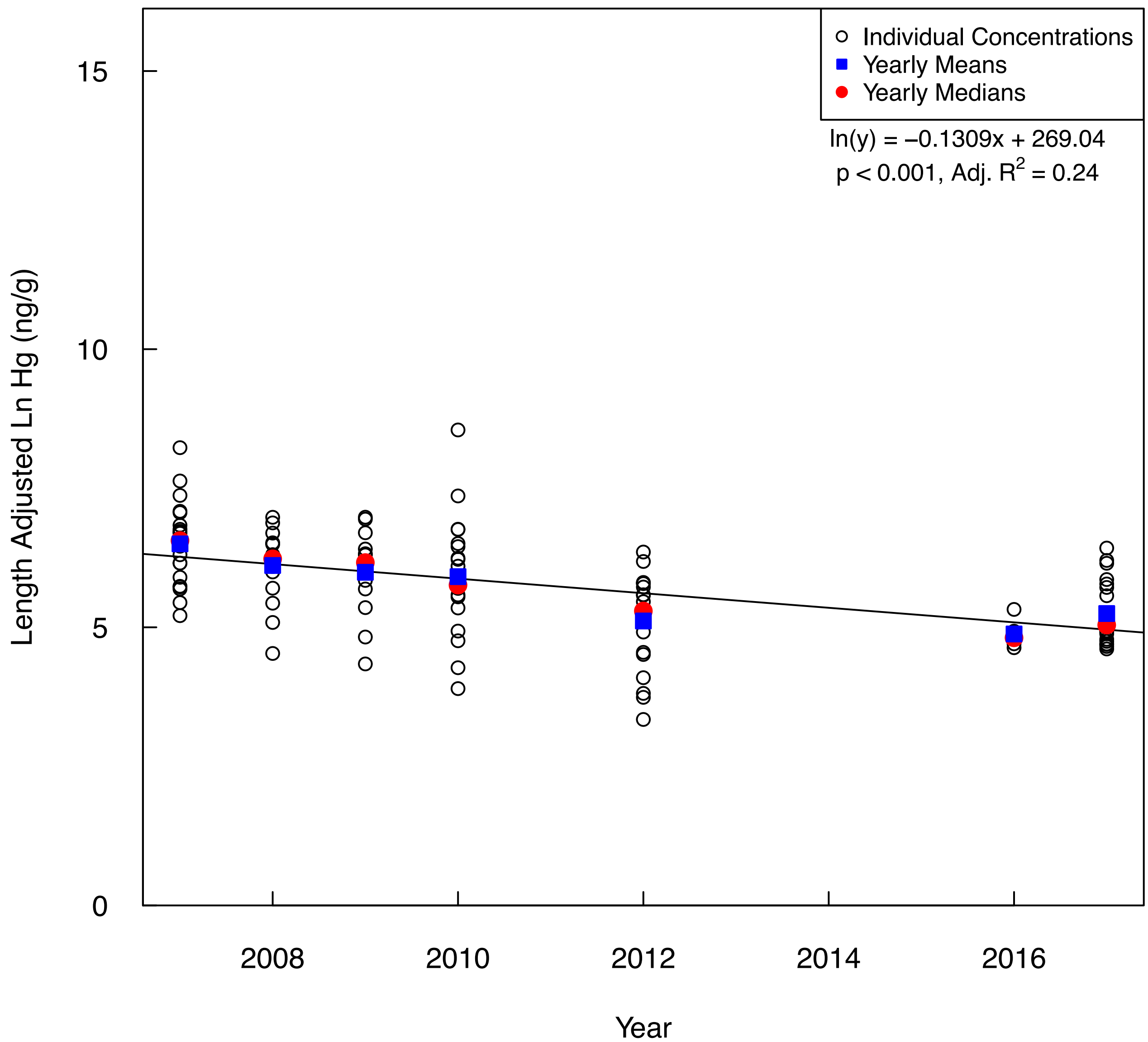
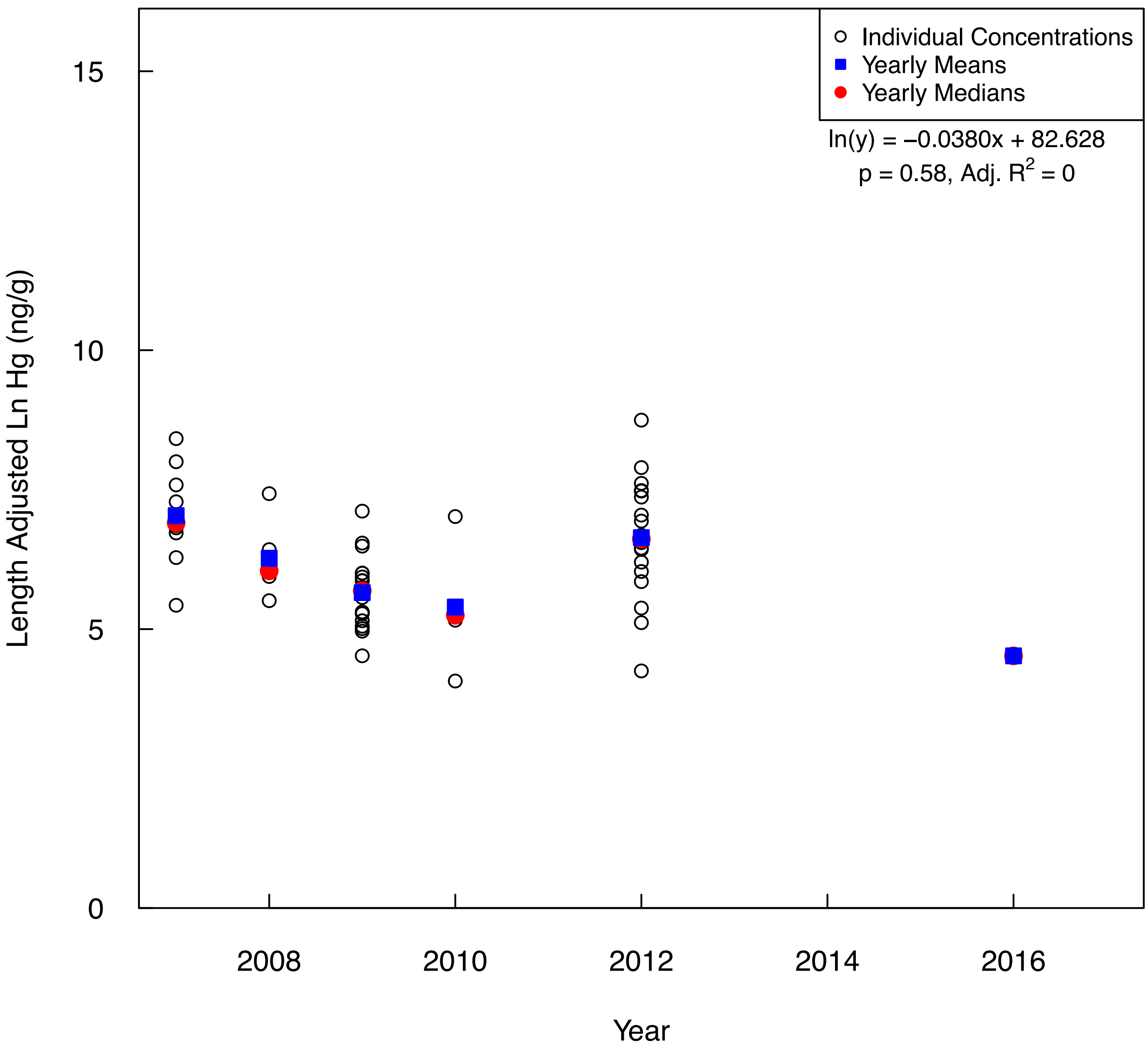
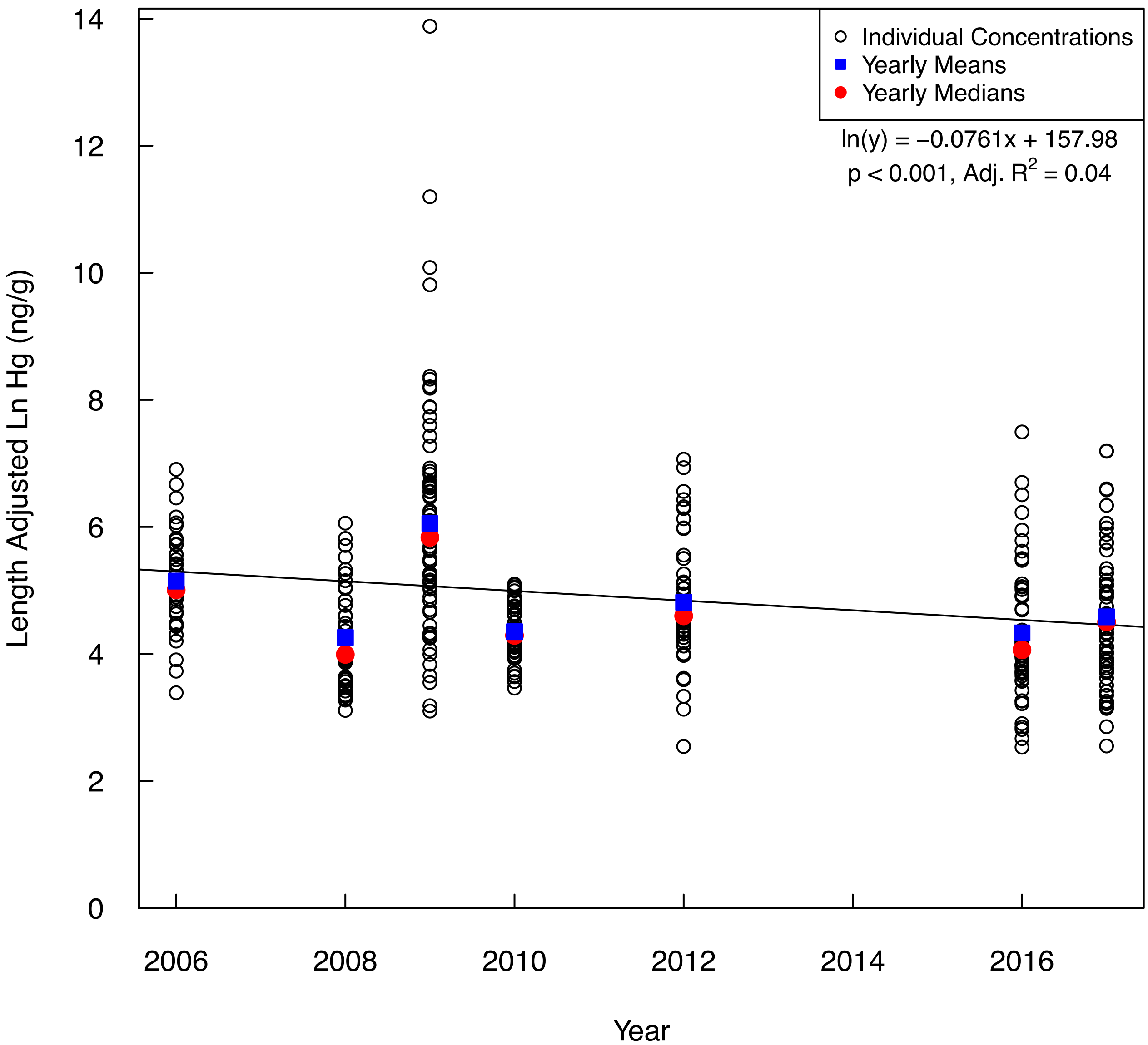


