2016 BIOTA MONITORING REPORT

Penobscot River Phase III - Engineering Study
Penobscot River, Maine

Prepared for:

United States District Court

District Of Maine

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LIST OF ACRONYMS

Amec Foster Wheeler	Amec Foster Wheeler Environment & Infrastructure, Inc.
BO	Brewer to Orrington
cm	Centimeter
COC	Chain of custody
Court	United States District Court for the District of Maine
DEP	Department of Environmental Protection
DUP	Duplicate
ES	Estuary
Estuary	Penobscot River Estuary
Eurofins	Eurofins Frontier Global Sciences, Inc.
Ft	Foot
g	Gram
GPS	Global Positioning System
HoltraChem	HoltraChem Manufacturing Company, LLC
km	Kilometer
MBOH	Maine Bureau of Health
MCDC	Maine Center for Disease Control and Prevention
ME	Maine
MM	Mendall Marsh
MS	Matrix spike
MSD	Matrix spike duplicate
ng/g	Nanograms per gram
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
OB	Orrington to Bucksport
OV	Orono to Veazie
Plan	Biota Monitoring Plan
PRMS	Penobscot River Mercury Study
PRMSP	Penobscot River Mercury Study panel
QA	Quality assurance
QAPP	Quality Assurance Project Plan
QC	Quality control
SDG	Sample delivery group
SE	Southeast
SOP	Standard Operating Procedure
SW	Southwest
TED	Technical Environmental Database
µL	Microliter
US	United States
USACE	United States Army Corps of Engineers
USEPA	United States Environmental Protection Agency
USFWS	United States Fish and Wildlife Service
W	Wetland/marsh platform

EXECUTIVE SUMMARY

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. 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 an 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 to determine current concentrations in biota 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 mercury in the Penobscot River Estuary in 2016. Biota data are used for: 1) documenting patterns of mercury concentrations in biota within the Penobscot River Estuary; 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. Future reports will use the biota data to understand the sediment to biota relationship and assess the potential for risk to potential receptors.

Twelve species/groups were selected to be representative of various trophic levels of terrestrial and aquatic species. Low trophic level species include terrestrial insects (collected as composite samples of many species), spiders (collected as composite samples of many species), polychaetes (collected as composite samples of species), and blue mussels. Mid and upper trophic level species include 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 which had samples collected as recently as winter 2014. The addition of 2016 data provides an update on tissue concentrations. Additional sampling in 2017 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.

Overall, mercury concentrations in aquatic biota (lobster, blue mussel, rainbow smelt, eel, tomcod, and mummichog) in the Penobscot River are generally decreasing (0.5 to 9 percent annual decline) or not changing, indicating the potential for some natural attenuation. Avian species at two locations (South Verona and Mendall Marsh SE) and blue mussels at one location had increasing mercury concentrations (3.4, 0.6, and 0.4 percent annual increase). Low trophic and terrestrial mid-trophic level species (one shellfish, two songbird, and one waterfowl 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 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 was dependent on the species. For many species, mercury concentrations decreased with distance downstream (on ebb tide).

1.0 INTRODUCTION

1.1 Purpose, Scope, And Objectives

This report describes the results of biota monitoring for mercury in the Penobscot River Estuary (Estuary) in 2016. 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 (ME) is the second-largest river in New England. The Estuary has a surface area of approximately 90 square kilometers (km) (35 square miles) and extends 35 km (22 miles) southward from Bangor, ME to about Searsport, ME, with Penobscot Bay extending farther south (**Figure 1-1**). A chlor-alkali plant located in Orrington, ME 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 (HoltraChem) 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 a Study Panel (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). The most recent report of sediment, surface water, and biota monitoring data was presented in the 2012 monitoring report (PRMSP, 2013b) and the 2014 black duck report (PRMSP, 2014).

Amec Foster Wheeler Environment & Infrastructure, Inc. (Amec Foster Wheeler) entered into an agreement with the United States District Court for the District of Maine (the Court) on February 2, 2016 to conduct an Engineering Study to identify and evaluate potential effective and cost-effective measures to remediate mercury present in the Penobscot River, from the former Veazie Dam south to Upper Penobscot Bay, including Mendall Marsh and the Orland River. As a component of this work, the Court awarded Amec Foster Wheeler the task of conducting biota monitoring in 2016, to continue the monitoring conducted primarily between 2006 and 2012 in the PRMS. 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 details 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.

This 2016 Biota Monitoring Report focuses upon the biota monitoring activities and the resulting data for the sampling period of July 2016 through February 2017. The 2016 biota monitoring results presented in this report are also used in conjunction with the historical data to assess temporal patterns of mercury and methyl mercury concentrations in the biota of the Penobscot River and Estuary. The 2016 sediment and surface water monitoring is addressed in a separate monitoring report prepared by Amec Foster Wheeler (Amec Foster Wheeler, 2017b).

1.2 Report Organization

- Section 1.0 - Introduction presents the purpose and organization of this 2016 Biota Monitoring Report.
- Section 2.0 - Approach, Methods, and Criteria summarizes the process, plan, criteria, and rationale for sampling.
- Section 3.0 - 2016 Biota Analytical Results presents the analytical results and discusses spatial mercury and methyl mercury distributions.
- Section 4.0 - Temporal Trends of Mercury presents the statistical analysis comparing 2016 results temporally with historical data spanning back to 2006.
- Section 5.0 - Conclusions and Recommendations presents the significant findings of the evaluations conducted in Section 4.0, and recommends species, frequency, and locations for long-term monitoring of biota related to remediation activities. This section also provides guidance for the risk assessment.
- Section 6.0 - References provides references to documents cited within this report.

2.0 SAMPLING APPROACH AND METHODS FOR BIOTA

Amec Foster Wheeler developed and implemented a Biota Monitoring Plan (Amec Foster Wheeler, 2016a) for the sample collection of various species of biota in the Estuary ecosystem. Priority was placed on species that provide the most information about potential system recovery and human health risk. In addition, to support temporal and spatial trend analysis, priority was placed on locations that have sufficient prior 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.)
  - Blue mussels (*Mytilus edulis*)
  - American lobster (*Homarus americanus*)
- Fish
  - American eel (*Anguilla rostrata*)
  - Atlantic tomcod (*Microgadus tomcod*)
  - Rainbow smelt (*Osmerus mordax*)
  - Mummichog (*Fundulus heteroclitus*)

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). **Table 2-1** lists the species collected by location. **Figure 2-1** depicts the Estuary biota locations. **Figure 2-2** depicts the reference biota locations. The following sections describe the methodology for sample collection. **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 (USFWS), United States Geological Survey, and National Oceanic and Atmospheric Administration (NOAA) (**Appendix A-1**).

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 collected from representative sample areas using hand nets and captured by using tweezers and sample collection containers (see Spider and Insect Sampling Standard Operating Procedures (SOP) S-11 in the draft Penobscot River Estuary Phase III Engineering Evaluation Quality Assurance Project Plan (QAPP) [Amec Foster Wheeler, 2016b]). The nets were swept over and through the marsh grasses to flush and capture invertebrates. Incidental debris and vegetation were removed. Coordinates of the sample locations were collected using a hand-held Global Positioning System (GPS) unit. The terrestrial insects were separated 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 (g) 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. in Bothell, Washington (Eurofins). Terrestrial insect and spider samples were analyzed for mercury (EPA Method 1631e), methyl mercury (EPA Method 1630), and percent lipids (Method: NOAA 1993a).

2.1.3 Terrestrial Insect and Spider Sample Quantity

The goal was to collect and analyze 5 composite samples of terrestrial insects and 5 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 2 g of tissue was to be collected per sample (1 g for mercury and methyl mercury, and 1 g for percent lipids). Five composite terrestrial insect samples were collected at each of 3 locations for a total of 15 composite terrestrial insect samples from the Estuary and 5 composite terrestrial insect samples from the reference location on the Pleasant River near Addison, ME. Similarly, 5 composite spider samples were collected at each of 3 locations for a total of 15 composite spider samples from the Estuary and 5 composite spider samples from the reference location on the Pleasant River near Addison, ME. See **Table 2-1** for sample locations and quantities.

2.2 Bird Species

The three bird species (red-winged blackbird (*Agelaius phoeniceus*), Nelson's sparrow (*Ammodramus nelsoni*), and American black duck (*Anas rubripes*)), which were sampled historically, were sampled again in 2016.

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 including 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, 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.

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 then immediately taken to the bird processing location to process and release the birds as quickly as possible 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 was located 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 Bleeding

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 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 3 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 placed on dry ice for transport to the field station. Needles were disposed of in a sharps container. Samples were shipped via COC procedures on dry ice to Eurofins. Samples were analyzed for mercury (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
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 of the mist nets at the sample location were collected using a hand-held GPS unit.

2.2.3 Songbird Sample Quantity

No more than three 70 µL capillary tubes of blood were collected per sample. A total of 52 Nelson's sparrow samples were collected from 4 sample locations, and a total of 3 red-winged blackbird samples were collected from 1 sample location. 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) 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 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 which 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 Cannon Net

The net was accordion folded along one edge, concealed with seaweed and attached to the ground. The projectiles are metal cylinders with threaded caps on one end and ports for gasses to escape on the opposite end. The cylinder projectiles are 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 cannon net.

Coordinates of the sample location (traps/ nets) were collected using a hand-held GPS unit. Sample identification numbers and date of collection were recorded on the field data record (**Appendix A-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 Blood

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 that were released were banded, aged, and sex determined prior to release. The capillary tubes were placed in a plastic tube for each bird sample, labeled, and placed on dry ice for transport to Eurofins. Samples were analyzed for mercury (Method 1631e).

Five ducks from each sampling location were euthanized after blood was drawn for breast muscle tissue collection (see section 2.2.5.2).

2.2.5.2 Tissue

Tissue from euthanized ducks was collected after blood was drawn. Both halves of the breast muscle tissue were collected from each duck. A shallow incision was made along the sternum and just below the breast muscles. The knife was inserted into the incision and the incision was lengthened along the ribs extending the cut on each side of the breast up to the wishbone. The knife was used to sever any remaining connections. Samples were placed in labeled sealable sample bags and frozen. Samples were shipped via chain of custody procedures on dry ice to Eurofins. Samples were analyzed for mercury (Method 1631e) and percent lipids (Method: NOAA 1993a).

2.2.6 American Black Duck Sample Quantity

Fifteen blood samples and 5 breast muscle samples were collected from each sample location. A total of 45 American Black Duck blood samples and 15 muscle samples were collected from 45 ducks at 3 locations. See **Table 2-1** for sample locations and quantities.

2.3 Aquatic Invertebrate Species

Polychaetes (*Glycera* spp.), blue mussel (*Mytilus edulis*), and American lobster (*Homarus americanus*) were sampled in 2016.

Polychaetes are a common prey item for many fish species, lobsters, and the black duck.

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 3-8**). 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 3-8**).

2.3.1 Polychaete Sample Processing

Polychaetes were collected within the top 0.25-foot (ft) interval of sediment (see Polychaete Sampling SOP S-15). Surficial sediment (0.25 ft) at the polychaete sample locations was collected using a hand shovel or stainless steel spoon. The 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 at a depth of 0.25 ft 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 polychaetes sample was recorded. The polychaetes were placed in sample containers with lab 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 of the sample location were collected using a hand-held GPS unit.

2.3.1.1 Polychaete Sample Processing

The polychaete samples in laboratory saline water were recorded for date of collection and allowed to depurate in the field laboratory at ambient temperature for 48 hours. The intent of the laboratory saline water was to allow the polychaetes to depurate the sediment from within the gut. After 48 hours, the sample container was drained and the polychaetes were rinsed with laboratory provided DI water before returning the polychaetes to the sample container. The mass of the composite polychaetes was recorded of the post-depuration samples. Sample weight was measured using a digital scale with 0.1 g accuracy. The depurated polychaete samples were preserved in a cooler containing dry ice. Samples were shipped via chain of custody procedures on dry ice to Eurofins. Polychaete samples were analyzed for mercury (Method 1631e), methyl mercury (Method 1630), and percent lipids (Method: NOAA 1993a).

2.3.1.2 Polychaete Sample Quantity

A minimum target mass of 3 g of tissue was to be collected per polychaete sample. If the sample mass was not achieved within the field event schedule, the area of sampling was widened concentrically to collect the specimens into a composited sample to achieve minimum mass requirements for chemical analysis (1 g for mercury and methyl mercury and 2 g for percent lipids). A total of 30 polychaete samples were collected from 6 locations. See **Table 2-1** for sample locations and quantities.

2.3.2 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. 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.

2.3.3 Blue Mussel Processing Procedures

Coordinates of the sample location were obtained using a hand-held GPS unit. Sample weight was measured using a digital scale with 0.1 g 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 (Method 1631e) and percent lipids (Method: NOAA 1993a). Sample identification numbers and date of collection were recorded on the field data record (**Appendix B-1**).

2.3.4 Blue Mussel Sample Quantity

A total of 80 blue mussels were collected from 4 sample locations. See **Table 2-1** for sample locations and quantities.

2.3.5 American Lobster Collection Procedures

American lobsters were captured by lobster trap described in the 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 48 inches by 21 inches by 13-1/2 inches. Both vented and non-vented traps were deployed. The vent is for smaller lobsters to escape. Each trap was on a single buoy. The traps were deployed in the desired sample collection location for 2 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 removing from the trap.

Coordinates of the sample location were collected using a hand-held GPS unit. Sample weight was measured using a digital scale with 0.1 g 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**.

2.3.6 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 (Method 1631e) and percent lipids (Method: NOAA 1993a).

2.3.7 American Lobster Sample Quantity

A total of 100 American lobster were collected from 5 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 2016.

Mummichog were chosen because these fish are typically found in brackish environments and are a prey fish, representing a lower trophic level fish. Mummichog have similar qualities to the tomcod, but 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 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 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. There was insufficient time after the initial sampling week in August, to re-mobilize before trapping would have collected both silver and yellow eels which would not have been representative of estuary conditions. Additional American eel collection was postponed until 2017.

2.4.1 Fish Collection Procedure

Fish were captured by various traps and nets using handling techniques described in the 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 are approximately 1-ft square by 3-ft long wire traps with a 2.5-inch by 2.5-

inch “funnel” that runs 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 ft in diameter with 0.5-inch mesh and 5 metal hoops spanning the 20-ft length. An illustration of a hoop net is provided in **Appendix B-2.** 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 (NMFS) and USFWS concerns related to the potential for interacting and/or capturing threatened and endangered species during the targeted sampling period. However, NMFS 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 ft by 50 ft 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. An illustration of a seine net is provided in **Appendix B-2.** 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 17-1/2 inches long and with a narrow, conical opening on each end. An illustration of a minnow trap is provided in **Appendix B-2.** 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 of each trap or net were collected using a hand-held GPS unit. 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 g accuracy. A target sample mass of 5 g was required for chemical analysis, but if necessary due to fish size, the minimum sample mass allowable was 3 g. If individual fish were too small to meet the 3 g 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 the statistical evaluation of data increases sample size. 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 A-2**). Samples were shipped via chain of custody procedures on dry ice to Eurofins. Samples were analyzed for mercury (Method 1631e) and percent lipids (Method: NOAA 1993a).

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 upon license 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 SOP S-19. 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) and duplicate (DUP) samples. Quality control samples were sent with field samples to the laboratory. QC samples sent to the laboratories from the field included temperature

blanks, equipment blanks, field blanks, field duplicates, and extra sample volumes for MS/MSD analyses. Equipment blanks were collected to verify the process of decontaminating field equipment as outlined in SOP S-17.

The laboratories separated the field samples into sample delivery groups (SDGs) based upon 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 provided 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 (USEPA, 2009). Data validation was completed using National Functional Guidelines for Inorganic Superfund Data Review (USEPA, 2014) and EPA New England Environmental Data Review Supplement for Regional Data Review Elements and Superfund Specific Guidance/Procedures (USEPA, 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
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.

Laboratory results were loaded to Amec Foster Wheeler's Technical Environmental Database (TED) 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 as **Appendices D and E**, respectively.

2.6 Statistical Methods

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 and 2016 with the exception of black duck data which included data from 2011 to 2014. Field duplicates were not included in the data set. All data at a location were used in statistical analysis; data were not tested for outliers.

Total 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. 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 dataset. By adjusting mercury concentrations by median length for the entire dataset, fish concentrations and trends are comparable among sampling locations. The central tendency of length (median rather than the average) of the dataset 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. An example calculation only using three samples from the data is provided here:

Sample	Mercury (nanograms per gram [ng/g])	Length (centimeters [cm])	Length-Adjusted Mercury (ng/g)
1	994	7.3	994
2	1104	6.2	1300
3	1247	7.3	1247

Median Length = 7.3 cm

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

Total 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 less data were available and data 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.

Correlations of tissue types were conducted using Spearman Ranks to account for non-normal data.

The statistical evaluation of biota data was conducted using the publicly available statistical software package “R”, version 3.3.2 (R Core Team 2016). 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.

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 (when analyzed) results by species and location are presented in **Appendix C** (wet weight). Lipid results are presented in **Appendix C** for each species and location, when analyzed, but not presented in this report.

3.1 Terrestrial Invertebrate Monitoring Results

3.1.1 Terrestrial Insects

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, Mendall Marsh Southeast (SE) and Mendall Marsh 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.

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 Mendall Marsh SE to 354 ng/g also at location Mendall Marsh SE (**Table 3-1; 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, likely due to the influence of the Mendall Marsh area, as median mercury concentrations would generally be hypothesized to decrease downstream (on ebb tide) (**Figure 3-1a**). From W-17-N (upstream of Mendall Marsh) to Mendall Marsh SE and Mendall Marsh SW, median insect mercury concentrations in 2016 samples by location were 30.4, 222, and 47.5 ng/g, respectively. 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. Birds consume multiple taxa and are exposed to a range of mercury concentrations represented by these composite samples.

Methyl mercury concentrations in terrestrial insect samples ranged from 2.5 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 6.9 ng/g at location Mendall Marsh SE to 241 ng/g also at location Mendall Marsh SE (**Table 3-1**), with a median concentration of 33.5 ng/g. The concentration of methyl mercury was 62 percent (mean) of total mercury concentrations in terrestrial insect composite samples collected in 2016. Similar to total 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 Mendall Marsh SE to Mendall Marsh SW, median terrestrial insect methyl mercury concentrations in 2016 samples by location were 56.7, 91.2, and 26.8 ng/g, respectively. There also appear to be two levels of methyl mercury concentrations in the insect samples similar to total mercury. The difference in concentration could be associated with the order of the insects within the composite samples. Birds consume multiple taxa and are exposed to a range of methyl mercury concentrations represented by these composite samples.

3.1.2 Spiders

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 of the Penobscot River marsh platform (W-17-N, Mendall Marsh SE and Mendall Marsh SW; **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), 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 Mendall Marsh SW to 771 ng/g at location Mendall Marsh SE (**Table 3-2; 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 (**Table 3-2**). From W-17-N (upstream of Mendall Marsh) to Mendall Marsh SE to Mendall Marsh SW, median spider mercury concentrations in 2016 samples by location were 263, 205, and 219 ng/g, respectively. There also appear to be two levels of mercury concentrations in the spider samples similar to the insect samples. The difference in concentration could be associated with the family of the spiders within the composite samples. Birds consume multiple taxa and are exposed to a range of mercury concentrations represented by these composite samples.

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 Mendall Marsh SE to 642 ng/g at location W-17-N (**Table 3-2; Figure 3-2b**), with a median concentration of 217 ng/g. The concentration of methyl mercury was 79 percent (mean)

of total 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 (**Table 3-2**). From W-17-N (upstream of Mendall Marsh) to Mendall Marsh SE to Mendall Marsh SW, median spider methyl mercury concentrations in 2016 samples by location were 282, 174, and 217 ng/g, respectively. 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 within the composite samples. 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

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

Mercury concentrations in Nelson's sparrow ranged from 290 to 740 ng/g, with a median of 467 ng/g at the Pleasant River reference location (**Table 3-3**). 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 (**Table 3-3**), with a median concentration for sparrows collected in the Penobscot River marsh platform in 2016 of 5,730 ng/g.

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 (on ebb tide) (**Table 3-3**). From W-17-N (upstream of Mendall Marsh) to Mendall Marsh SE to Mendall Marsh SW, median sparrow mercury concentrations in 2016 samples by location were 5,000, 6,130, and 5,840 ng/g, respectively (**Figure 3-3**).

The blood effect level recommended in the Technology Screening Report (Amec Foster Wheeler, 2017c) for mercury concentrations in Nelson's sparrow blood is 3,000 ng/g (Hallinger and Cristol, 2011; Fuchsman et al., 2017). From W-17-N (upstream of Mendall Marsh) to Mendall Marsh SE to Mendall Marsh SW, the percentage of sparrows with blood mercury concentrations in 2016 above the effect level was 60 percent, 100 percent, and 100 percent.

3.2.2 Red-winged Blackbird

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 (**Table 3-4; 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 Technology Screening Report (Amec Foster Wheeler, 2017c) for mercury concentrations in red-winged blackbird blood is 3,000 ng/g (Hallinger and Cristol, 2011; Fuchsman et al., 2017). The percentage of blackbirds with mercury concentrations above the effect level was 33 percent.

3.2.3 American Black Duck

A total of 45 American black ducks were captured for blood and tissue samples during winter 2017, which were analyzed for mercury. The 45 ducks were sampled for blood, while 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**).

3.2.3.1 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 3-5; Figure 3-5a**). 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 (**Table 3-5**), with a median concentration for black duck blood collected in the Estuary in 2017 of 400 ng/g.

3.2.3.2 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 3-6; Figure 3-5b**). 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 (**Table 3-6**), with a median concentration for black duck tissue collected in the Estuary in 2017 of 348 ng/g.

3.2.3.3 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 (on ebb tide) (**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 while median black duck blood concentrations were higher in Mendall Marsh (504 ng/g) than at South Verona (377 ng/g) in 2017 (**Table 3-5**). 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 duck tissue human consumption effect level for mercury is 200 ng/g (based on Maine Center for Disease Control and Prevention (MCDC) [formerly Maine Bureau of Health] freshwater finfish tissue action levels and assumes a similar number and size of meals as for fish ingestion; PRMSP, 2013b). The percentage of black ducks with breast muscle tissue mercury concentrations in excess of the state limit were 40 percent at Mendall Marsh, and 100 percent at South Verona (**Table 3-6**). All of the 2017 black duck blood samples from the Penobscot River Estuary were less than 1,000 ng/g except for one duck blood sample at 1,400 ng/g at Mendall Marsh. The Frenchman Bay reference location duck blood samples were less than 110 ng/g (**Table 3-5**).

3.3 Aquatic Invertebrate Monitoring Results

3.3.1 Polychaetes

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, MMPOLY/Mendall Marsh, 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 4 of the 5 polychaete samples collected at the Frenchman Bay reference location were non-detect while one sample had a mercury concentration of 3.18 ng/g (**Table 3-7; Figure 3-14a**). In contrast within the Estuary, polychaete mercury concentrations ranged from 12.8 ng/g at location ES-13 to 321 ng/g at location MMPOLY in Mendall Marsh (**Table 3-7; 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 (on ebb tide) 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 (on ebb tide), median polychaete mercury concentrations in 2016 samples by location were 185, 215, 190, 24.7, and 24.5 ng/g, respectively (**Table 3-7**).

Methyl mercury was not detected in polychaetes collected at the Frenchman Bay reference location (**Table 3-7; 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 (**Table 3-7; 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 total mercury. From upstream to downstream (on ebb tide), 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 3-7**). The concentration of methyl mercury was 8.6 percent (mean) of total mercury concentrations in polychaete composite samples collected in 2016.

3.3.2 Blue Mussel

A total of 80 blue mussel samples were collected and analyzed (whole body) for mercury during 2016. The mussels were collected from four areas in the Estuary (ES-15, ES-13, ES-03, ES-FP; **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 (**Table 3-8**), 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 (on ebb tide), median blue mussel mercury concentrations in 2016 samples by location were 56.9, 60.9, 77.5, and 58.9 ng/g, respectively (**Table 3-8**).

3.3.3 Lobster

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 (**Table 3-9**), 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 (on ebb tide) (**Figure 3-8**). From upstream to downstream (on ebb tide), median lobster mercury concentrations in 2016 samples by location were 207, 366, 180, 164, and 102 ng/g, respectively (**Table 3-9**). 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.

The State of Maine fish tissue action level of 200 ng/g (MBOH, 2001) for mercury was assumed for shellfish tissue (e.g., lobster). As with mercury concentrations, the percentage of lobster with mercury concentrations in excess of the advisory level generally decreases downstream (on ebb tide). From upstream to downstream (on ebb tide), the percentage of lobster with mercury

concentrations at or above the advisory level were 55 percent, 90 percent, 35 percent, 20 percent, and 0 percent in 2016 (**Table 3-9**). Again, it should be noted that the percentage of lobster mercury concentrations above the advisory level at South Verona (90 percent) does not follow the general decreasing pattern downstream.

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. Lobsters forage readily on the bait in lobster traps and represent mercury concentrations in dietary items whether bait or natural prey items. Lobster movements/migration and interannual variability also affect lobster tail concentrations. In the absence of baited traps, the diet of lobsters is composed entirely of natural prey items and lobsters are not subject to harvesting pressure.

3.4 Fish Monitoring Results

3.4.1 Mummichog

A total of 65 mummichog samples were collected and analyzed (whole body) for mercury during 2016. Mummichog were collected from four areas in the Estuary (BO-04, OB-05, OB-01, and Mendall Marsh; **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 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 4.94 to 13.5 ng/g at the Frenchman Bay reference location, with a median of 7.96 ng/g (**Table 3-10**). 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 (**Table 3-10**), 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 (on ebb tide) (**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 (on ebb tide), median mummichog mercury concentrations in 2016 samples by

location were 71.2, 89.1, 134, and 159 ng/g, respectively. Few samples were collected at the two downstream locations (i.e., OB-01 [1 sample] and Mendall Marsh [4 samples]).

3.4.2 Rainbow Smelt

A total of 62 rainbow smelt samples were collected and analyzed (whole body) for mercury during 2016. Smelt were collected from five areas in the Estuary (OB-05, OB-04, OB-01, ES-15, and ES-FP; **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 2 to 3. Individual samples were collected from OB-05 (1 sample), OB-04 (5 samples), OB-01 (15 samples), and ES-15 (1 sample). Samples for smelt were obtained from NOAA trawls which spanned a stretch of river and were matched as closely as possible to target locations identified in the 2016 Biota Monitoring Plan. 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 3-11; 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) (**Table 3-11; 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 (on ebb tide) than 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 (on ebb tide), median smelt mercury concentrations in 2016 samples by location were 201 (OB-05 – 1 sample), 54.9 (OB-04), 90.8 (OB-01 just outside of Mendall Marsh), 38.4 (ES-15 – 1 sample), and 55.4 (ES-FP) ng/g, respectively (**Table 3-11**).

3.4.3 American Eel

A total of seven American eel were collected and analyzed (whole body) for mercury during 2016. Eels were collected from three areas in the Estuary (BO-04, OB-05, and OB-01; **Figure 3-11**). All eel met the target sample weight and were analyzed as individual samples; no composite samples were required.

Mercury concentrations in American eels ranged from 391 ng/g at location OB-05 to 1,370 ng/g at location BO-04 (**Table 3-12; 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.

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

Although a tissue effects level of 200 ng/g, which is based on human consumption of fish (advisory level), would be the preferred goal, a target level below regional upstream/reference station concentrations may not be achievable. The mean of eels collected historically (2007 to 2012 unadjusted data) in the OV reach for mercury concentrations in American eel is 310 ng/g. American eels in the OV reach tend to be longer than eels captured at downstream locations. The upstream reference mercury concentration in American eels will be updated once additional eels are collected and analyzed. All seven of the American eels collected and analyzed in 2016 were above the mean mercury concentration for OV reach data (**Figure 3-11**).

3.4.4 Tomcod

A total of 55 Atlantic tomcod were collected and analyzed (whole body) for mercury during 2016. Tomcod were collected from five areas in the Estuary (BO-04, OB-05, OB-01, ES-13, and ES-FP; **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; no composite samples were required.

The tomcod mercury concentration (1 sample) at the Frenchman Bay reference location was 36.5 ng/g (**Table 3-13; Figure 3-14a**). In contrast, within the Estuary, tomcod mercury concentrations ranged from 55.6 ng/g at location ES-FP near Fort Point to 315 ng/g at location BO-04 (**Table 3-13; 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 (on ebb tide) (**Figure 3-12**). From upstream to downstream (on ebb tide), median tomcod mercury concentrations in 2016 samples by location were 308, 152, 174, 103, and 64.9 ng/g, respectively.

The State of Maine fish tissue action level for mercury concentrations in tomcod is 200 ng/g (MBOH, 2001). As with mercury concentrations, the percent of tomcod with mercury concentrations in excess of the advisory level generally decreases downstream (on ebb tide). From upstream to downstream (on ebb tide), the percent of tomcod with mercury concentrations above the advisory level was 75 percent, 28 percent, 32 percent, 9 percent, and 0 percent in 2016 (**Table 3-13**).

4.0 TEMPORAL TRENDS OF MERCURY IN BIOTA

Throughout this section, figures with data and regressions, correlations, or Kruskal-Wallis statistics are referenced. **Figure 4-0** presents a figure legend for these figures to aid in the interpretation of **Figure 4-1 through Figure 4-86**.

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 3 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). Figures of the data are presented with natural log transformed concentrations so that data across species can be compared. Figure titles indicate whether a statistical temporal trend evaluation was performed (e.g., Loglinear Regression) or not (e.g., Ln Mercury Concentrations). 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 2016 co-located with the songbird samples. Terrestrial insects were historically sampled in 2009 at two locations: Marshall Brook near Bass Harbor and along the Spurwink River near Cape Elizabeth, Maine. Terrestrial insects at the Pleasant River and Spurwink River locations typically have average mercury tissue concentrations of 29 ng/g (**Table 3-1**) while Bass Harbor samples showed concentrations approximately four times higher than the other two reference locations (**Figure 4-1**). No further statistical analysis was conducted to compare these data because samples were collected from multiple locations.

Terrestrial insects at the Pleasant River and Spurwink River locations typically have average methyl mercury tissue concentrations of 18 to 19 ng/g (**Table 3-1**) while Bass Harbor samples showed concentrations four to five times higher than the other two reference locations (**Figure 4-2**). Two samples at Bass Harbor and 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 2016 had detected methyl mercury concentrations. No further statistical analysis was conducted to compare these data because samples were collected from multiple locations.

Tissue composited from terrestrial insects was collected from two Mendall Marsh locations (Mendall Marsh SE and Mendall Marsh SW) and from W-17-N in 2009 and 2016 (**Figure 2-1**; figure presents 2016 only). Terrestrial insect tissue from the site typically exceeded mercury concentrations in insects sampled at the Pleasant River and Spurwink River reference locations, but were sometimes similar to concentrations at Bass Harbor. Terrestrial insects show much intra-

and interannual variability in tissue mercury concentrations (**Table 3-1; Figure 4-3 through Figure 4-6**). No further statistical analysis was conducted to compare these data because only two years of data were available.

Terrestrial insect tissue from the Estuary typically exceeded methyl mercury concentrations in insects sampled at the Pleasant River and Spurwink River reference locations, but were similar to concentrations at Bass Harbor. Insect samples collected at Mendall Marsh SW had similar methyl mercury concentrations to insects collected at the Pleasant River and the Spurwink River. Terrestrial insects show much intra- and interannual variability in tissue methyl mercury concentrations (**Table 3-1; Figure 4-7 through Figure 4-10**). No further statistical analysis was conducted to compare these data because only two years of data were available.

4.1.2 Spiders

Tissue composited from spiders was collected from the reference location on the Pleasant River in 2016 so that samples were co-located with songbird samples. Spiders were historically sampled in 2009 at two locations: Marshall Brook near Bass Harbor and along the Spurwink River near Cape Elizabeth, Maine. Spiders at the Pleasant River and Spurwink River locations typically have average mercury tissue concentrations of 35 to 44 ng/g (**Table 3-2**) while Bass Harbor samples showed concentrations approximately three times higher than the other two reference locations (**Figure 4-11**). No further statistical analysis was conducted to compare these data because samples were collected from multiple locations.

Spiders at the Pleasant River and Spurwink River locations typically have average methyl mercury tissue concentrations of 25 to 29 ng/g (**Table 3-2**) while Bass Harbor samples showed concentrations four to five times higher than the other two reference locations (**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.

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

Spider tissue from the Estuary typically exceeded methyl mercury concentrations in insects sampled at the Pleasant River and Spurwink River reference locations. Methyl mercury

concentrations in spiders at Mendall Marsh SW were similar to spider methyl mercury concentrations at Bass Harbor. Spiders show 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 only two years of data were available and samples 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. 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) and along the coast in southern Maine (Spurwink River, Scarborough River, and Moody Beach areas), New Hampshire (Great Bay area), and Massachusetts (Parker River Marshes). Nelson's sparrows at the Pleasant River reference location typically have blood mercury concentrations lower than 1,000 ng/g (**Figure 4-21**). 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, 6,337 ng/g).

Blood from Nelson's sparrows was collected from two Mendall Marsh locations (Mendall Marsh SE and Mendall Marsh SW) from 2006 to 2010, 2012, and 2016 and from W-17-N from 2008 to 2010, 2012, and 2016 (**Figure 2-1**; figure presents 2016 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 3-3**), and no overall change in blood mercury concentrations when sampling locations W-17-N, Mendall Marsh SE, and Mendall Marsh SW are considered as a combined dataset (**Figure 4-22**). Mercury concentrations significantly increased by approximately 0.6 percent per year in Mendall Marsh SE (**Figure 4-23**), but have not changed, neither increasing nor decreasing, in Mendall Marsh SW (**Figure 4-24**) or at W-17-N (**Figure 4-25**).

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. No red-winged blackbirds were observed or sampled at the Pleasant River site in 2016. 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 4-26**). 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 (Mendall Marsh SE and Mendall Marsh SW) from 2006 to 2010, and 2012. Red-winged blackbirds were targeted in 2016, but no blackbirds were captured or sampled in Mendall Marsh in 2016. Blood was collected from red-winged blackbirds from W-17-N in 2009, 2010, 2012, and 2016 (**Figure 2-1**). Red-winged blackbird blood from the site exceeded mercury concentrations in birds sampled at reference locations. Red-winged blackbirds show much intra- and interannual variability in blood mercury concentrations (**Table 3-4**). Mercury concentrations have not changed in Mendall Marsh SE (**Figure 4-27**) or in Mendall Marsh SW (**Figure 4-28**). Blood mercury concentrations in red-winged blackbirds have not changed, neither increasing nor decreasing, in W-17-N (**Figure 4-29**). No further statistical evaluation of a combined dataset is presented because only three red-winged blackbirds were sampled in 2016.

4.2.3 American Black Duck

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 4-30**). 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 were lower than in ducks collected from sites in the Estuary (**Table 3-5**).

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 2016 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 3-5**), but no overall change in blood mercury concentrations when sampling locations Mendall Marsh and South Verona are considered as a combined dataset (**Figure 4-31**). Mercury concentrations did not change in Mendall Marsh (**Figure 4-32**). Mercury concentrations significantly increased over time at South Verona, primarily due to the sample concentrations collected in 2017 compared to previous years (**Figure 4-33**).

4.2.3.2 American Black Duck Muscle

Duck muscle at the reference location at Frenchman Bay was sampled in the winters of 2013-2014 and 2016-2017. Black duck muscle concentrations have significantly decreased since the winter of 2010-2011 (**Figure 4-34**). Black duck muscle mercury concentrations were lower than in ducks collected from sites in the Estuary (**Table 3-6**).

Muscle from American black ducks was collected at Mendall Marsh in the winters of 2010-2011, 2011-2012, 2013-2014, and 2016-2017 and at South Verona (ES-13) in the winter of 2016-2017 (**Figure 2-1**; figure presents 2016 only). American black duck muscle from the site exceeded mercury concentrations in birds sampled at the reference location. Regression of tissue mercury concentrations indicated a possible decrease in tissue concentrations through time ($p = 0.082$) in Mendall Marsh (**Figure 4-35**). Tissue concentrations at South Verona were not statistically evaluated, but were similar to duck muscle concentrations in Mendall Marsh (**Figure 4-36**).

4.2.3.3 American Black Duck Blood and Muscle Tissue Correlation

Sampling events in 2010, 2012, 2013, and 2014, black ducks were sampled for blood and breast tissue, but few samples were collected from the same birds. The majority of historical blood samples were collected from one bird group while a second set of birds were sampled historically for muscle tissue which did not allow for correlations to be developed between the two tissue types. Samples of blood and muscle collected from the same individual ducks were used to develop a correlation for muscle and blood tissues from 2011, 2014, and 2017.

Twenty-three ducks were sampled for blood and muscle tissue and used to develop a significant, positive correlation between these two tissues. The correlation coefficient was 0.94 (Spearman's rho; $p < 0.001$), indicating that blood and muscle concentrations are strongly correlated (**Figure 4-37**). The correlation equation is:

$$\text{muscle mercury (ng/g ww)} = 0.7956 * \text{blood mercury (ng/g ww)} + 25.0515$$

Blood mercury concentrations are an indication of recent exposure to mercury whereas tissue muscle mercury concentrations show bioaccumulation of mercury. As shown in the equation, it is possible that ducks have detectable concentrations of mercury in muscle tissue and not in blood. Because ducks migrate, tissue mercury concentrations (more indicative of a longer time period of exposure including some time from where the ducks migrated and some time 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.

4.3 Aquatic Invertebrates

4.3.1 Polychaetes

Tissue composited from polychaetes was collected from the reference location in Frenchman Bay in 2016 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 have mercury tissue concentrations between 15 and 30 ng/g (**Table 3-7**) while OV-04 samples showed concentrations approximately two to four times higher than the East Branch Penobscot River

reference location and more than an order of magnitude greater than Frenchman Bay polychaete mercury concentrations (**Figure 4-38**). Frenchman Bay polychaete mercury concentrations were non-detect except for one sample with a concentration of 3.18 ng/g. 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.

Polychaetes at the OV-04 location (2 samples) had methyl mercury concentrations of 2.21 and 3.21 ng/g (**Table 3-7**) while Frenchman Bay samples (5 samples) had non-detect methyl mercury concentrations (**Figure 4-39**). 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.

Tissue composited from polychaetes was collected from three locations (BO-04, ES-13, and ES-FP) in 2009 and 2016 and two location (OB-05 and Mendall Marsh) in 2016 (**Figure 2-1**; figure presents 2016 only). Polychaete tissue from the site exceeded mercury concentrations in polychaetes sampled at the reference locations. Polychaetes show some intra-annual variability in tissue mercury concentrations (**Table 3-7**), but no overall change in mercury concentrations when sampling locations BO-04, ES-13, and ES-FP are considered as a combined dataset (**Figure 4-40 through Figure 4-45**). No further statistical analysis was conducted to compare these sites because only two years of data were collected.