**Figure 4–69**
**American Eel – OB–01**
**Length Adjusted Loglinear Regression**



## Figure 4–70
## Atlantic Tomcod – Whole River
## Length Adjusted Loglinear Regression




Includes Atlantic Tomcod sampled at BO–04, OB–05, OB–01, and ES–13

**Figure 4–71**
**Atlantic Tomcod – BO–04**
**Length Adjusted Loglinear Regression**

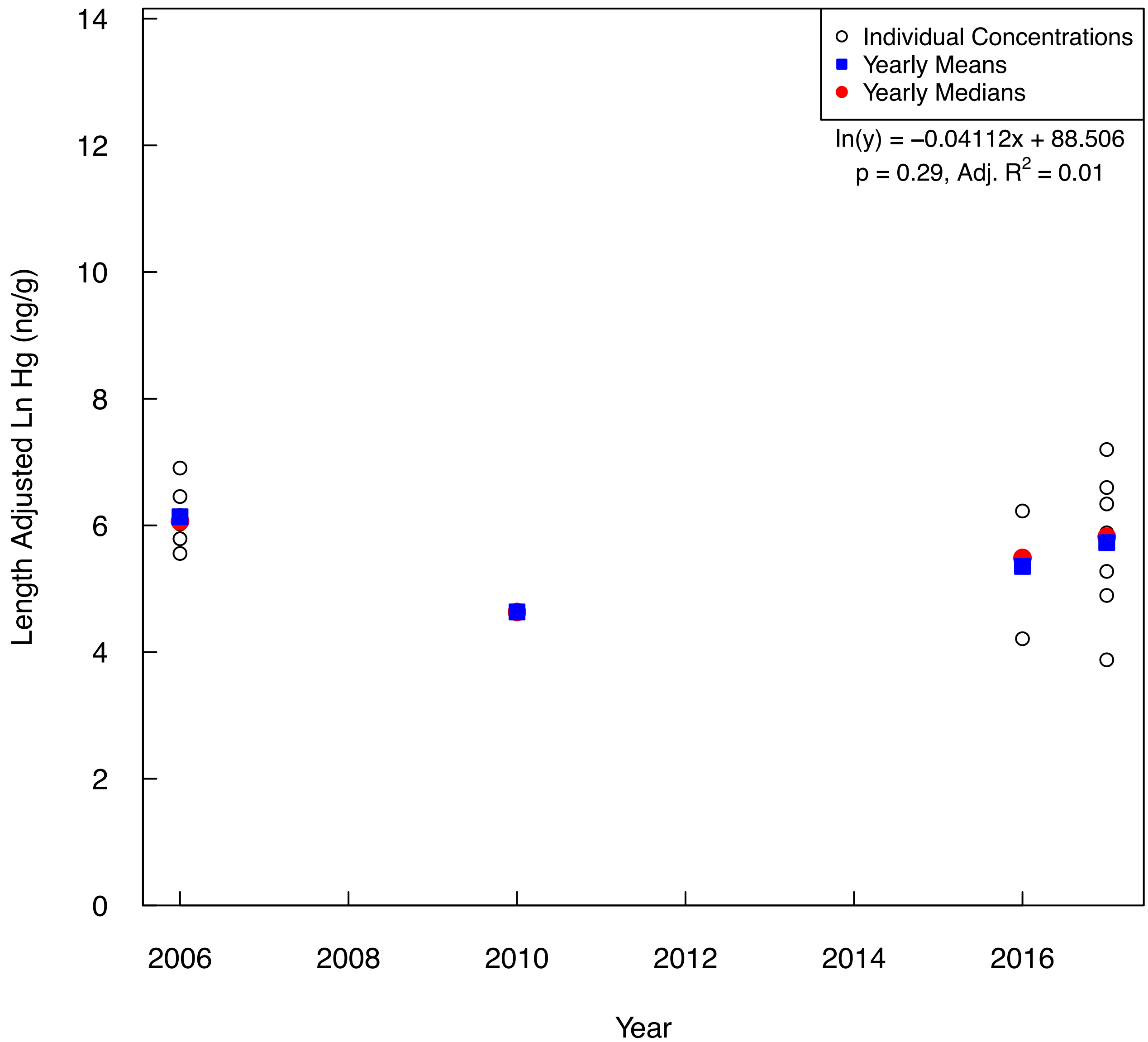
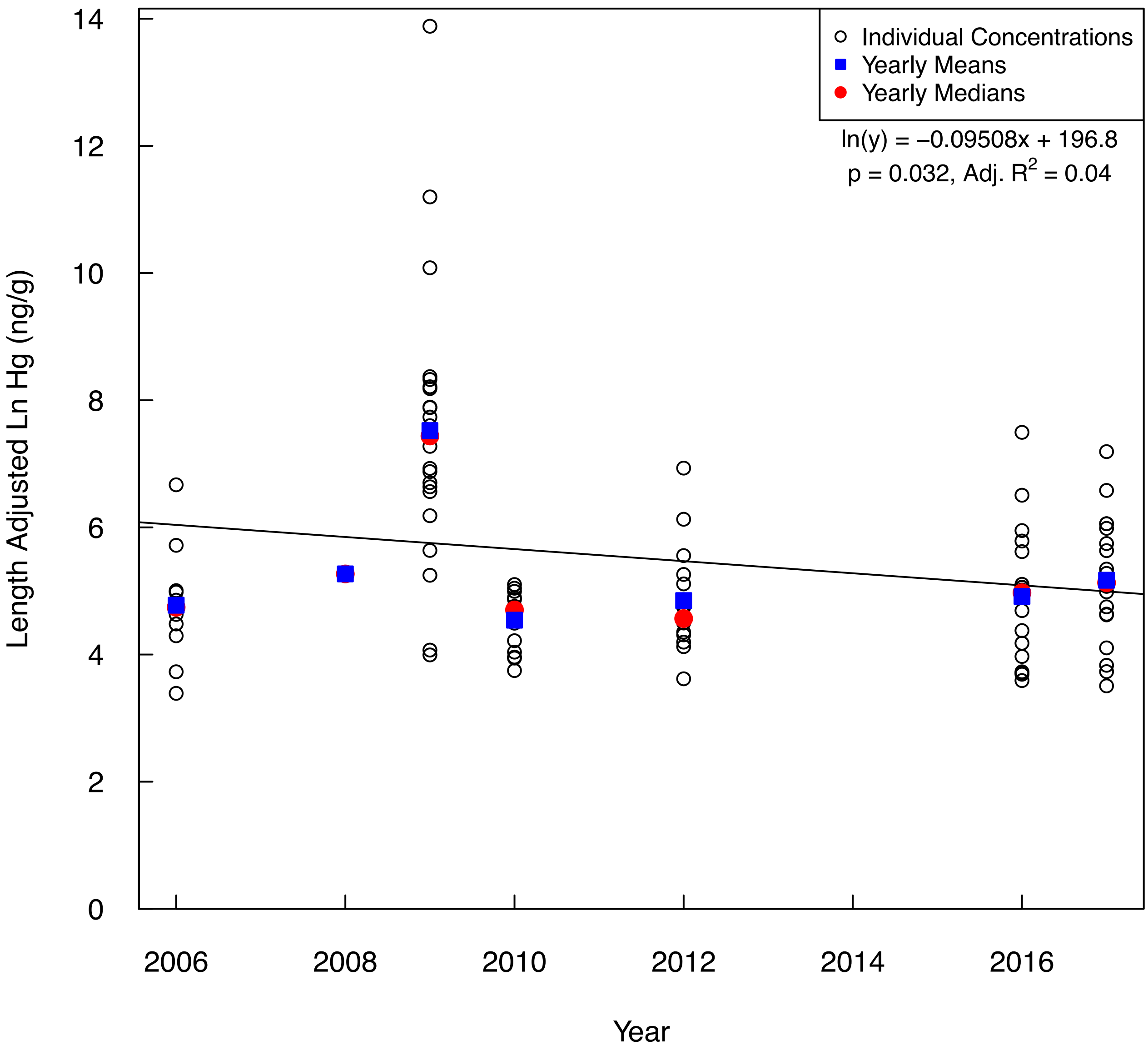