Polychaete tissue from the site exceeded methyl mercury concentrations in polychaetes sampled at the Frenchman Bay reference location. Polychaete methyl mercury tissue concentrations at ES-13 were similar to concentrations at OV-04. Polychaetes show some intra-annual variability in tissue methyl mercury concentrations (**Table 3-7**), suggest a decrease in methyl mercury concentrations when sampling locations BO-04, ES-13, and ES-FP are considered as a combined dataset (**Figure 4-46 through Figure 4-51**). No further statistical analysis was conducted to compare these sites because only two years of data were collected.

4.3.2 Blue Mussel

Blue mussels were collected in 2009 in the Narragaugus River and in the St. George River outside the influence of the Estuary (**Figure 4-52**). Additional, recently collected data (since 2006) from the NOAA program Mussel Watch was evaluated. Two samples in 2007 and two samples in 2011 from the Maine coast are included as reference samples. One sample result in each year was collected near Stover Point in Merriconeag Sound and near Kennebunkport in Cape Arundel. Mussel data from near Searsport are not presented as this site is influenced by the Estuary. No further statistical analysis to compare these reference data was conducted because samples were collected from multiple locations and years.

Blue mussels were collected from four locations (ES-15, ES-13, ES-03, and ES-FP) in 2006, 2008 to 2010, 2012, and 2016 (**Figure 2-1**; figure presents 2016 only). In some years, mussels were not collected from one of these four locations (**Table 3-8**). Blue mussels from the Estuary

exceeded mercury concentrations in mussel sampled at the reference location. Overall, blue mussel tissue mercury concentrations showed a statistically significant decrease in the river since 2006 when sampling locations ES-13, ES-15, ES-03, and ES-FP are considered as a combined dataset (**Figure 4-53**). Mercury concentrations decreased significantly at ES-15 (**Figure 4-54**) and at ES-13 (**Figure 4-55**). Mussel mercury concentrations have not changed statistically through time at ES-03 (**Figure 4-56**). Mercury concentrations at ES-FP showed a statistically significant increase, with more variability and some higher mercury concentrations in mussel samples in 2016 (**Figure 4-57**).

4.3.3 Lobster

4.3.3.1 Lobster Tail

Reference data for lobster are available for a handful of locations along the Maine coast. The historical samples were analyzed as composites of claw and tail tissue. These data have not been included in this report, but will be included in the risk assessment and as part of the risk reduction calculations that will be a portion of the Phase III Engineering Study Report.

Lobster were collected from four locations (Odom Ledge, South Verona, Turner Point, and Harborside) in 2006, 2008 to 2010, 2012, and 2014 to 2016 and from Cape Jellison from 2014 to 2016 (**Figure 2-1**; figure presents 2016 only). In some years, lobsters were not collected from one of these five locations (**Table 3-9**). Lobster show some intra-annual variability in tissue mercury concentrations (**Table 3-9**). 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 dataset (**Figure 4-58**). Length-adjusted mercury concentrations did not change at Odom Ledge (**Figure 4-59**). Length-adjusted mercury concentrations decreased significantly at South Verona (**Figure 4-60**), Cape Jellison (**Figure 4-61**), Turner Point (**Figure 4-62**), and Harborside (**Figure 4-63**).

4.3.3.2 Lobster Tail and Claw Tissue Correlation

Historical sampling events collected tail and claw tissue for analysis from the same lobster. Samples of tail and claw collected from the same individual lobster were used to develop a correlation for these two tissues. Lobster claws were not analyzed in 2016 due to the strength of this correlation.

A total of 1,469 lobsters were sampled for tail and claw tissue and used to develop a significant, positive correlation between these two tissues. The correlation coefficient was 0.68 (Spearman's rho; $p < 0.001$), indicating that tail and claw concentrations are strongly correlated (**Figure 4-64**). The correlation equation is:

$$\text{claw mercury (ng/g ww)} = 0.433 * \text{tail mercury (ng/g ww)}$$

4.4 Fish

4.4.1 Mummichog

Frenchman Bay was sampled as a reference location in 2016. 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, and 2016 and at BO-04 in 2006 and 2016 (**Figure 2-1**; figure presents 2016 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 3-10**). Length-adjusted mummichog tissue mercury concentrations did not change when sampling locations OB-05, OB-01, and Mendall Marsh are considered as a combined dataset (**Figure 4-65**). Length-adjusted mercury concentrations do not appear to have changed at OB-05 (**Figure 4-66**), however, three of the five years of data only have one sample. Mercury concentrations in mummichog have significantly decreased in Mendall Marsh (**Figure 4-67**). Mummichog tissue mercury concentrations at OB-01 were not statistically evaluated due to the small sample size in 2006 and 2016 (**Figure 4-68**). 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. No statistical analysis was conducted for this site because only one year of data has been collected at this location. The smelt collected at the Frenchman Bay reference location had mercury concentrations lower than fish collected in the Estuary (**Figure 4-69**).

Rainbow smelt were collected from four locations (OB-05, OB-01, ES-13, and ES-FP) in 2006, 2008 to 2010, 2012, and 2016 (**Figure 2-1**; figure presents 2016 only) with some exceptions (**Table 3-11**). Rainbow smelt from the site exceeded mercury concentrations in the smelt sampled at the reference location. Rainbow smelt show much intra- and interannual variability in tissue mercury concentrations (**Table 3-11**). 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-15, and ES-FP are considered as a combined dataset (**Figure 4-70**). Length-adjusted mercury concentrations at OB-05 (**Figure 4-71**) did not change significantly. Length-adjusted smelt mercury concentrations have significantly decreased at OB-04 (**Figure 4-72**) and OB-01 (**Figure 4-73**). Statistical analysis was not conducted for rainbow smelt samples collected at ES-15 (**Figure 4-74**). Length-adjusted mercury concentrations at ES-FP did not change significantly (**Figure 4-75**).

4.4.3 American Eel

Eels posed a challenge for sampling, with a limited number of samples collected in 2016. There was insufficient time after the initial week in August to re-mobilize before trapping would have collected both silver and yellow eels. Silver eels have migrated unlike yellow eels which are considered resident and represent local concentrations. Additional efforts to collect eel were postponed until 2017 to target yellow eels and limit capturing silver eels.

The reference location of OV-04 was sampled in 2007-2010 and in 2012. This location was intended to be sampled in 2016, but effort was focused on downstream locations because few samples were captured at these locations. No American eel were sampled at OV-04 in 2016. American eel at the OV-04 reference location length-adjusted mercury concentrations were generally lower than downstream locations and did not change among years (**Figure 4-76**).

American eel were collected from three locations (OB-01, BO-04, OB-05) from 2006 to 2010, 2012, and also in 2016 (**Figure 2-1**; figure presents 2016 only). American eel from the site exceeded mercury concentrations in eel sampled historically (2007 to 2012) at the reference location (**Table 3-12**). 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 dataset (**Figure 4-77**). Mercury concentrations in American eel have significantly decreased at BO-04 (**Figure 4-78**) and at OB-5 (**Figure 4-79**) while length-adjusted mercury concentrations have not changed at OB-01 (**Figure 4-80**).

4.4.4 Atlantic Tomcod

Frenchman Bay was sampled as a reference location in 2016. No statistical analysis was conducted for this location because only one year of data has been collected there. The one tomcod sample collected at the Frenchman Bay reference location had a mercury concentration lower than fish collected in the Estuary (**Table 3-13**).

Atlantic tomcod were collected from five locations (BO-04, OB-05, OB-01, ES-13, and ES-FP) in 2006, 2008 to 2010, 2012, and 2016 (**Figure 2-1**; figure presents 2016 only). Atlantic tomcod from the site exceeded mercury concentrations in the single Atlantic tomcod sampled at the reference location. Atlantic tomcod show much interannual variability in tissue mercury concentrations (**Table 3-13**). 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 dataset (**Figure 4-81**). Length-adjusted mercury concentrations at BO-04 (**Figure 4-82**) and OB-05 (**Figure 4-83**) do not decrease significantly, but the p-values were just above the alpha value of 0.05 (BO-04: $p = 0.055$ and OB-05: $p = 0.089$). Length-adjusted tomcod mercury concentrations have significantly decreased at OB-01 (**Figure 4-84**) and ES-13 (**Figure 4-85**). A Kruskal-Wallis statistical comparison of the two years of data at ES-FP indicated that mercury concentrations in 2016 were significantly lower than in 2012 (**Figure 4-86**).

4.5 Trending Interpretation

For the statistical evaluation figures, the 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 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.

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 (0.6 to 9 percent annual decline) or not changing, indicating the potential for some natural attenuation. Tissue concentrations in avian species typically did not show changes in concentrations (yellow highlighting on the table) whether for individual locations or when locations were considered as a combined dataset (**Table 5-1**). Avian species at two locations (South Verona and Mendall Marsh SE) and blue mussels at one location had increasing mercury concentrations (3.4, 0.6, and 0.4 percent annual increase). Tissue concentrations in aquatic biota (i.e., fish and shellfish) typically had decreasing temporal regression trends (green highlighting on the table) for individual locations and when locations were considered as a combined dataset (**Table 5-2**). Compared to the 2012 Report from the PRMS (PRMSP, 2013a), more fish showed more significant declines with the addition of 2016 data at individual locations and when the locations are combined to represent the Estuary. Songbird results were similar to what was found in the 2012 Report.

Trophic Levels

Concentrations of mercury in biota tend to be 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 blood of Nelson's sparrows were approximately an order of magnitude 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 aquatic invertebrates. Tomcod appear to fall somewhere between these two groups.

Effects Levels

Three effects levels were established for biota to be protective of fish and wildlife and human consumers of the fish and wildlife. A majority of Nelson's sparrows and one of the three sampled red-winged blackbirds had blood mercury concentrations greater than the blood effects level of 3,000 ng/g. The effects level of 3,000 ng/g is in the middle of the recommended range of effects levels for small birds such as Nelson's sparrows and red-winged blackbirds (Fuchsman et al., 2017). Seven hatch year Nelson's sparrows were banded and bled in 2016 on W-17-N and one hatch year Nelson's sparrow in 2016 at Addison. A nest with at least three red-winged blackbird

nestlings was found in Mendall Marsh SW. Reproduction is occurring on the marsh platforms for both songbird species. Also, four Nelson's sparrows were recaptured that had been banded in previous years in the same marsh. Three of these birds exceeded the previously known longevity record of 7 years, 1 month old for Nelson's sparrows, with the oldest of these being approximately 10 years old. This indicates that birds show strong philopatry (return to a particular area) and can survive for many years while exposed to elevated mercury concentrations.

For large avian species such as the black duck, Fuchsman et al. (2017) recommend a blood effects level greater than 3,000 ng/g. Black duck blood concentrations were below the effects level of 3,000 ng/g for small 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.

While black ducks do not appear to accumulate sufficient mercury concentrations to be of ecological concern relative to blood effects levels for black ducks, breast tissue mercury concentrations exceeded the duck tissue human consumption advisory level (200 ng/g) in 70 percent of the ducks. This effect level assumes a similar number and size of meals as for fish/shellfish ingestion and that tissue from biota for these meals was only harvested from the Estuary.

Lobster is a tissue that is commonly consumed and tomcod and eel are also likely consumed by humans. A substantial portion of the samples of these species analyzed were above the State of Maine fish tissue consumption advisory level of 200 ng/g. For tomcod and eel, it was more likely that samples exceeded the advisory level if the samples were collected close to the former HoltraChem facility. Tomcod from locations near Penobscot Bay (i.e., South Verona and ES-FP) typically had concentrations below the advisory level. Lobster tissues were highest and showed the majority of exceedances around Odom Ledge and South Verona. Cape Jellison and Turner Point also had a number of lobster exceedances, but these exceedances were fewer in number and the magnitude of the concentrations were lower. Outside the lobster closure area (Harborside), no lobsters exceeded the fish tissue consumption advisory level.

Spatial Distribution

It was hypothesized that mercury concentrations in biota would decrease downstream (on ebb tide), as this is farther from the site of release. However, the strong tide moves material upstream, functionally mixing mercury concentrations. Biota show different spatial patterns of mercury concentration in the river. Blue mussel and mummichog showed no strong spatial patterns of mercury concentrations within the estuary where sampled. In contrast, mercury concentrations in tomcod, smelt, lobster, and polychaetes tended to decrease farther downstream (on ebb tide). 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 background or low mercury concentrations. Polychaete mercury concentrations were nearly an order of magnitude lower between the area from the former HoltraChem facility to OB-01 and the area from South Verona to Fort Point Cove.

Polychaetes have very small home ranges and are typically good indicators of sediment concentrations in the area from which the polychaetes were collected.

Terrestrial insects, Nelson's sparrow, and black duck (muscle tissue) tended to have increasing mercury concentrations with distance downstream. This pattern is somewhat hard to distinguish given the small number of sampling locations available for collecting sparrow and duck tissue. Sparrows and insects showed higher concentrations at Mendall Marsh SE than at locations upstream (on ebb tide). This is corroborated by elevated concentrations in mummichog in Mendall Marsh SE. Biota from the area around South Verona also tended to have higher concentrations than downstream (on ebb tide) locations. Duck muscle tissue and lobster tissue concentrations were greater in this area than in other sampling locations.

Temporal Trends

Mercury concentrations in low trophic level species (e.g., blue mussel, mummichog) and terrestrial mid-trophic level species (e.g., Nelson's sparrow, red-winged blackbird) either did not change through time or showed limited changes through time (**Table 5-1** and **Table 5-2**). Upper trophic level species (e.g., tomcod, eel, lobster) showed decreasing trends for the whole estuary and at individual locations. These decreases are between 1 and 9 percent per year. Low trophic level species are frequently in contact with sediment and likely are repeatedly exposed to similar concentrations of mercury. Terrestrial mid-trophic level species may not change much because these species inhabit environments that are less dynamic than the river (e.g., marshes and floodplains typically are accretional environments). Upper trophic level species have larger home ranges than low trophic level species and may range across areas with lower or decreasing concentrations of mercury in biota and sediment. The source of mercury has been reduced in the last two to three decades and upper and lower level trophic species may still be recovering (i.e., reducing mercury concentrations). Mercury concentrations biomagnify in each successively higher trophic level so the ratio of uptake is higher from a prey fish to a predatory fish than from sediment to a benthic macroinvertebrate. The recovery is easier to document in upper trophic level species because concentrations are higher and biomagnification ratios are higher which makes even a small percentage of decrease more noticeable in upper trophic level compared to lower trophic level species over time. The larger concentrations also are less susceptible to effects from seasonal or intra- / interannual variability in the datasets.

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 an indication of the trends in the Estuary. Given the variability inherent in biotic data and the variability in the sample design, it is encouraging to note that there is an overall trend in biota data indicating a reduction in mercury

concentrations in many 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

Recommendations

The 2017 Biota Monitoring Plan (Amec Foster Wheeler, 2017a) is appropriate to understand the current conditions in the estuary and continue trending concentrations in individual tissues in a variety of trophic levels. Investigation of biota trends and correlation of tissues for certain biota leads to a few recommendations, to be started in 2017, detailed here.

The correlation of lobster claw and tail tissue was tested to determine whether the analysis of one tissue was sufficient to conservatively represent mercury concentrations in lobster. Tail and claw mercury concentrations were correlated. Tail concentrations are greater than claw concentrations so the use of tail for monitoring purposes is more conservative. The recommendation that tail is the only tissue analyzed for mercury in lobster was implemented in fall 2016 and should be continued into the future.

The correlation of black duck blood and breast muscle tissue was tested to determine whether the analysis of one tissue was sufficient to represent mercury concentrations in black ducks. Blood and muscle tissue were correlated. It is recommended that blood is the only tissue collected and analyzed for mercury in black ducks in the future starting in the winter of 2017/2018.

A number of species were challenging to capture and so were not captured at the target locations and/or at target numbers proposed for 2016 sampling. The number of samples collected historically and in 2016 limited the interpretation of some spatial and/or temporal trends. Additional effort to collect more samples for temporal trending purposes is recommended for 2017:

- Mummichog: Mendall Marsh and OB-01
- Rainbow smelt: OB-05 at ES-13
- Atlantic tomcod: BO-04 at ES-FP
- Red-winged blackbird: W-17-N

Additional effort to collect samples at targeted sampling locations to gain a better understanding of the spatial distribution is recommended for:

- Blue mussels: upstream (on ebb tide) of ES-15
- American eel: throughout the Estuary
- Red-winged blackbird: Mendall Marsh (SE and SW)

One tomcod sample was collected in Frenchman Bay (reference location). Additional samples are necessary to establish a reference mercury concentration for this species.

At the time the 2016 Biota Monitoring Plan was written, it was understood that data for mercury concentrations in lobster tail were available for locations outside the area of influence of the Estuary. Communication with the Maine Department of Environmental Protection (DEP) regarding lobster concentrations indicates that most available mercury concentration data for lobster in the Gulf of Maine outside of the area of influence of the Penobscot River are a composite of claw and tail tissues. Composite tissue samples would necessitate an understanding of weight of each tissue included in the composite in order to back-calculate to a tail mercury concentration representative of each sample. If data to separate these results by claw and tail individually are not available from Maine DEP by the end of June, a lobster reference location is recommended to be sampled in 2017. The primary recommended location is in Frenchman Bay, which is outside the potential area of influence of the Penobscot River, however, other locations may be considered.

The addition of six polychaete sampling locations to better understand the spatial gradient of polychaete mercury concentrations should be considered starting in 2017. These sampling locations would be at three established biota sampling locations: ES-15, Odom Ledge, and ES-03 to correspond to other biota sampling locations. Three new polychaete sampling locations would be established: a sampling location near Bucksport, ES-02E (Orland River), and a location at the tip of South Verona Island. The location near Bucksport has the potential to describe where polychaete mercury concentrations decrease to concentrations seen at ES-13 and Fort Point. The ES-02E location has the potential to describe concentrations in the Orland River. The location at the tip of South Verona Island has the potential to describe concentrations in the Penobscot Bay rather than a cove of South Verona. This new sampling location would be important to understand risk and areas considered for remediation.

Terrestrial insect and spider composite samples were collected throughout each marsh in the area that songbirds were collected and assigned the same set of coordinates. Samples in 2017 should be collected in separate areas and assigned individual sets of coordinates based on the area in which each was collected and possibly separating the types of insects and spiders within each sample of terrestrial insects and spiders to better understand the mercury concentration by insect/spider type because two signals were noticeable in the 2016 datasets. Limiting the coverage of each composite sample will increase the understanding of the spatial distribution of

mercury concentrations at each sampling location and verify the representativeness of the samples collected in 2016.

Overall, mercury concentrations in biota in the Penobscot are generally decreasing or not changing, indicating the potential for some natural attenuation. For many species, mercury concentrations decreased with distance downstream (on ebb tide). Mercury concentrations increased with trophic level, as hypothesized, given that 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 which tended to show no change in concentrations. 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 was dependent 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). Additional sampling in 2017, with additional emphasis on target areas, is recommended to increase the robustness of the statistical analyses, to better understand the distribution and trend of mercury concentrations, and to describe spatial differences in mercury bioaccumulation within the Estuary.

6.0 REFERENCES

Amec Foster Wheeler, 2016a. *Proposed Penobscot River Biota Monitoring Plan,* Penobscot River, Maine, June 2016.

Amec Foster Wheeler, 2016b. *Draft Penobscot River Estuary Phase III – Engineering Study Quality Assurance Project Plan*, Penobscot River, Maine, July 2016.

Amec Foster Wheeler, 2017a. *Biota Monitoring Work Plan. Penobscot River Estuary Phase III – Engineering Study*, Penobscot River, Maine, March 2017.