**Figure 4–72**
**Atlantic Tomcod – OB–05**
**Length Adjusted Loglinear Regression**



# Figure 4–73
## Atlantic Tomcod – OB–01
## Length Adjusted Loglinear Regression

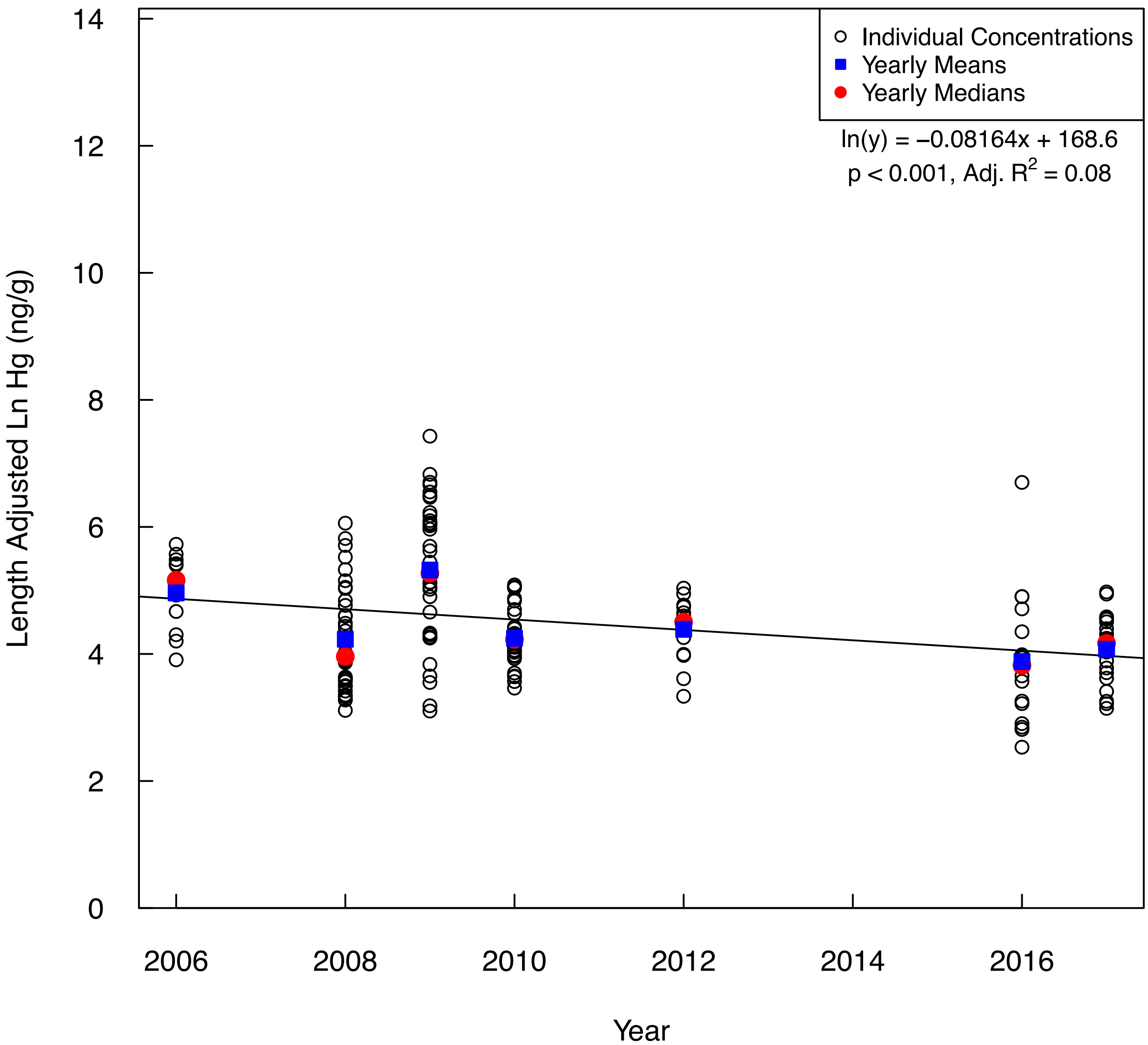


**Figure 4–74**
**Atlantic Tomcod – ES–13**
**Length Adjusted Loglinear