Amec Foster Wheeler, 2017b. *2016 Sediment and Water Quality and Monitoring Report*. *Penobscot River Estuary Phase III – Engineering Study,* Penobscot River, Maine, March 2017.

Amec Foster Wheeler, 2017c. *Technology Screening Report*. *Penobscot River Estuary Phase III – Engineering Study,* Penobscot River, Maine, March 2017.

Casco Bay Estuary Partnership, 2007. *Toxic Pollution in Casco Bay: Sources and Impacts*. Casco Bay, Maine. pp 92. URL https://www.cascobayestuary.org/wp-content/uploads/2014/09/toxics-report-low-res.pdf.

Fuchsman, PC, Brown LE, Henning MH, Bock MJ, Magar VS, 2017. *Toxicity Reference Values for Methylmercury Effects on Avian Reproduction: Critical Review and Analysis*. Environmental Toxicology & Chemistry. 36(2): 294-319.

Gilbert, RO, 1987. *Statistical Methods for Environmental Pollution Monitoring*. Van Nostrand Reinhold Company, Inc., New York, NY. 334 pp.

Hallinger K, Cristol DA, 2011. *The Role of Weather in Mediating the Effect of Mercury Exposure on Reproductive Success in Tree Swallows*. Ecotoxicology 20:1368–1377.

Maine Bureau of Health (MBOH), 2001. *Maine Bureau of Health Advisory for Fish Tissue; Bureau of Health Fish Tissue Action Levels*. February 2001. http://www.maine.gov/dhhs/mecdc/environmental-health/eohp/fish/documents/action-levels-writeup.pdf

Maine Center for Disease Control and Prevention (MCDC), 2016. *Penobscot River Estuary Lobster and Rock Crab Mercury Study; 2014 Sample Period Data Report*. May 2016.

National Oceanic and Atmospheric Administration (NOAA), 1998. *NOAA Technical Memorandum NOS ORCA 130: Sampling and Analytical Methods of the National Status and Trends Program Mussel watch Project: 1993 1996 Update*.

Penobscot River Mercury Study Panel (PRMSP), 2013a. *Results of 2012 Monitoring of Mercury in the Penobscot River and Bay with Comparisons to Previous Years*. Penobscot River Mercury Study. December 2013.

Penobscot River Mercury Study Panel (PRMSP), 2013b. *Final Report: Mercury Contamination of the Penobscot River Estuary: Current Situation, Remediation Targets, and Possible Remediation Procedures*. Penobscot River Mercury Study. April 2013.

Penobscot River Mercury Study Panel (PRMSP), 2014. *Monitoring Mercury in American Black Ducks, 2013 – 2014 with Comparisons to Previous Years*. Penobscot River Mercury Study. March 2014.

R Core Team, 2016. *R: A language and environment for statistical computing*. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/.

United States Environmental Protection Agency (USEPA), 2009. *Guidance for Labeling Externally Validated Laboratory Analytical data for Superfund Use.* Office of Solid Waste and Emergency Response. EPA 540-R-08-005. January 13, 2009.

United States Environmental Protection Agency (USEPA), 2013. *EPA New England Environmental Data Review Supplement for Regional Data Review Elements and Superfund Specific Guidance/Procedures*. Quality Assurance Unit Staff; Office of Environmental Measurement and Evaluation. April 22, 2013.

United States Environmental Protection Agency (USEPA), 2014. *National Functional Guidelines for Inorganic Superfund Data Review*. Office of Superfund Remediation and Technology Innovation. EPA-540-R-013-001. August 2014.

TABLES

TABLE 2-1
2016 BIOTA SAMPLE COLLECTION COUNTS BY LOCATION

2016 BIOTA MONITORING REPORT

		Terrestrial Invertebrates		Birds				Aquatic Invertebrates			Fish			
		Terrestrial Insects*	Spiders**	Nelson Sparrow	Red-Winged Blackbird	American Black Duck (Blood)	American Black Duck (Muscle)	Polychaetes	Blue Mussel	Lobster	Tomcod	Rainbow Smelt	Mummichog	Eel
	Sampling Timeframe:	**July**	**July**	**July**	**July**	**January-February**	**January-February**	**July/ September**	**September**	**September**	**September-October**	**September-October**	**September-October**	**August**
Location ID (Ordered North to South)	BO-04							5			4		20	1
	OB-05							5			18	1	20	5
	OB-04											5		
	OB-01										19	15	1	1
	W-17-N	5	5	15	3									
	MMMC-01												4	
	MMPOLY-01							5						
	MMBKD-01					15	5							
	MMSE-01	5	5	15										
	MMSW-C	5	5	11										
	OL-01 (L10-52)									20				
	ES-15								20			1		
	ES-13					15	5	5	20		11			
	SVE-01									20				
	ES-03								20					
	ES-FP							5	20		2	20		
	CPJL									20				
	Turner Point (L9-45)									20				
	HB-01									20				
Reference Locations	ADD-01	5	5	11										
	FRB-01					15	5	5			1	20	20	

Notes:
Biota samples were collected between July 2016 and February 2017.

*Terrestrial insects include: grasshoppers (order: Orthoptera), damselflies (order: Odonata), dragonflies (order: Odonata), greenhead flies (order: Diptera), leafhoppers (order: Hemiptera), flies (order: Diptera), and mosquitoes (order: Diptera)
**Spiders include: wolf spider (family: Lycosidae), jumping spider (family: Salticidae), and crab spider (family: Thomisidae)

PREPARED BY/DATE: JPM 05/04/17
CHECKED BY/DATE: JAB 05/04/17

TABLE 2-2
2016 BIOTA SAMPLE ANALYSIS BY SPECIES

2016 BIOTA MONITORING REPORT

Species	Media	Hg	MeHg	Lipid
		Total 1631e	Total 1630	NOAA 1993a
Polychaetes	Whole Body	X	X	X
Terrestrial Insects	Whole Body	X	X	X
Spiders	Whole Body	X	X	X
Blue Mussel	Whole Body	X	--	X
Lobster	Tail Tissue	X	--	X
American Eel	Whole Body	X	--	X
Rainbow Smelt	Whole Body	X	--	X
Atlantic Tomcod	Whole Body	X	--	X
Mummichog	Whole Body	X	--	X
American Black Duck	Breast Muscle Tissue	X	--	X
American Black Duck	Blood	X	--	--
Red-Winged Blackbird	Blood	X	--	--
Nelson's Sparrow	Blood	X	--	--

PREPARED BY/DATE: BPW 04/24/17
CHECKED BY/DATE: LSV 04/24/17

TABLE 3-1

SUMMARY OF MERCURY AND METHYL MERCURY CONCENTRATIONS FOR TERRESTRIAL INSECTS ALONG THE PENOBSCOT RIVER BY YEAR

2016 BIOTA MONITORING REPORT

		Mercury		Methyl Mercury	
Pleasant River (near Addison, ME)*		**2009**	**2016**	**2009**	**2016**
	Number of Samples	NA	5	NA	5
	Mean	NA	29.1 ± 11.4	NA	18.0 ± 4.95
	Median	NA	16.8	NA	18.6
Spurwink River*		**2009**	**2016**	**2009**	**2016**
	Number of Samples	20	NA	20	NA
	Mean	29.3 ± 6.85	NA	19.3 ± 5.91	NA
	Median	8.86	NA	5.79	NA
Bass Harbor*		**2009**	**2016**	**2009**	**2016**
	Number of Samples	25	NA	25	NA
	Mean	137 ± 37.8	NA	90.7 ± 31.3	NA
	Median	43.6	NA	58.9	NA
Mendall Marsh SE		**2009**	**2016**	**2009**	**2016**
	Number of Samples	40	5	40	5
	Mean	90.9 ± 23.4	195 ± 68.8	59.4 ± 13.2	101 ± 38.5
	Median	21.9	222	14.4	91.2
Mendall Marsh SW		**2009**	**2016**	**2009**	**2016**
	Number of Samples	20	5	20	5
	Mean	209 ± 89.7	47.5 ± 4.31	150 ± 74.7	22.7 ± 4.58
	Median	15.1	47.5	8.87	26.8
W-17-N		**2009**	**2016**	**2009**	**2016**
	Number of Samples	41	5	41	5
	Mean	179 ± 51.1	77.8 ± 44.3	153 ± 49.0	57.7 ± 17.1
	Median	41.9	30.4	37.2	56.7

Notes:

Concentrations in nanograms/gram (ng/g) wet weight

Mean concentrations are followed by the standard error of the mean.

* = Reference location

NA = Not available

PREPARED BY/DATE: JPM 05/01/17

CHECKED BY/DATE: NTG 05/12/17

TABLE 3-2
SUMMARY OF MERCURY AND METHYL MERCURY CONCENTRATIONS FOR SPIDERS ALONG THE PENOBSCOT RIVER BY YEAR

2016 BIOTA MONITORING REPORT

		Mercury			Methyl Mercury		
Pleasant River (near Addison, ME)*		**2009**	**2010**	**2016**	**2009**	**2010**	**2016**
	Number of Samples	NA	NA	5	NA	NA	5
	Mean	NA	NA	35.1 ± 3.67	NA	NA	28.9 ± 8.00
	Median	NA	NA	31.4	NA	NA	22.90
Spurwink River*		**2009**	**2010**	**2016**	**2009**	**2010**	**2016**
	Number of Samples	15	NA	NA	15	NA	NA
	Mean	43.8 ± 7.63	NA	NA	25.2 ± 3.01	NA	NA
	Median	28.1	NA	NA	24	NA	NA
Bass Harbor*		**2009**	**2010**	**2016**	**2009**	**2010**	**2016**
	Number of Samples	10	NA	NA	10	NA	NA
	Mean	149 ± 17.8	NA	NA	128 ± 20.4	NA	NA
	Median	140	NA	NA	119	NA	NA
Mendall Marsh-SE		**2009**	**2010**	**2016**	**2009**	**2010**	**2016**
	Number of Samples	21	3	5	21	3	5
	Mean	221 ± 20.6	2133 ± 145	316 ± 114	152 ± 17.5	2130 ± 147	180 ± 17.7
	Median	214	2070	205	143	2070	174.00
Mendall Marsh-SW		**2009**	**2010**	**2016**	**2009**	**2010**	**2016**
	Number of Samples	14	39	5	14	39	5
	Mean	152 ± 32.3	1552 ± 138	222 ± 18.9	134 ± 33.7	1423 ±140	235 ± 30.9
	Median	149	1320	219	101	1180	217
W-17-N		**2009**	**2010**	**2016**	**2009**	**2010**	**2016**
	Number of Samples	12	NA	5	12	NA	5
	Mean	328 ± 73.2	NA	305 ± 50.5	302 ± 62.5	NA	378 ± 79.9
	Median	263	NA	263	258	NA	282

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

PREPARED BY/DATE: JPM 05/01/17
CHECKED BY/DATE: NTG 05/12/17

TABLE 3-3
SUMMARY OF NELSON'S SPARROW MERCURY CONCENTRATIONS IN WETLANDS ALONG THE PENOBSCOT RIVER BY YEAR

2016 BIOTA MONITORING REPORT

Pleasant River (near Addison, ME)*		**2006**	**2007**	**2008**	**2009**	**2010**	**2012**	**2016**
	Number of Samples	NA	NA	NA	NA	NA	10	11
	Mean	NA	NA	NA	NA	NA	399 ± 36.5	469 ± 44.0
	Median	NA	NA	NA	NA	NA	365	467
	Percent of Samples Above 3000 ng/g	NA	NA	NA	NA	NA	0	0
Maine*		**2006**	**2007**	**2008**	**2009**	**2010**	**2012**	**2016**
	Number of Samples	NA	2	NA	8	NA	1	NA
	Mean	NA	6188 ± 149	NA	666 ± 73.7	NA	3590	NA
	Median	NA	6188	NA	701	NA	3590	NA
	Percent of Samples Above 3000 ng/g	NA	100	NA	0	NA	100	NA
New Hampshire*		**2006**	**2007**	**2008**	**2009**	**2010**	**2012**	**2016**
	Number of Samples	NA	10	8	16	10	NA	NA
	Mean	NA	431 ± 92.4	806 ± 172	689 ± 114	511 ± 56.5	NA	NA
	Median	NA	341	914	537	459	NA	NA
	Percent of Samples Above 3000 ng/g	NA	0	0	0	0	NA	NA
W-17-N		**2006**	**2007**	**2008**	**2009**	**2010**	**2012**	**2016**
	Number of Samples	NA	NA	9	7	4	9	15
	Mean	NA	NA	4263 ± 106	4949 ± 913	5281 ± 1447	5009 ± 226	4712 ± 764
	Median	NA	NA	4221	5109	5924	4990	5000
	Percent of Samples Above 3000 ng/g	NA	NA	100	71	75	100	60
Mendall Marsh SE		**2006**	**2007**	**2008**	**2009**	**2010**	**2012**	**2016**
	Number of Samples	3	40	82	30	18	5	15
	Mean	4276 ± 726	6451 ± 380	3525 ± 176	3859 ± 204	5474 ± 349	10290 ± 485	6191 ± 428
	Median	4200	6946	3445	3715	5490	10470	6130
	Percent of Samples Above 3000 ng/g	100	85	63	77	94	100	100
Mendall Marsh SW		**2006**	**2007**	**2008**	**2009**	**2010**	**2012**	**2016**
	Number of Samples	12	39	30	17	19	5	11
	Mean	5329 ± 518	7404 ± 348	5321 ± 286	3325 ± 350	6964 ± 480	7516 ± 816	5845 ± 408
	Median	5664	7290	5506	3291	6620	7630	5840
	Percent of Samples Above 3000 ng/g	83	97	93	65	100	100	100

Notes:

Concentrations in nanograms/gram (ng/g) wet weight

* Reference locations

Maine reference samples do not include the data for Addison.

Mean concentrations are followed by the standard error of the mean.

NA = Not available

PREPARED BY/DATE: LSV 04/03/17

CHECKED BY/DATE: NTG 04/25/17

TABLE 3-4
SUMMARY OF RED-WINGED BLACKBIRD MERCURY CONCENTRATIONS IN WETLANDS ALONG THE PENOBSCOT RIVER BY YEAR

2016 BIOTA MONITORING REPORT

Pleasant River (near Addison, ME)*		**2007**	**2008**	**2009**	**2010**	**2012**	**2016**
	Number of Samples	NA	NA	NA	NA	3	NA
	Mean	NA	NA	NA	NA	453 ± 181	NA
	Median	NA	NA	NA	NA	399	NA
	Percent of Samples Above 3000 ng/g	NA	NA	NA	NA	0	NA
Maine*		**2007**	**2008**	**2009**	**2010**	**2012**	**2016**
	Number of Samples	NA	2	NA	NA	NA	NA
	Mean	NA	227 ± 87.4	NA	NA	NA	NA
	Median	NA	227	NA	NA	NA	NA
	Percent of Samples Above 3000 ng/g	NA	0	NA	NA	NA	NA
W-17-N		**2007**	**2008**	**2009**	**2010**	**2012**	**2016**
	Number of Samples	NA	NA	6	4	6	3
	Mean	NA	NA	2555 ± 713	2828 ± 398	7518 ± 1951	2816 ± 1668
	Median	NA	NA	2597	2815	8755	2500
	Percent of Samples Above 3000 ng/g	NA	NA	50	50	83	33
Mendall Marsh SE		**2007**	**2008**	**2009**	**2010**	**2012**	**2016**
	Number of Samples	3	12	32	2	2	NA
	Mean	7885 ± 2789	919 ± 244	1983 ± 464	9650 ± 950	11040 ± 710	NA
	Median	5506	732	666	9650	11040	NA
	Percent of Samples Above 3000 ng/g	100	NA	25	100	100	NA
Mendall Marsh SW		**2007**	**2008**	**2009**	**2010**	**2012**	**2016**
	Number of Samples	17	33	29	10	4	NA
	Mean	4545 ± 842	3279 ± 575	3154 ± 577	5232 ± 1476	14810 ± 836	NA
	Median	3377	1874	1970	4348	14350	NA
	Percent of Samples Above 3000 ng/g	53	42	34	50	100	NA

Notes:
Concentrations in nanograms/gram (ng/g) wet weight
* Reference locations
Maine reference samples do not include the data for Addison.
Mean concentrations are followed by the standard error of the mean.
NA = Not available

PREPARED BY/DATE: LSV 04/03/17
CHECKED BY/DATE: NTG 04/25/17

TABLE 3-5
SUMMARY OF AMERICAN BLACK DUCK BLOOD MERCURY CONCENTRATIONS IN WETLANDS ALONG THE PENOBSCOT RIVER BY YEAR

2016 BIOTA MONITORING REPORT

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

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

PREPARED BY/DATE: LSV 04/05/17
CHECKED BY/DATE: NTG 04/25/17

TABLE 3-6
SUMMARY OF AMERICAN BLACK DUCK BREAST MUSCLE TISSUE MERCURY CONCENTRATIONS IN THE PENOBSCOT RIVER BY YEAR

2016 BIOTA MONITORING REPORT

Frenchman Bay*		**2011**	**2012**	**2014**	**2017**
	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		**2011**	**2012**	**2014**	**2017**
	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		**2011**	**2012**	**2014**	**2017**
	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:
Concentrations in nanograms/gram (ng/g) wet weight
* Reference location
Mean concentrations are followed by the standard error of the mean.
NA = Not available

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

TABLE 3-7

SUMMARY OF MERCURY AND METHYL MERCURY CONCENTRATIONS FOR POLYCHAETES IN THE PENOBSCOT RIVER BY YEAR

2016 BIOTA MONITORING REPORT

		Mercury			Methyl Mercury		
East Branch Penobscot River*		**2006**	**2009**	**2016**	**2006**	**2009**	**2016**
	Number of Samples	3	NA	NA	NA	NA	NA
	Mean	20.3 ± 3.76	NA	NA	NA	NA	NA
	Median	20.0	NA	NA	NA	NA	NA
OV-04*		**2006**	**2009**	**2016**	**2006**	**2009**	**2016**
	Number of Samples	NA	2	NA	NA	2	NA
	Mean	NA	55.3 ± 7.20	NA	NA	2.71 ± 0.50	NA
	Median	NA	55.3	NA	NA	2.71	NA
Frenchman Bay*		**2006**	**2009**	**2016**	**2006**	**2009**	**2016**
	Number of Samples	NA	NA	5	NA	NA	5
	Mean	NA	NA	3.18	NA	NA	ND
	Median	NA	NA	ND	NA	NA	ND
BO-04		**2006**	**2009**	**2016**	**2006**	**2009**	**2016**
	Number of Samples	NA	2	5	NA	2	5
	Mean	NA	139 ± 25.0	214 ± 30.5	NA	26.6 ± 6.75	8.06 ± 0.423
	Median	NA	139	185	NA	26.6	8.30
OB-05		**2006**	**2009**	**2016**	**2006**	**2009**	**2016**
	Number of Samples	NA	NA	5	NA	NA	5
	Mean	NA	NA	213 ± 7.26	NA	NA	12.2 ± 0.365
	Median	NA	NA	215	NA	NA	12.7
Mendall Marsh		**2006**	**2009**	**2016**	**2006**	**2009**	**2016**
	Number of Samples	NA	NA	5	NA	NA	5
	Mean	NA	NA	192 ± 42.6	NA	NA	8.38 ± 1.83
	Median	NA	NA	190	NA	NA	9.90
ES-13		**2006**	**2009**	**2016**	**2006**	**2009**	**2016**
	Number of Samples	NA	5	5	NA	5	5
	Mean	NA	35.4 ± 3.19	35.0 ± 10.5	NA	13.4 ± 3.99	2.50 ± 0.716
	Median	NA	36.9	24.7	NA	8.82	1.50
ES-FP		**2006**	**2009**	**2016**	**2006**	**2009**	**2016**
	Number of Samples	NA	4	5	NA	4	5
	Mean	NA	32.8 ± 3.89	29.7 ± 4.79	NA	8.81 ± 1.24	7.90 ± 2.63
	Median	NA	33.4	24.5	NA	8.64	5.30

Notes:

Concentrations in nanograms/gram (ng/g) wet weight

Mean concentrations are followed by the standard error of the mean.

* = Reference location

NA = Not available

ND = Non-detect

PREPARED BY/DATE: JPM 05/01/17

CHECKED BY/DATE: NTG 05/12/17

TABLE 3-8
SUMMARY OF BLUE MUSSEL MERCURY CONCENTRATIONS IN THE PENOBSCOT RIVER BY YEAR

2016 BIOTA MONITORING REPORT

Narraguagus River*		**2006**	**2008**	**2009**	**2010**	**2012**	**2016**
	Number of Samples	NA	NA	60	NA	NA	NA
	Mean	NA	NA	26.7 ± 0.779	NA	NA	NA
	Median	NA	NA	26.5	NA	NA	NA
St. George River*		**2006**	**2008**	**2009**	**2010**	**2012**	**2016**
	Number of Samples	NA	NA	60	NA	NA	NA
	Mean	NA	NA	26.0 ± 0.883	NA	NA	NA
	Median	NA	NA	24.7	NA	NA	NA
Southern Cove		**2006**	**2008**	**2009**	**2010**	**2012**	**2016**
	Number of Samples	NA	NA	40	NA	NA	NA
	Mean	NA	NA	77.0 ± 3.22	NA	NA	NA
	Median	NA	NA	74.6	NA	NA	NA
ES-15		**2006**	**2008**	**2009**	**2010**	**2012**	**2016**
	Number of Samples	20	30	40	35	15	20
	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
	Median	91.1	70.9	72.8	63.4	61.5	56.9
ES-13		**2006**	**2008**	**2009**	**2010**	**2012**	**2016**
	Number of Samples	20	30	40	34	30	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
	Median	142	88.4	81.0	73.8	83.5	60.9
ES-03		**2006**	**2008**	**2009**	**2010**	**2012**	**2016**
	Number of Samples	20	30	40	35	NA	20
	Mean	103 ± 10.5	76.4 ± 2.56	63.3 ± 2.21	64.3 ± 2.28	NA	82.0 ± 4.97
	Median	88.4	75.7	61.9	62.5	NA	77.5
ES-FP		**2006**	**2008**	**2009**	**2010**	**2012**	**2016**
	Number of Samples	NA	NA	20	15	15	20
	Mean	NA	NA	53.9 ± 1.31	57.4 ± 1.79	52.2 ± 1.53	62.6 ± 3.90
	Median	NA	NA	52.1	55.4	52.3	58.9

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

PREPARED BY/DATE: LSV 04/06/17
CHECKED BY/DATE: NTG 04/25/17

TABLE 3-9
SUMMARY OF LOBSTER MERCURY CONCENTRATIONS IN THE PENOBSCOT RIVER BY YEAR

2016 BIOTA MONITORING REPORT

Odom Ledge		**2006**	**2008**	**2009**	**2010**	**2012**	**2014**	**2015**	**2016**
	Number of Samples	NA	21	16	19	15	40	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
	Median	NA	306	182	257	214	371	324	207
	Percent of Samples Above 200 ng/g	NA	90	44	79	53	88	80	55
South Verona		**2006**	**2008**	**2009**	**2010**	**2012**	**2014**	**2015**	**2016**
	Number of Samples	NA	10	5	12	15	12	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
	Median	NA	504	445	466	335	336	395	366
	Percent of Samples Above 200 ng/g	NA	100	100	92	80	92	85	90
Fort Point		**2006**	**2008**	**2009**	**2010**	**2012**	**2014**	**2015**	**2016**
	Number of Samples	NA	11	12	21	15	43	28	NA
	Mean	NA	240 ± 31.8	273 ± 51.1	197 ± 21.6	232 ± 29.6	364 ± 49.3	310 ± 48.8	NA
	Median	NA	211	217	190	214	295	209	NA
	Percent of Samples Above 200 ng/g	NA	55	67	43	53	70	57	NA
Cape Jellison		**2006**	**2008**	**2009**	**2010**	**2012**	**2014**	**2015**	**2016**
	Number of Samples	NA	NA	NA	NA	NA	39	24	20
	Mean	NA	NA	NA	NA	NA	252 ± 29.6	171 ± 16.7	199 ± 16.5
	Median	NA	NA	NA	NA	NA	196	151	180
	Percent of Samples Above 200 ng/g	NA	NA	NA	NA	NA	49	29	35
Turner Point		**2006**	**2008**	**2009**	**2010**	**2012**	**2014**	**2015**	**2016**
	Number of Samples	5	34	21	20	15	29	22	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
	Median	398	174	171	156	146	230	135	164
	Percent of Samples Above 200 ng/g	80	41	33	30	33	55	23	20
Sears Island/ Marshall Point		**2006**	**2008**	**2009**	**2010**	**2012**	**2014**	**2015**	**2016**
	Number of Samples	2	88	22	20	16	59	31	NA
	Mean	133 ± 11.5	112 ± 4.67	120 ± 10.8	114 ± 11.6	128 ± 20.4	162 ± 12.9	124 ± 9.46	NA
	Median	133	106	99.1	94.0	104	128	114	NA
	Percent of Samples Above 200 ng/g	0	3	14	10	25	29	6	NA
Kelly's Cove		**2006**	**2008**	**2009**	**2010**	**2012**	**2014**	**2015**	**2016**
	Number of Samples	NA	2	20	20	NA	NA	NA	NA
	Mean	NA	87.9 ± 3.85	109 ± 10.6	134 ± 20.1	NA	NA	NA	NA
	Median	NA	87.9	96.6	106	NA	NA	NA	NA
	Percent of Samples Above 200 ng/g	NA	0	5	15	NA	NA	NA	NA

TABLE 3-9
SUMMARY OF LOBSTER MERCURY CONCENTRATIONS IN THE PENOBSCOT RIVER BY YEAR

2016 BIOTA MONITORING REPORT

		2006	2008	2009	2010	2012	2014	2015	2016
Harborside	**Number of Samples**	1	40	40	40	30	10	NA	20
	Mean	319	185 ± 14.3	123 ± 6.51	158 ± 13.7	131 ± 18.2	137 ± 36.4	NA	98.0 ± 6.27
	Median	319	169	116	137	113	103	NA	102
	Percent of Samples Above 200 ng/g	100	40	5	28	10	20	NA	0

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

PREPARED BY/DATE: LSV 04/05/17
CHECKED BY/DATE: NTG 04/25/17

TABLE 3-10
SUMMARY OF MUMMICHOG MERCURY CONCENTRATIONS IN WETLANDS ALONG THE PENOBSCOT RIVER BY YEAR

2016 BIOTA MONITORING REPORT

Frenchman Bay*		**2006**	**2008**	**2009**	**2010**	**2012**	**2016**
	Number of Samples	NA	NA	NA	NA	NA	20
	Mean	NA	NA	NA	NA	NA	8.06 ± 0.447
	Median	NA	NA	NA	NA	NA	7.96
BO-04		**2006**	**2008**	**2009**	**2010**	**2012**	**2016**
	Number of Samples	5	NA	NA	NA	NA	20
	Mean	138 ± 22.4	NA	NA	NA	NA	95.6 ± 12.6
	Median	120	NA	NA	NA	NA	71.2
OB-05		**2006**	**2008**	**2009**	**2010**	**2012**	**2016**
	Number of Samples	1	1	24	1	NA	20
	Mean	251	234	189 ± 13.8	328	NA	89.7 ± 4.20
	Median	251	234	196	328	NA	89.1
OB-01		**2006**	**2008**	**2009**	**2010**	**2012**	**2016**
	Number of Samples	2	NA	12	NA	NA	1
	Mean	421 ± 134	NA	224 ± 11.0	NA	NA	134
	Median	421	NA	222	NA	NA	134
MM Locations		**2006**	**2008**	**2009**	**2010**	**2012**	**2016**
	Number of Samples	NA	NA	NA	14	15	4
	Mean	NA	NA	NA	352 ± 20.6	181 ± 18.1	172 ± 28.3
	Median	NA	NA	NA	343	158	159

Notes:
Concentrations in nanograms/gram (ng/g) wet weight
* Reference location
Mean concentrations are followed by the standard error of the mean.
MM Locations consist of both W-21 and Mendall Marsh sampling locations.
NA = Not available

PREPARED BY/DATE: LSV 04/04/17
CHECKED BY/DATE: NSR 04/10/17

TABLE 3-11
SUMMARY OF RAINBOW SMELT MERCURY CONCENTRATIONS IN THE PENOBSCOT RIVER BY YEAR

2016 BIOTA MONITORING REPORT

Frenchman Bay*		**2006**	**2008**	**2009**	**2010**	**2012**	**2016**
	Number of Samples	NA	NA	NA	NA	NA	20
	Mean	NA	NA	NA	NA	NA	6.76 ± 0.197
	Median	NA	NA	NA	NA	NA	6.64
OB-05		**2006**	**2008**	**2009**	**2010**	**2012**	**2016**
	Number of Samples	1	8	NA	5	3	1
	Mean	96.5	142 ± 30.4	NA	65.4 ± 7.64	151 ± 42.7	201
	Median	96.5	102	NA	67.5	110	201
OB-04		**2006**	**2008**	**2009**	**2010**	**2012**	**2016**
	Number of Samples	1	1	3	6	NA	5
	Mean	186	91.0	181 ± 112	95.4 ± 10.4	NA	56.9 ± 6.61
	Median	186	91.0	90.4	88.4	NA	54.9
OB-01		**2006**	**2008**	**2009**	**2010**	**2012**	**2016**
	Number of Samples	9	NA	30	5	15	15
	Mean	92.1 ± 8.46	NA	100 ± 4.52	155 ± 46.4	108 ± 18.8	86.2 ± 8.87
	Median	90.1	NA	91.2	125	92.1	90.8
ES-15		**2006**	**2008**	**2009**	**2010**	**2012**	**2016**
	Number of Samples	NA	16	7	NA	NA	1
	Mean	NA	52.4 ± 5.07	75.4 ± 9.89	NA	NA	38.4
	Median	NA	48.0	76.4	NA	NA	38.4
ES-FP		**2006**	**2008**	**2009**	**2010**	**2012**	**2016**
	Number of Samples	NA	NA	20	15	15	20
	Mean	NA	NA	56.0 ± 3.19	36.9 ± 1.96	59.1 ± 9.14	59.7 ± 5.65
	Median	NA	NA	54.6	36.3	47.3	55.4

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

PREPARED BY/DATE: SAG 04/05/17
CHECKED BY/DATE: NTG 04/25/17

TABLE 3-12
SUMMARY OF AMERICAN EEL MERCURY CONCENTRATIONS IN THE PENOBSCOT RIVER BY YEAR

2016 BIOTA MONITORING REPORT

OV-04*		**2007**	**2008**	**2009**	**2010**	**2012**	**2016**
	Number of Samples	24	18	7	26	41	NA
	Mean	348 ± 39.4	355 ± 39.2	282 ± 58.9	353 ± 35.3	247 ± 24.4	NA
	Median	268	360	221	333	186	NA
	Percent of Samples Above 310 ng/g	46	56	29	54	24	NA
BO-04		**2007**	**2008**	**2009**	**2010**	**2012**	**2016**
	Number of Samples	18	19	5	14	20	1
	Mean	625 ± 37.5	586 ± 74.8	704 ± 90.8	682 ± 82.7	495 ± 41.8	1370
	Median	590	652	717	649	458	1370
	Percent of Samples Above 310 ng/g	100	74	100	86	90	100
OB-05		**2007**	**2008**	**2009**	**2010**	**2012**	**2016**
	Number of Samples	22	16	13	20	20	5
	Mean	500 ± 51.0	395 ± 27.3	549 ± 61.9	520 ± 51.5	609 ± 65.0	469 ± 31.8
	Median	449	395	569	472	613	461
	Percent of Samples Above 310 ng/g	73	81	85	85	90	100
OB-01		**2007**	**2008**	**2009**	**2010**	**2012**	**2016**
	Number of Samples	10	5	20	4	18	1
	Mean	561 ± 21.7	413 ± 52.5	409 ± 40.8	506 ± 40.3	497 ± 31.0	394
	Median	552	413	390	494	465	394
	Percent of Samples Above 310 ng/g	100	80	65	100	94	100

Notes:

Concentrations in nanograms/gram (ng/g) wet weight

*Reference location includes historical data for sampling locations OV-02, OV-05, and OV-04.

Mean concentrations are followed by the standard error of the mean.

NA = Not available

PREPARED BY/DATE: LSV 04/05/17

CHECKED BY/DATE: NTG 04/25/17

TABLE 3-13
SUMMARY OF ATLANTIC TOMCOD MERCURY CONCENTRATIONS IN THE PENOBSCOT RIVER BY YEAR

2016 BIOTA MONITORING REPORT

Frenchman Bay*		**2006**	**2008**	**2009**	**2010**	**2012**	**2016**
	Number of Samples	NA	NA	NA	NA	NA	1
	Mean	NA	NA	NA	NA	NA	36.5
	Median	NA	NA	NA	NA	NA	36.5
	Percent of Samples Above 200 ng/g	NA	NA	NA	NA	NA	0
BO-04		**2006**	**2008**	**2009**	**2010**	**2012**	**2016**
	Number of Samples	7	NA	NA	1	NA	4
	Mean	289 ± 16.9	NA	NA	325	NA	282 ± 28.9
	Median	302	NA	NA	325	NA	308
	Percent of Samples Above 200 ng/g	86	NA	NA	100	NA	75
OB-05		**2006**	**2008**	**2009**	**2010**	**2012**	**2016**
	Number of Samples	10	1	22	15	15	18
	Mean	198 ± 26.7	254	160 ± 7.35	172 ± 19.6	193 ± 12.3	164 ± 13.1
	Median	175	254	152	162	203	152
	Percent of Samples Above 200 ng/g	40	100	14	27	53	28
OB-01		**2006**	**2008**	**2009**	**2010**	**2012**	**2016**
	Number of Samples	10	37	38	30	15	19
	Mean	162 ± 20.3	160 ± 12.4	134 ± 9.43	191 ± 17.4	166 ± 24.7	169 ± 15.4
	Median	144	139	119	187	155	174
	Percent of Samples Above 200 ng/g	10	27	11	40	27	32
ES-13		**2006**	**2008**	**2009**	**2010**	**2012**	**2016**
	Number of Samples	7	NA	14	NA	15	11
	Mean	115 ± 7.49	NA	92.3 ± 7.07	NA	113 ± 10.4	109 ± 14.8
	Median	115	NA	90.1	NA	98.8	103
	Percent of Samples Above 200 ng/g	0	NA	0	NA	0	9

TABLE 3-13
SUMMARY OF ATLANTIC TOMCOD MERCURY CONCENTRATIONS IN THE PENOBSCOT RIVER BY YEAR

2016 BIOTA MONITORING REPORT

		2006	2008	2009	2010	2012	2016
ES-FP	**Number of Samples**	NA	NA	NA	NA	15	2
	Mean	NA	NA	NA	NA	88.6 ± 9.33	64.9 ± 9.40
	Median	NA	NA	NA	NA	71.7	64.9
	Percent of Samples Above 200 ng/g	NA	NA	NA	NA	0	0

Notes:

Concentrations in nanograms/gram (ng/g) wet weight

* Reference location

Mean concentrations are followed by the standard error of the mean.

NA = Not available

PREPARED BY/DATE: LSV 04/04/17

CHECKED BY/DATE: NTG 04/25/17

TABLE 5-1
AVIAN SPECIES REGRESSION SUMMARY

2016 BIOTA MONITORING REPORT

Species	Location	Overall Regression Direction	Site-Specific Regression Direction	Percent Annual Change
Nelson's Sparrow	Overall	No Trend		N/A
	W-17		No Trend	N/A
	Mendall Marsh SE		Increasing	0.6%
	Mendall Marsh SW		No Trend	N/A
	Reference		N/A	N/A
Red-winged Blackbird	Overall	N/A		N/A
	W-17		No Trend	N/A
	Mendall Marsh SE		No Trend	N/A
	Mendall Marsh SW		No Trend	N/A
	Reference		N/A	N/A
American Black Duck Blood	Overall	No Trend		N/A
	Mendall Marsh		No Trend	N/A
	South Verona		Increasing	3.4%
	Reference		Decline	-2.2%
American Black Duck Muscle	Overall	N/A		N/A
	Mendall Marsh		Decline*	-2.1%
	South Verona		N/A	N/A
	Reference		N/A	N/A

Notes:

N/A = not applicable

Decline or Increasing means p-value < 0.05

* indicates p-value ≥ 0.05 and < 0.10

No Trend means p-value ≥ 0.10 and the slope is not statistically different than zero

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

Declining

Declining (near significance)

No trend

Increasing

Prepared by/Date: JAW 4/13/17

Checked by/Date: LSV 5/16/17

TABLE 5-2
AQUATIC BIOTA REGRESSION SUMMARY

2016 BIOTA MONITORING REPORT

Species	Location	Overall Regression Direction	Site-Specific Regression Direction	Percent Annual Change
Blue Mussel	Overall	Decline		-0.8%
	ES-15		Decline	-0.8%
	ES-13		Decline	-1.3%
	ES-03		No Trend	N/A
	ES-FP		Increasing	0.4%
	Reference		N/A	N/A
Lobsters	Overall	Decline		-0.5%
	Odom Ledge		No Trend	N/A
	South Verona		Decline	-2.3%
	Cape Jellison		Decline	-7.4%
	Turner Point		Decline	-1.2%
	Harborside		Decline	-1.2%
Mummichog	Overall	No Trend		N/A
	OB-05		N/A	N/A
	OB-01		N/A	N/A
	Mendall Marsh		Decline	-2.3%
	Reference		N/A	N/A
Rainbow Smelt	Overall	Decline		-6.1%
	OB-05		No Trend	N/A
	OB-04		Decline	-6.7%
	OB-01		Decline	-9.2%
	ES-15		N/A	N/A
	ES-FP		No Trend	N/A
	Reference		N/A	N/A

TABLE 5-2
AQUATIC BIOTA REGRESSION SUMMARY

2016 BIOTA MONITORING REPORT

Species	Location	Overall Regression Direction	Site-Specific Regression Direction	Percent Annual Change
American Eel	Overall	Decline		-3.5%
	BO-04		Decline	-5.3%
	OB-05		Decline	-3.3%
	OB-01		No Trend	N/A
	Reference		No Trend	N/A
Atlantic Tomcod	Overall	Decline		-1.7%
	BO-04		Decline*	-1.3%
	OB-05		Decline*	-2.0%
	OB-01		Decline	-1.9%
	ES-13		Decline	-2.7%
	ES-FP		N/A	N/A
	Reference		N/A	N/A

Notes:

N/A = not applicable

Decline or Increasing means p-value < 0.05

* indicates p-value ≥ 0.05 and < 0.10

No Trend means p-value ≥ 0.10 and the slope is not statistically different than zero

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

Declining

Declining (near significance)