Regression**

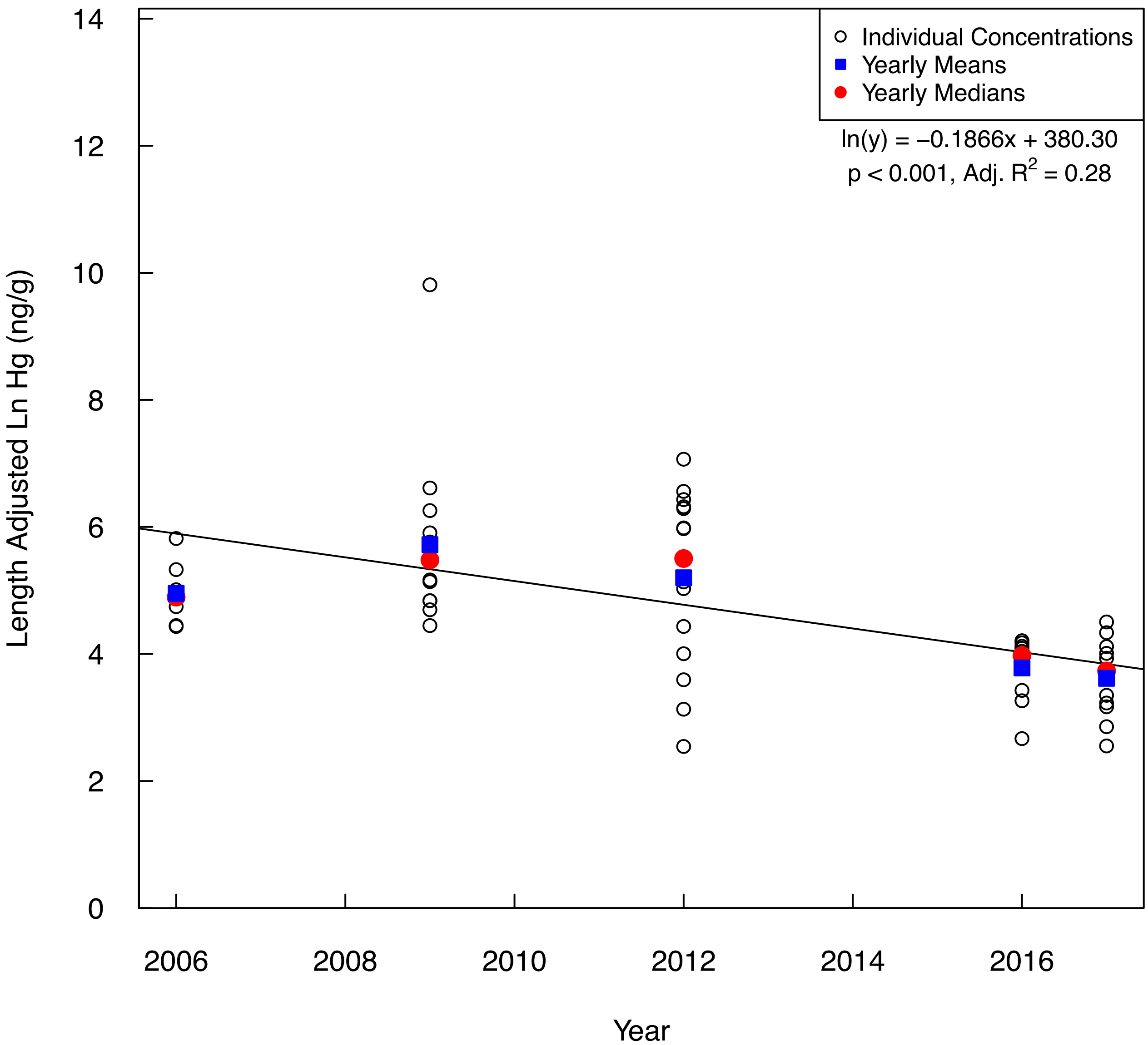


**Figure 4–75**
**Atlantic Tomcod – ES–FP**
**Length Adjusted Loglinear Regression**