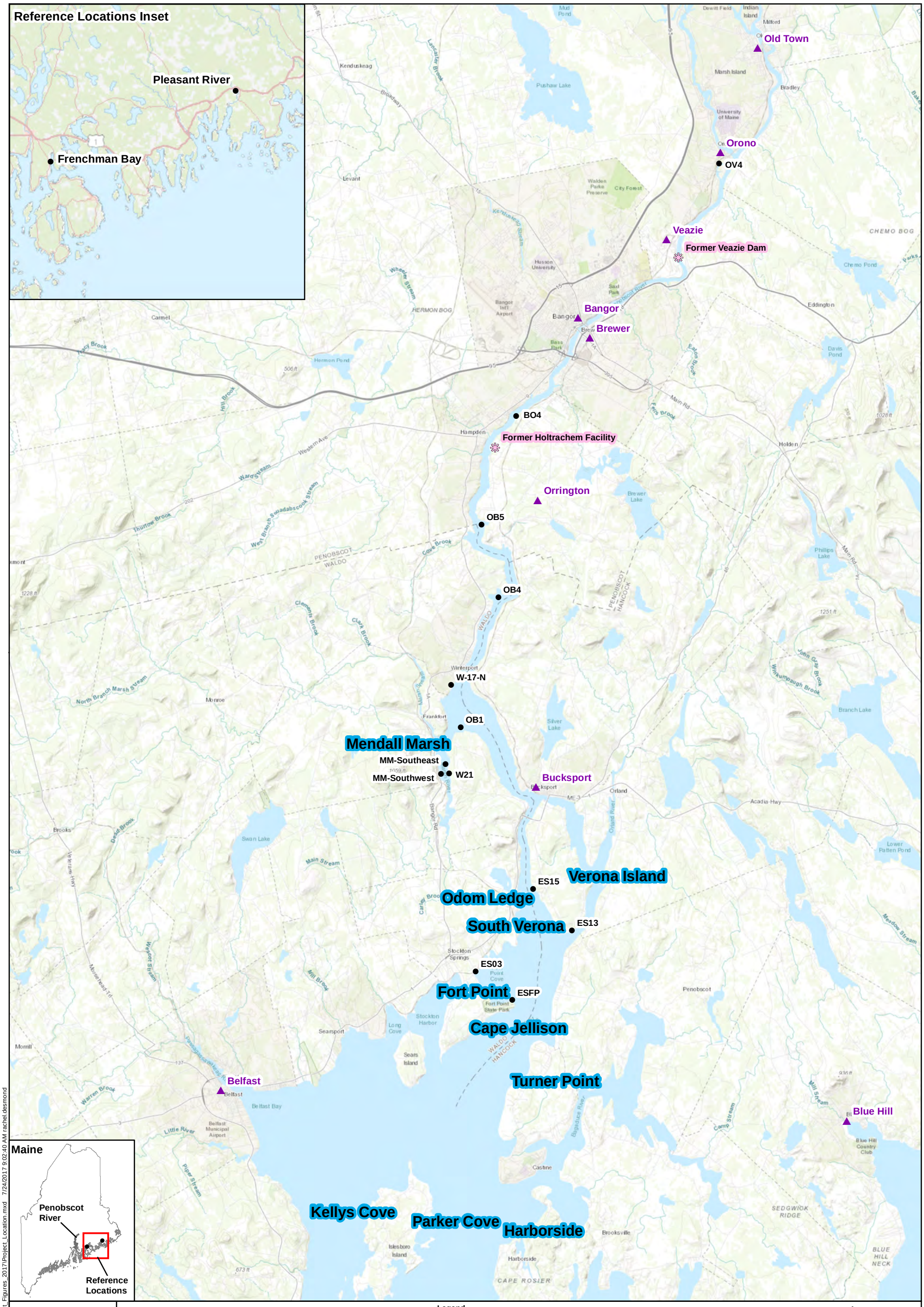
No trend

Increasing

Prepared by/Date: JAW 4/13/17

Checked by/Date: LSV 5/16/17

FIGURES


Reference Locations Inset
Pleasant River
Frenchman Bay
Old Town
Orono
OV4
Veazie
Former Veazie Dam
Bangor
Brewer
BO4
Former Holtrachem Facility
Orrington
OB5
OB4
W-17-N
OB1
Mendall Marsh
MM-Southeast
MM-Southwest
W21
Bucksport
ES15
Verona Island
Odom Ledge
South Verona
ES13
ES03
Fort Point
ESFP
Cape Jellison
Turner Point
Belfast
Blue Hill
Kellys Cove
Parker Cove
Harborside
Maine
Penobscot River
Reference Locations
Legend
City
Relevant Site Landmark
Area ID
Mendall Marsh
Geographic Area Label
N
0
1.5
3
Miles
amec foster wheeler
Figure 1-1
Site Location
2016 Biota Monitoring Report
Penobscot River
Phase III Engineering Study
Project: 3616166052
Prepared/Date: RD 7/24/2017
Checked/Date: LSV 7/24/2017
NAD83 State Plane Maine East, US Survey Feet
Document:G:\Penobscot River\mxds\Report_Figures_2017\Project_Location.mxd 7/24/2017 9:02:40 AM rachel.desmond

BO5
RM 25
BO4
Former Holtrachem Facility
Orrington
RM 20
OB5
OB4
RM 15
W-17-N
OB1
Mendall Marsh
RM 10
MM-Southeast
W21
MM-Southwest
Bucksport
RM 5
Verona Island
ES15
Odom Ledge
ES13
South Verona
Devereaux Cove
ES03
Fort Point Cove
ESFP
Fort Point
RM 0
Cape Jellison
Belfast
Turner Point
Kellys Cove
Parker Cove
Harborside

Legend

- River Mile Marker
- City
- Relevant Site
- Area ID
- Mendall Geographic Area Label

N

0 1 2 Miles

amec foster wheeler

Project: 3616166052 | Prepared/Date: RD 8/14/2017 | Checked/Date: LSV 8/14/2017 | NAD83 State Plane Maine East, US Survey Feet

Figure 2-1
2016 Penobscot Biota Monitoring Locations

2016 Biota Monitoring Report
Penobscot River
Phase III Engineering Study

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Frenchman Bay Inset

Penobscot River

Pleasant River

Frenchman Bay

Pleasant River

Addison

Addison/Pleasant River Inset

Ellsworth

Frenchman Bay

Trenton

Legend

- City
- Area ID
- Fish (Mummichog, Rainbow Smelt, and Tomcod)
- American Black Duck
- Nelson's Sparrow
- Polychaetes
- Spiders and Terrestrial Insects
- **Pleasant River** Geographic Area Label

N

0 5 10 Miles

Notes: Blue box does not represent areal extent, but is exaggerated in size to emphasize the sampling location.

amec foster wheeler

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Figure 2-2
2016 Biota
Reference Sampling Locations

2016 Biota Monitoring Report
Penobscot River
Phase III Engineering Study

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

Concentrations reported in wet weight (ww)

Legend

- Area ID
- Terrestrial Insect Sample Location
- **Mendall Marsh** Geographic Area Label

N

0 0.25 0.5 Miles

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

2016 Biota Monitoring Report
Penobscot River
Phase III Engineering Study

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

Concentrations reported in wet weight (ww)

Legend

- Area ID
- Terrestrial Insect Sample Location

Mendall Geographic
Marsh Area Label

N

0 0.25 0.5 Miles

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

2016 Biota Monitoring Report
Penobscot River
Phase III Engineering Study

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W-17-N

431
420
263J
213J
197J

OB1

Mendall Marsh

771
208
205
200
198

MM-Southeast

MM-Southwest

270
257J
219
200
166J

W21

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

Concentrations reported in wet weight (ww)

Legend

- Area ID
- Spider Sample Location
- **Mendall** Geographic
- **Marsh** Area Label

N

0 0.25 0.5 Miles

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

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Penobscot River
Phase III Engineering Study

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W-17-N

642 J
480 J
282
278 J
210

OB1

Mendall Marsh

244
181
174
166
136

MM-Southeast

MM-Southwest

330 J
274 J
217
201
151

W21

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

Concentrations reported in wet weight (ww)

Legend

- Area ID
- Spider Sample Location
- **Mendall** Geographic **Marsh** Area Label

N

0 0.25 0.5 Miles

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

2016 Biota Monitoring Report
Penobscot River
Phase III Engineering Study

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5240
W-17-N
7570
6680
9590
2140
10300
6020
1960
2920
3990
1630
734
5000
1560
5350
OB1
Mendall Marsh
4020
8070
8450
7450
5730
4130
6380
5730
4880
4590
4330
9240
MM-Southeast
6130
7520
6220
7630
6770
6620
5840
5670
5310
3280
7790
5240
5910
4230
W21
MM-Southwest

Note:
Concentrations reported in wet weight (ww)

Legend

- Area ID
- Nelson's Sparrow Sample Location
- **Mendall** Geographic **Marsh** Area Label

Mercury Results (ng/g)

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

N

0 0.25 0.5 Miles

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

2016 Biota Monitoring Report
Penobscot River
Phase III Engineering Study

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2500
99.4
W-17-N
5850

Note:
Concentrations reported in wet weight (ww)

Legend

- Area ID
- Red-winged Blackbird Sample Location

Mercury Results (ng/g)

- 3000 - 6000
- 1000 - 3000
- <1000

N

0 100 200 Feet

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

2016 Biota Monitoring Report
Penobscot River
Phase III Engineering Study

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OB1

264
157

RM 10

Mendall Marsh

MM-Southeast

1400
961
701
628
589
558
533
504
409
379
330
284
242

W21

MM-Southwest

Bucksport

RM 5

Verona Island

ES15

Odom Ledge

700
596
487
472
408
403
396
377
362
331
319
310
209
198
126

ES13

South Verona

Devereaux Cove

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

Concentrations reported in wet weight (ww)

N

0 0.25 0.5 Miles

Legend

- River Mile Marker
- City
- Relevant Site Landmark
- Area ID
- American Black Duck Sample Location

Mercury Results (ng/g)

- 1000 - 3000
- <1000

Mendall Marsh — Geographic Area Label

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

2016 Biota Monitoring Report
Penobscot River
Phase III Engineering Study

Project: 3616166052 | Prepared/Date: RD 8/14/2017 | Checked/Date: LSV 8/14/2017 | NAD83 State Plane Maine East, US Survey Feet

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OB1

177
121

RM 10

Mendall Marsh

MM-Southeast

854
325
170

MM-Southwest

W21

Bucksport

RM 5

Verona Island

ES15

Odom Ledge

717 J
507
441
371
243

ES13

South Verona

Devereaux Cove

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

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

N Concentrations reported in wet weight (ww)

0 0.25 0.5 Miles

Legend

- River Mile Marker
- City
- Relevant Site Landmark
- Area ID
- American Black Duck Sample Location

Mercury Results (ng/g)

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

Mendall Marsh — Geographic Area Label

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

2016 Biota Monitoring Report
Penobscot River
Phase III Engineering Study

Project: 3616166052 | Prepared/Date: RD 8/14/2017 | Checked/Date: LSV 8/14/2017 | NAD83 State Plane Maine East, US Survey Feet

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BO5
RM 25
BO4
311 J
256 J
185 J
176 J
142 J
Former Holtrachem Facility
230 J
224 J
215 J
205 J
189 J
Orrington
RM 20
OB5
OB4
RM 15
W-17-N
321 J
239 J
190 J
142 J
69.9 J
OB1
Mendall Marsh
RM 10
MM-Southeast
MM-Southwest
W21
Bucksport
ES02E
RM 5
ES15
Verona Island
Odom Ledge
71.3
45.2
ES13
24.7
20.8
12.8
South Verona
Devereaux Cove
ES03
Fort Point Cove
46.1 J
34.6 J
24.5 J
24.0 J
19.4 J
ESFP
Fort Point
RM 0

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

Concentrations reported in wet weight (ww)

N
0 1 2 Miles

Legend

- River Mile Marker
- City
- Relevant Site Landmark
- Area ID
- Polychaete Sample Location
- **Mendall Marsh** Geographic Area Label

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

2016 Biota Monitoring Report
Penobscot River
Phase III Engineering Study

Project: 3616166052 | Prepared/Date: RD 8/14/2017 | Checked/Date: LSV 8/14/2017 | NAD83 State Plane Maine East, US Survey Feet

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BO5
RM 25
BO4
9.2 J
8.6 J
8.3 J
7.3 J
6.9 J
Former Holtrachem Facility
12.8 J
12.8 J
12.7 J
11.7 J
11.0 J
Orrington
RM 20
OB5
OB4
RM 15
W-17-N
11.3 J
11.1 J
9.90 J
8.20 J
1.40 J
OB1
Mendall Marsh
RM 10
MM-Southeast
MM-Southwest
W21
Bucksport
ES02E
RM 5
ES15
Verona Island
Odom Ledge
4.10
3.30
1.50 J
1.10 J
<0.40 U
ES13
South Verona
Devereaux Cove
ES03
Fort Point Cove
15.7 J
6.20 J
5.30 J
4.40 J
<0.40 UJ
ESFP
Fort Point
RM 0

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

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

UJ - The target compound was not detected and the reporting limit is considered to be estimated

Concentrations reported in wet weight (ww)

N

0 1 2 Miles

Legend

- River Mile Marker
- City
- Relevant Site Landmark
- Area ID
- Polychaete Sample Location
- Mendall Marsh — Geographic Area Label

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

2016 Biota Monitoring Report
Penobscot River
Phase III Engineering Study

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RM 5

ES15

96.0
77.0
68.0
67.4
65.6
65.0
64.8
64.1
62.7
58.2
55.5
55.4
55.3
51.1
49.8
49.7
48.1
46.9
45.6
44.8

Verona Island

Odom Ledge

ES13

106
76.9
75.2
73.5
70.8
69.0
66.4
63.5
63.0
62.1
59.6
59.2
58.5
56.7
56.5
54.8
53.9
48.9
48.9
48.4

South Verona

Devereaux Cove

138
118
116
107
88.9
87.5
81.9
81.4
80.4
77.7
77.3
76.0
71.4
71.0
69.0
68.6
61.1
60.4
57.8
51.0

ES03

Fort Point Cove

111
86.0
80.4
79.3
74.1
73.4
64.3
63.7
62.4
59.1
58.6
55.8
55.7
55.4
52.0
48.5
45.4
45.2
41.3
40.0

ESFP

Fort Point

RM 0

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Note:
Concentrations reported in wet weight (ww)

N
0 0.25 0.5 Miles

Legend

- River Mile Marker
- Area ID
- Blue Mussel Sample Location
- South Verona — Geographic Area Label

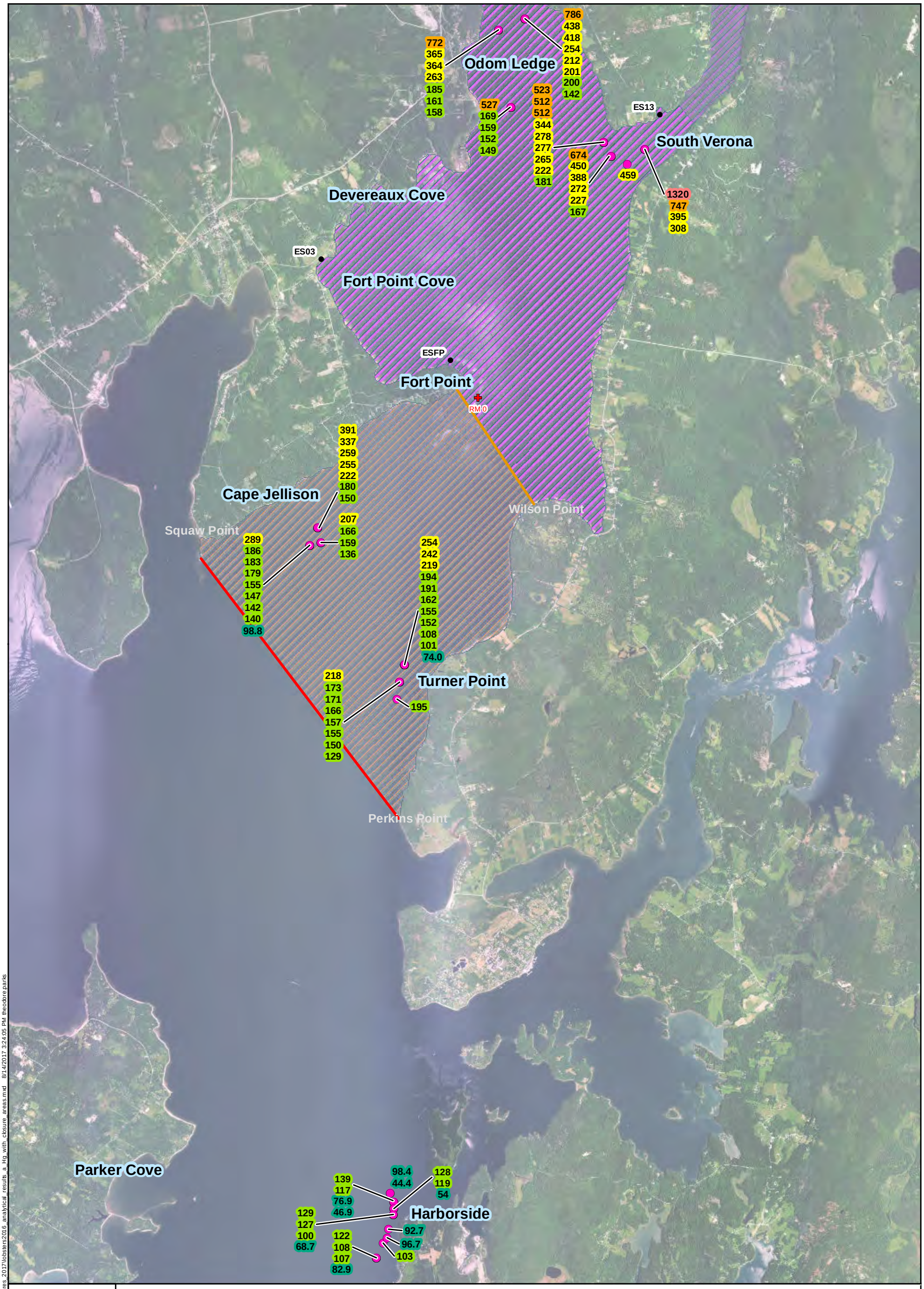
Mercury Results (ng/g)

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

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

2016 Biota Monitoring Report
Penobscot River
Phase III Engineering Study

Project: 3616166052 | Prepared/Date: RD 8/14/2017 | Checked/Date: LSV 8/14/2017 | NAD83 State Plane Maine East, US Survey Feet



Notes:
Concentrations reported in wet weight (ww)

South Verona Geographic Area Label

Legend

- River Mile Marker
- Area ID
- Lobster Sample Location
- 2014 Closure Line
- 2016 Closure Line
- 2014 Closure
- 2016 Closure

Mercury Results (ng/g)

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

N

0 1 2 Miles

amec foster wheeler

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

2016 Biota Monitoring Report
Penobscot River
Phase III Engineering Study

Project: 3616166052 | Prepared/Date: RD 8/14/2017 | Checked/Date: LSV 8/14/2017 | NAD83 State Plane Maine East, US Survey Feet

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Note:
Concentrations reported in wet weight (ww)

Legend

- River Mile Marker
- City
- Mendall Marsh — Geographic Area Label
- Relevant Site Landmark
- Area ID
- Mummichog Sample Location

Mercury Results (ng/g)

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

N

0 1 2 Miles

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

2016 Biota Monitoring Report
Penobscot River
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OB5
201
81.9
55.6
54.9
47.5
44.5
OB4
RM 15
W-17-N
146
140
116
103
102
95.4
94.6
90.8
82.8
79.5
75.3
58.2
44.2
33.6
31.8
OB1
Mendall Marsh
RM 10
MM-Southeast
W21
MM-Southwest
Bucksport
ES02E
38.4
RM 5
ES15
Verona Island
Odom Ledge
ES13
South Verona
113
108
93.6
84.6
78.4
74.1
64.0
60.7
60.5
56.0
54.7
49.3
48.7
44.4
39.8
36.2
35.4
33.4
31.4
27.1
Devereaux Cove
ES03
Fort Point Cove
ESFP
Fort Point

Note:
Concentrations reported in wet weight (ww)

Legend

- River Mile Marker
- City
- Area ID
- Rainbow Smelt Sample Location
- **Mendall Marsh** Geographic Area Label

Mercury Results (ng/g)

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

N

0 1 2 Miles

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

2016 Biota Monitoring Report
Penobscot River
Phase III Engineering Study

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BO5
RM 25
1370J
BO4
Former Holtrachem Facility
428
Orrington
579
485
391
RM 20
461
OB5
OB4
RM 15
W-17-N
394
OB1

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

Concentrations reported in wet weight (ww)

N
0 1 2 Miles

Legend
- City
- Relevant Site Landmark
- Area ID
- River Mile Marker
- Eel Sample Location

Mercury Results (ng/g)
- >1000
- 330 - 1000
- 200 - 330
- 100 - 200
- <100

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

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Penobscot River
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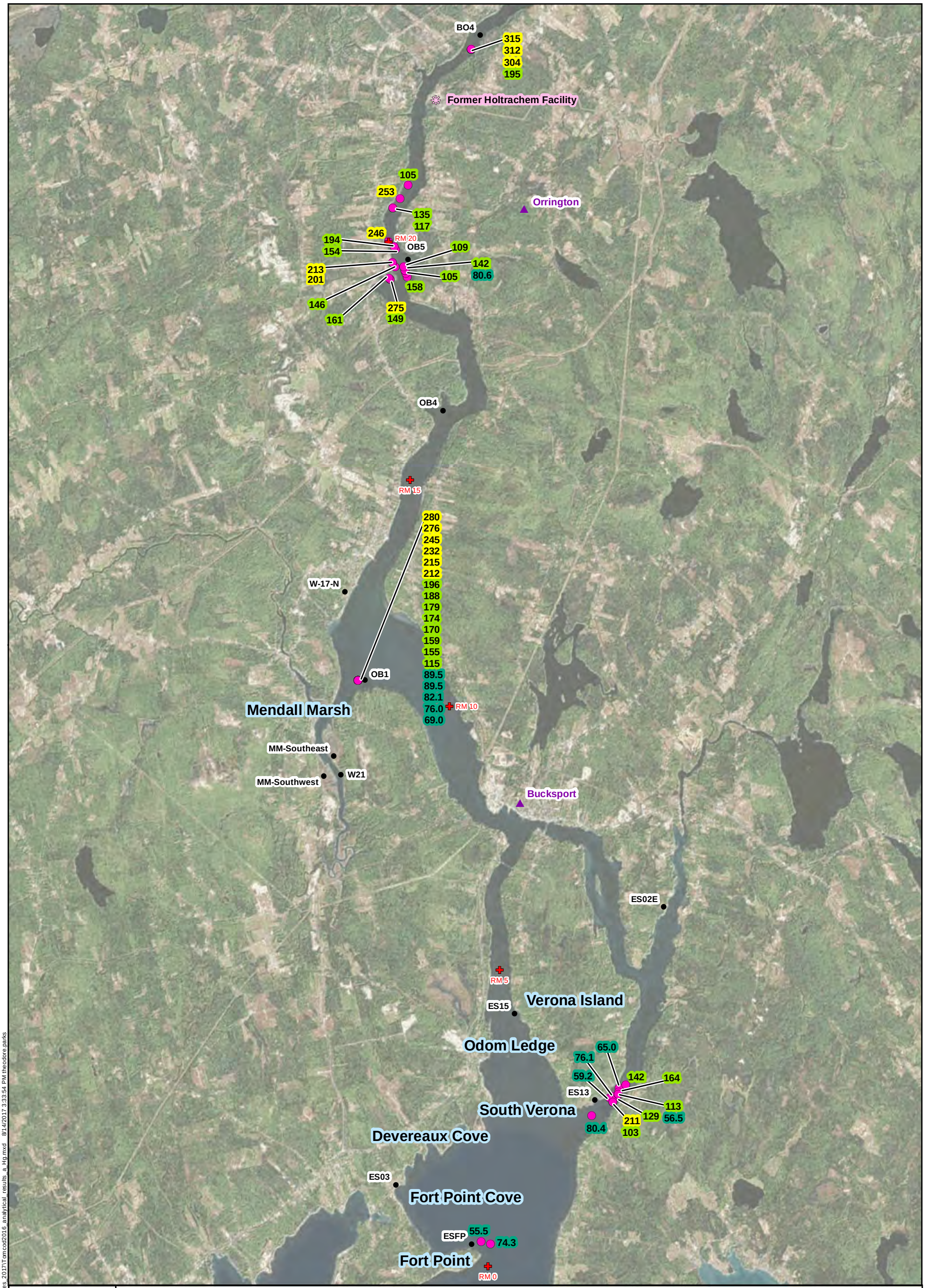

Note:
Concentrations reported in wet weight (ww)

Legend

- River Mile Marker
- City
- Relevant Site Landmark
- Area ID
- Tomcod Sample Location
- Mendall Marsh — Geographic Area Label

Mercury Results (ng/g)

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

N

0 1 2 Miles

amec foster wheeler

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

2016 Biota Monitoring Report
Penobscot River
Phase III Engineering Study

Project: 3616166052 | Prepared/Date: RD 8/14/2017 | Checked/Date: LSV 8/14/2017 | NAD83 State Plane Maine East, US Survey Feet

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Pleasant River

296
566
382
317
558
467
740
637
290
469
434

44.2 J
43.3
31.4
30.5
25.9

63.2
49.2
16.8 J
8.85 J
7.37 J

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

Concentrations reported in wet weight (ww)

N
0 100 200 Feet

Legend

Nelson's Sparrow
Spider
Terrestrial Insect
Pleasant River Geographic Area Label

Mercury Results (ng/g)
<1000

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

2016 Biota Monitoring Report
Penobscot River
Phase III Engineering Study

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Pleasant River

60.2 J
24.0 J
22.9 J
22.9 J
14.6 J

31.2 J
24.9 J
18.6 J
12.7 J
2.50 J

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

Concentrations reported in wet weight (ww)

N

0 100 200 Feet

Legend

- Spider
- Terrestrial Insect
- **Pleasant River** Geographic Area Label

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

2016 Biota Monitoring Report
Penobscot River
Phase III Engineering Study

Project: 3616166052	Prepared/Date: RD 8/15/2017	Checked/Date: LSV 8/15/2017	NAD83 State Plane Maine East, US Survey Feet

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Polychaetes Results
3.18
<0.074 U
<0.077 U
<0.083 U
<0.075 U

Mummichog Results
13.5
11.1
9.83
9.38
9.29
8.58
8.43
8.37
8.19
8.01
7.90
7.83
7.67
7.05
6.90
6.77
6.49
5.76
5.16
4.94

Rainbow Smelt Results
8.37
8.26
8.00
7.62
7.35
7.27
7.03
6.89
6.79
6.67
6.60
6.52
6.50
6.46
6.37
6.19
5.96
5.72
5.46
5.07

Frenchman Bay

Tomcod Results
36.5

American Black Duck Blood Results
109
89.3
83.9
70.6
69.0
53.8
53.1
43.5
43.3
41.5
35.5
32.6
31.5
31.2
11.3

American Black Duck Tissue Results
47.6
46.5
44.8
41.7
10.1

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amec foster wheeler

N

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

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

Concentrations reported in wet weight (ww)

Legend
- American Black Duck
- Mummichog
- Polychaete worms
- Rainbow Smelt
- Tomcod

Mercury Results (ng/g)
- 100 - 200
- <100

Frenchman Bay — Geographic Area Label

0 100 200 Feet

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

2016 Biota Monitoring Report
Penobscot River
Phase III Engineering Study

1.90 U
2.46 U
1.15 U
1.82 U

Frenchman Bay

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

Concentrations reported in wet weight (ww)

Legend

Polychaete Sample Location

Frenchman Bay — Geographic Area Label

N

0 100 200 Feet

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

2016 Biota Monitoring Report
Penobscot River
Phase III Engineering Study

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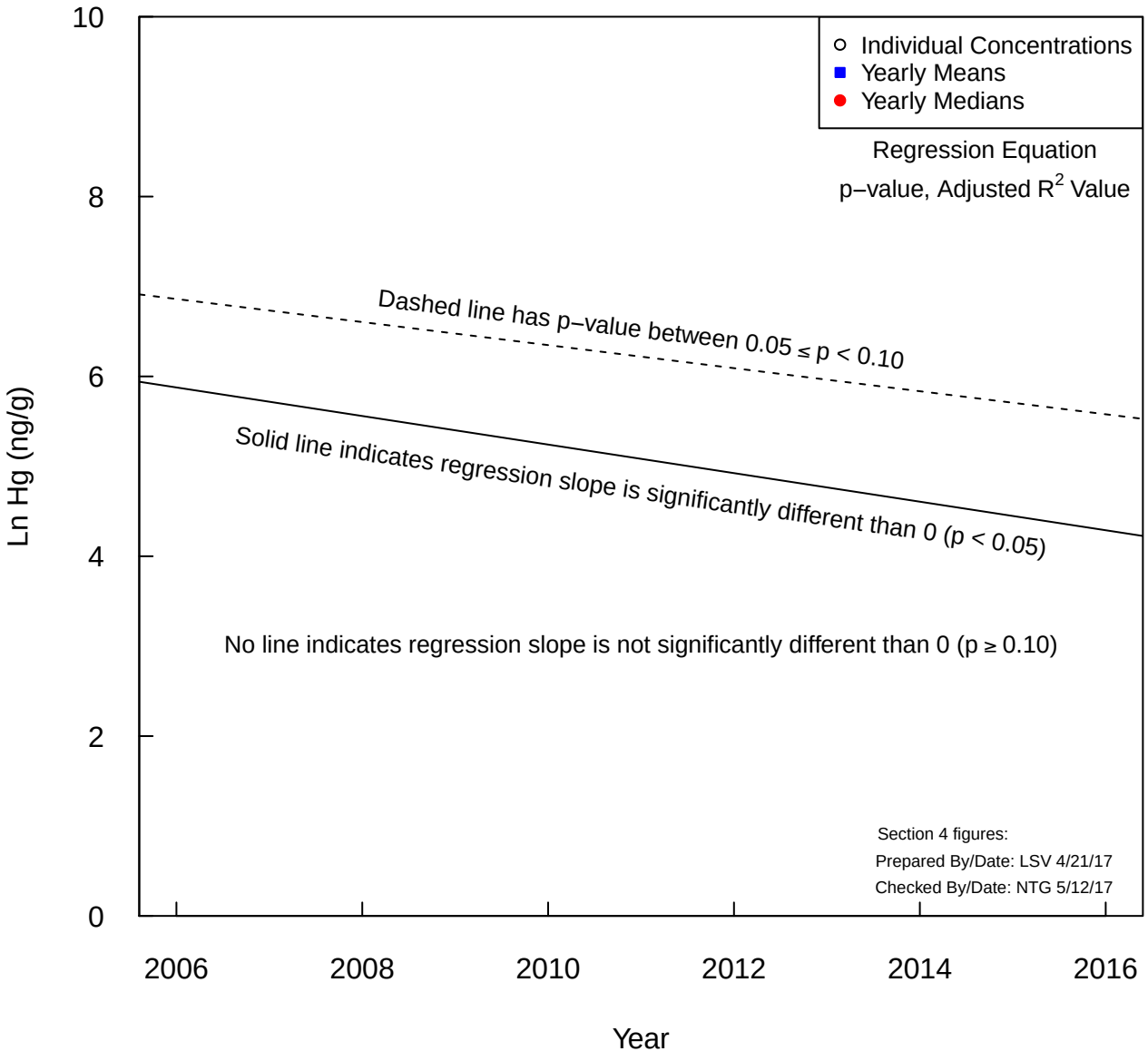
Figure 4–0
Figure Legend For Section 4 Figures



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

Figure 4–1
Terrestrial Insect – Reference Locations
Ln Mercury Concentrations

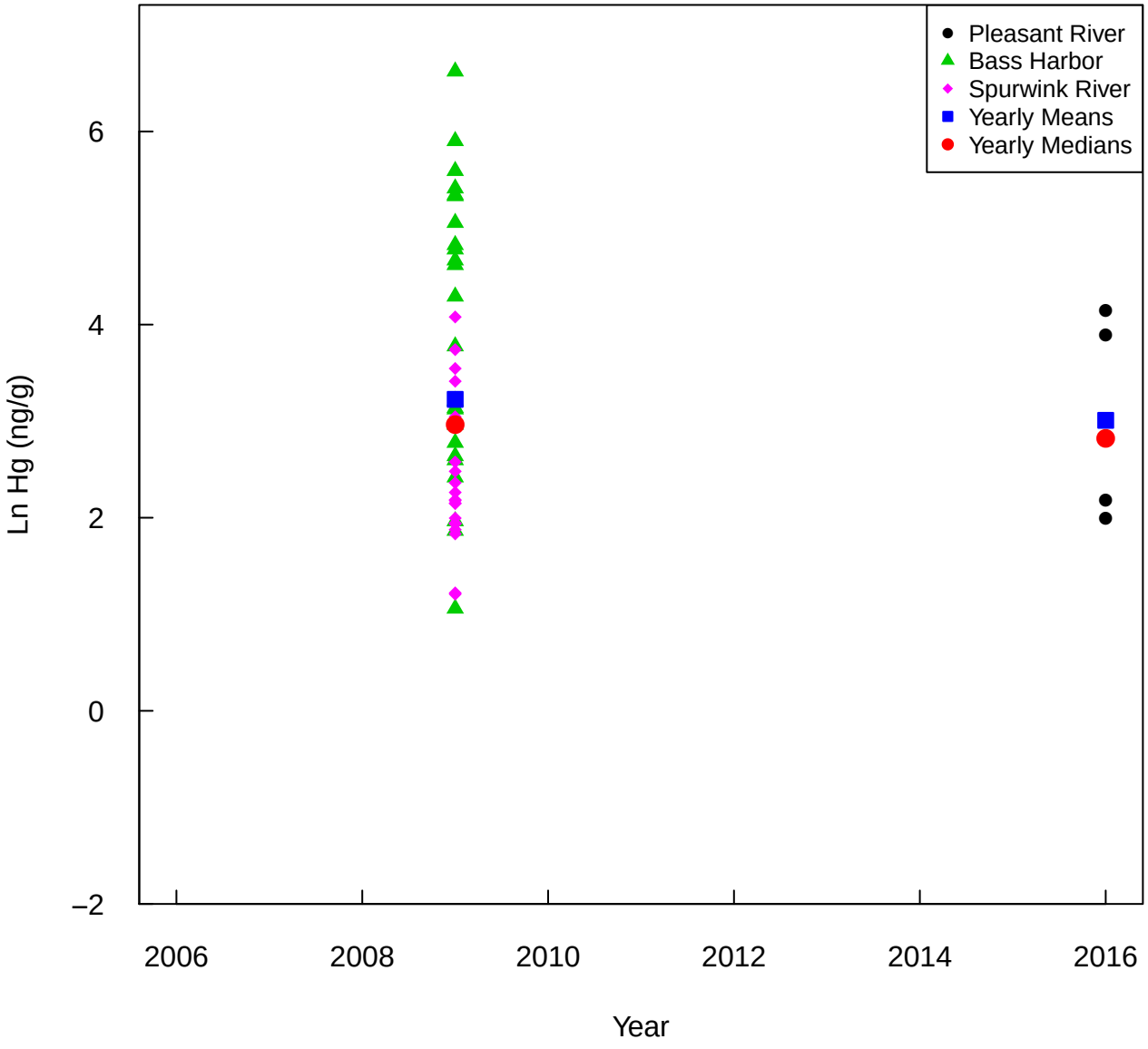
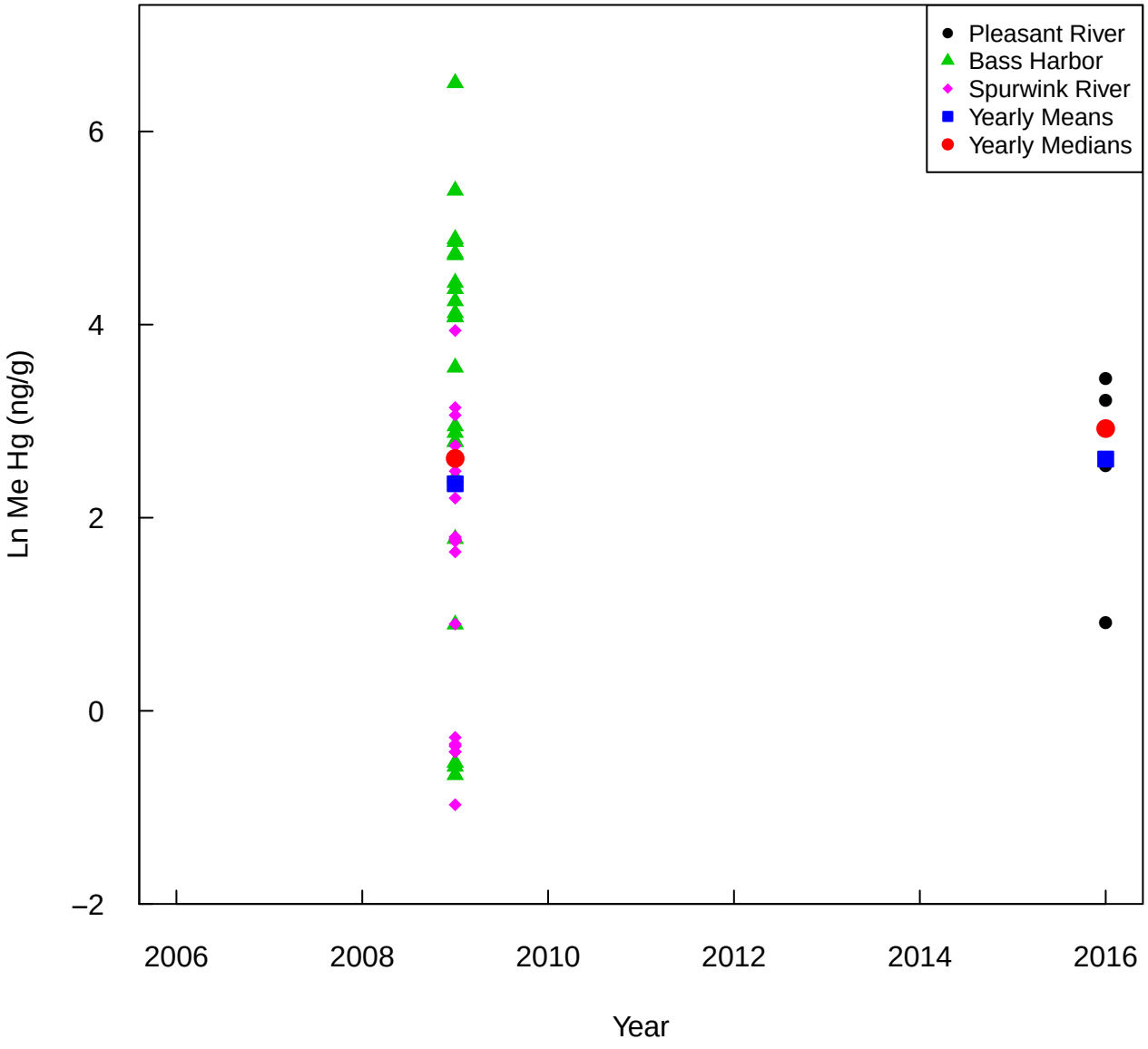
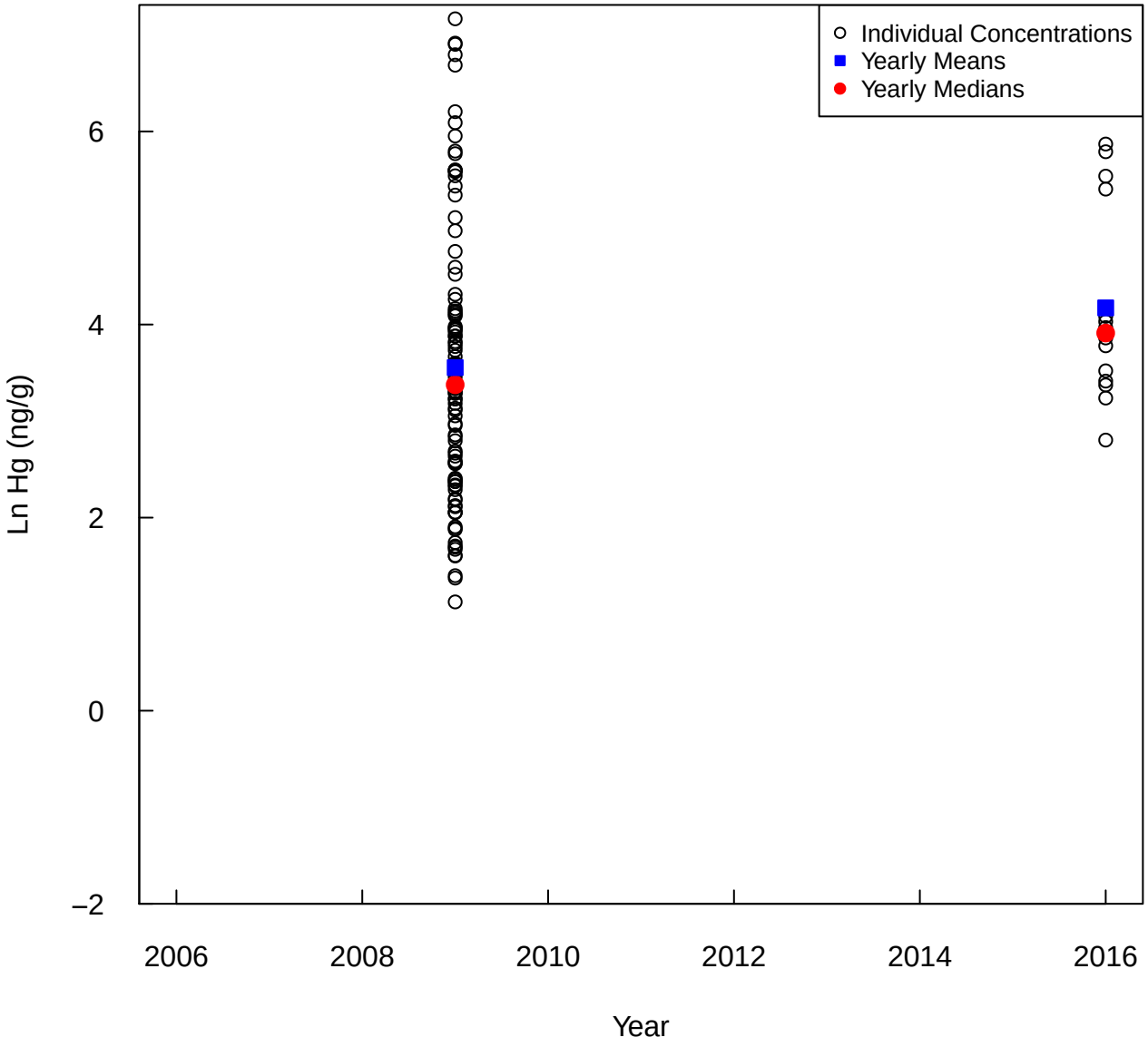


Figure 4–2
Terrestrial Insect – Reference Locations
Ln Methyl Mercury Concentrations



Two samples at Bass Harbor and 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

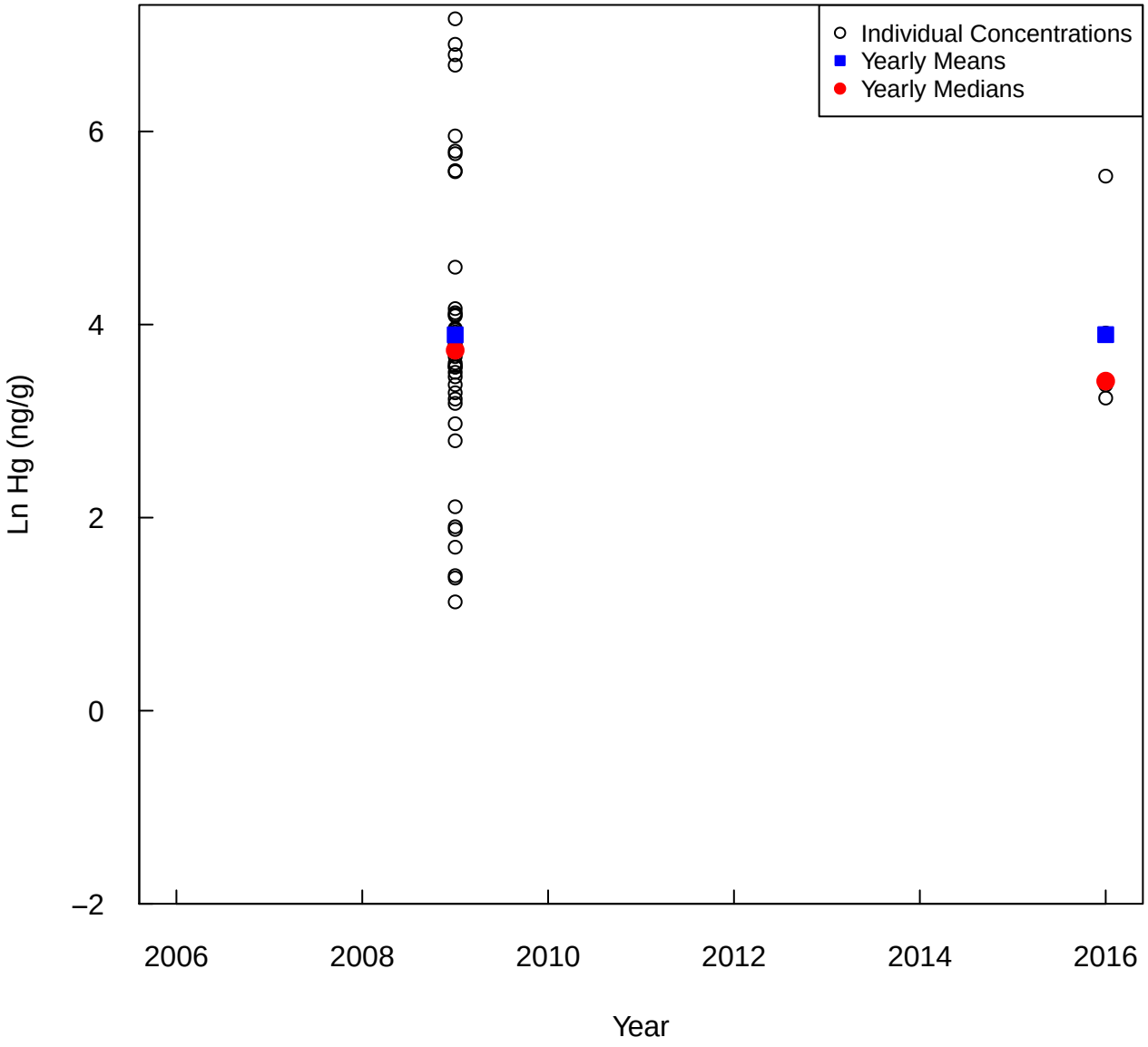


Figure 4–5
Terrestrial Insect – Mendall Marsh SE
Ln Mercury Concentrations

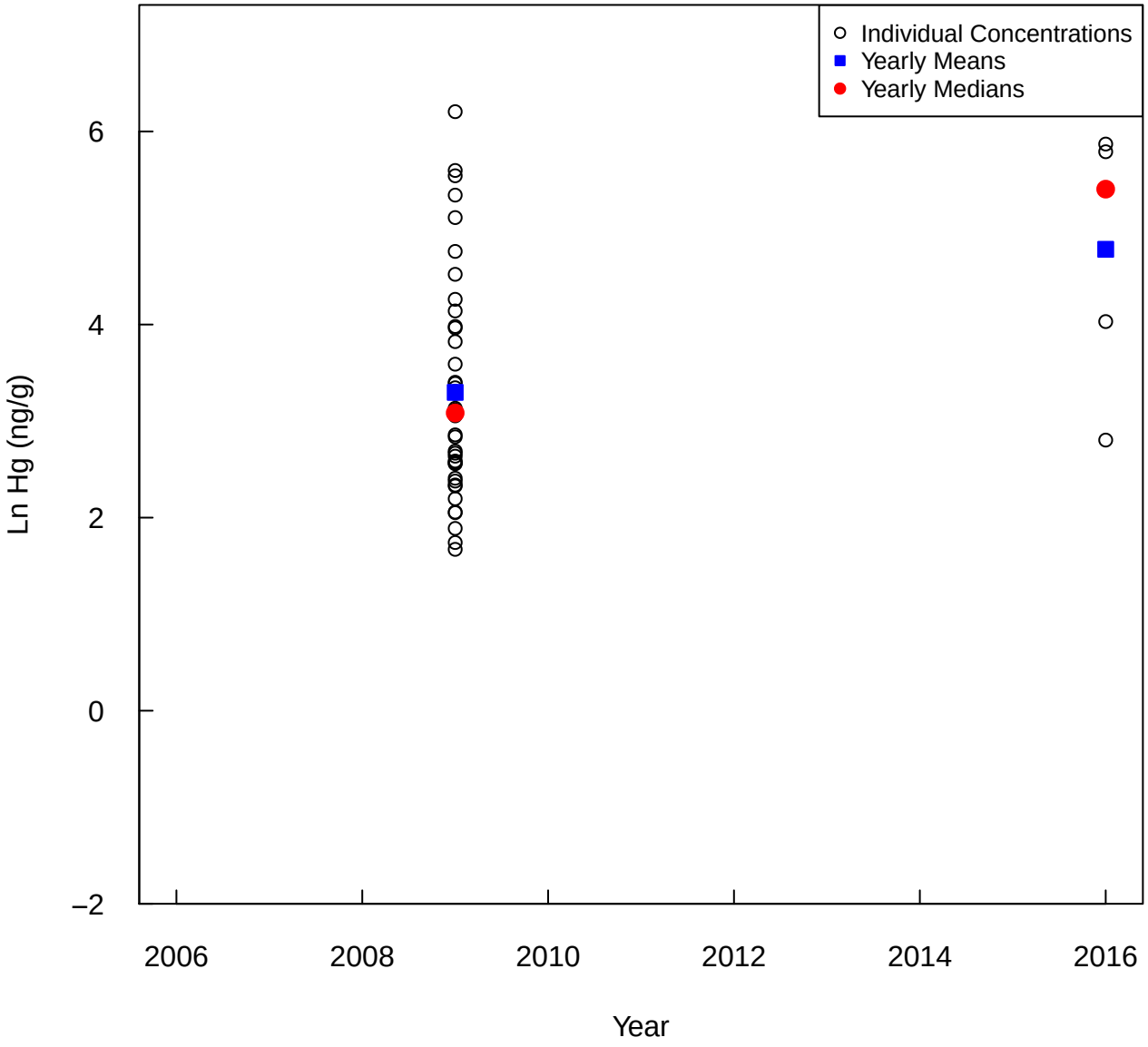


Figure 4–6
Terrestrial Insect – Mendall Marsh SW
Ln Mercury Concentrations

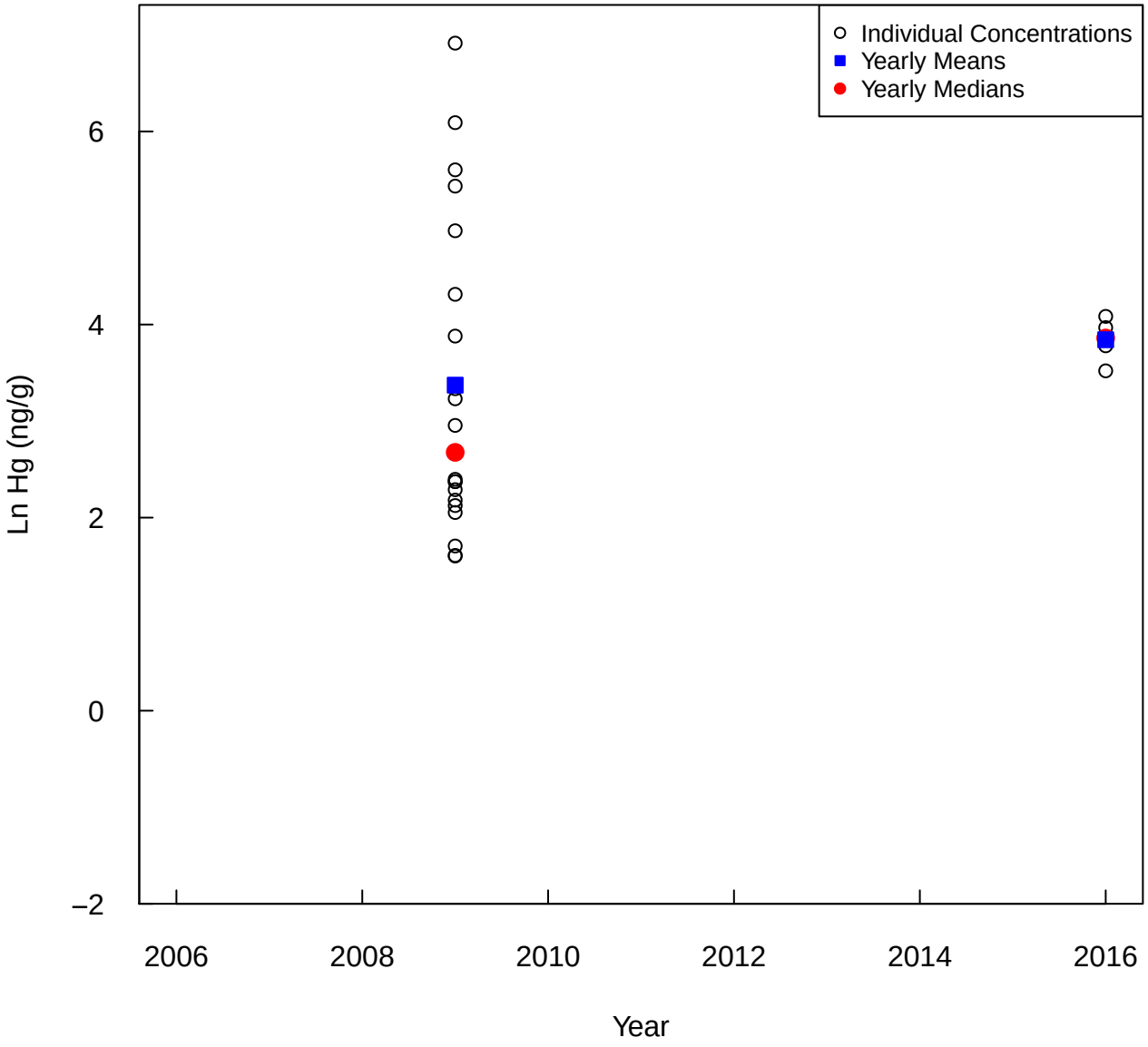
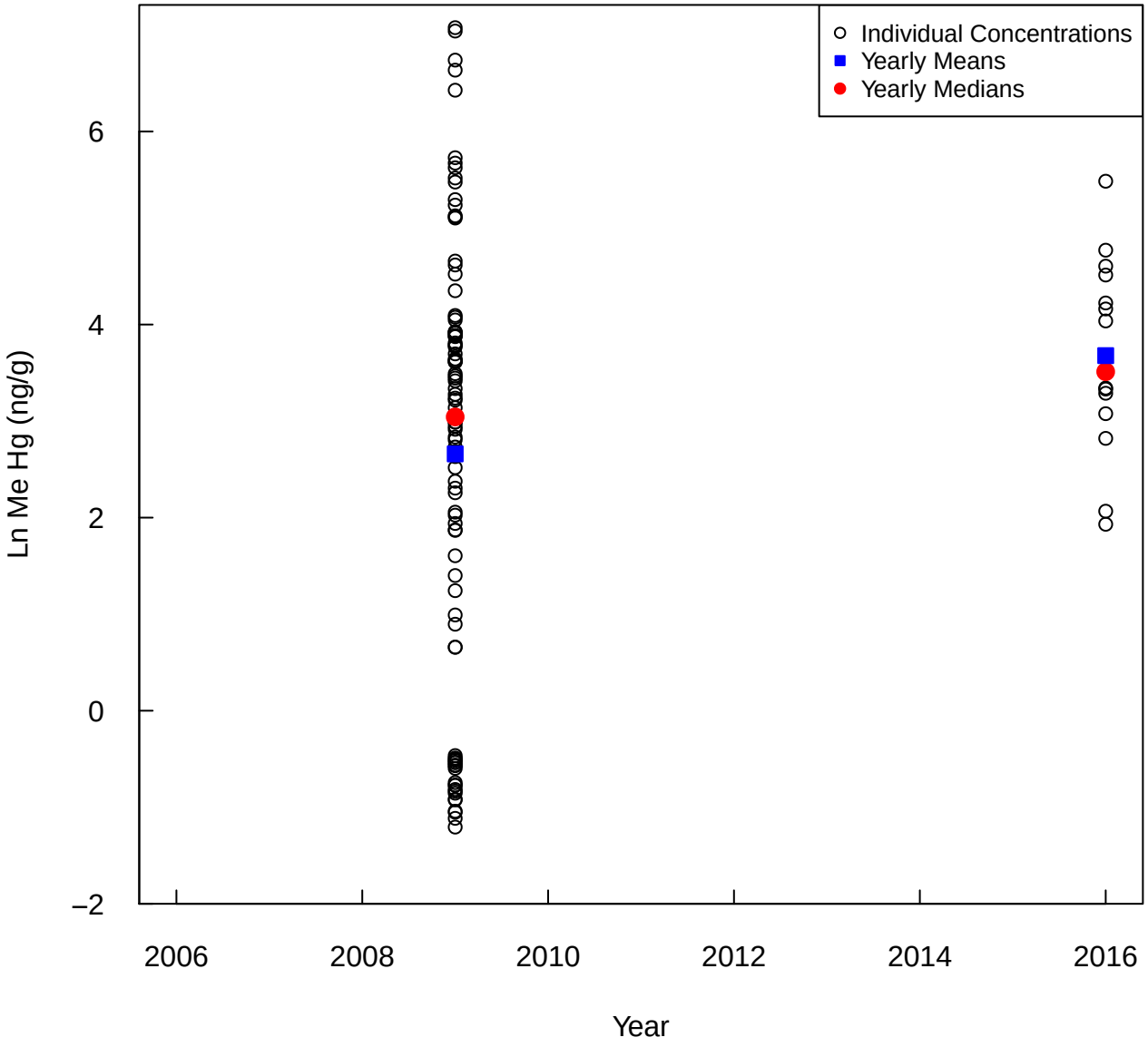
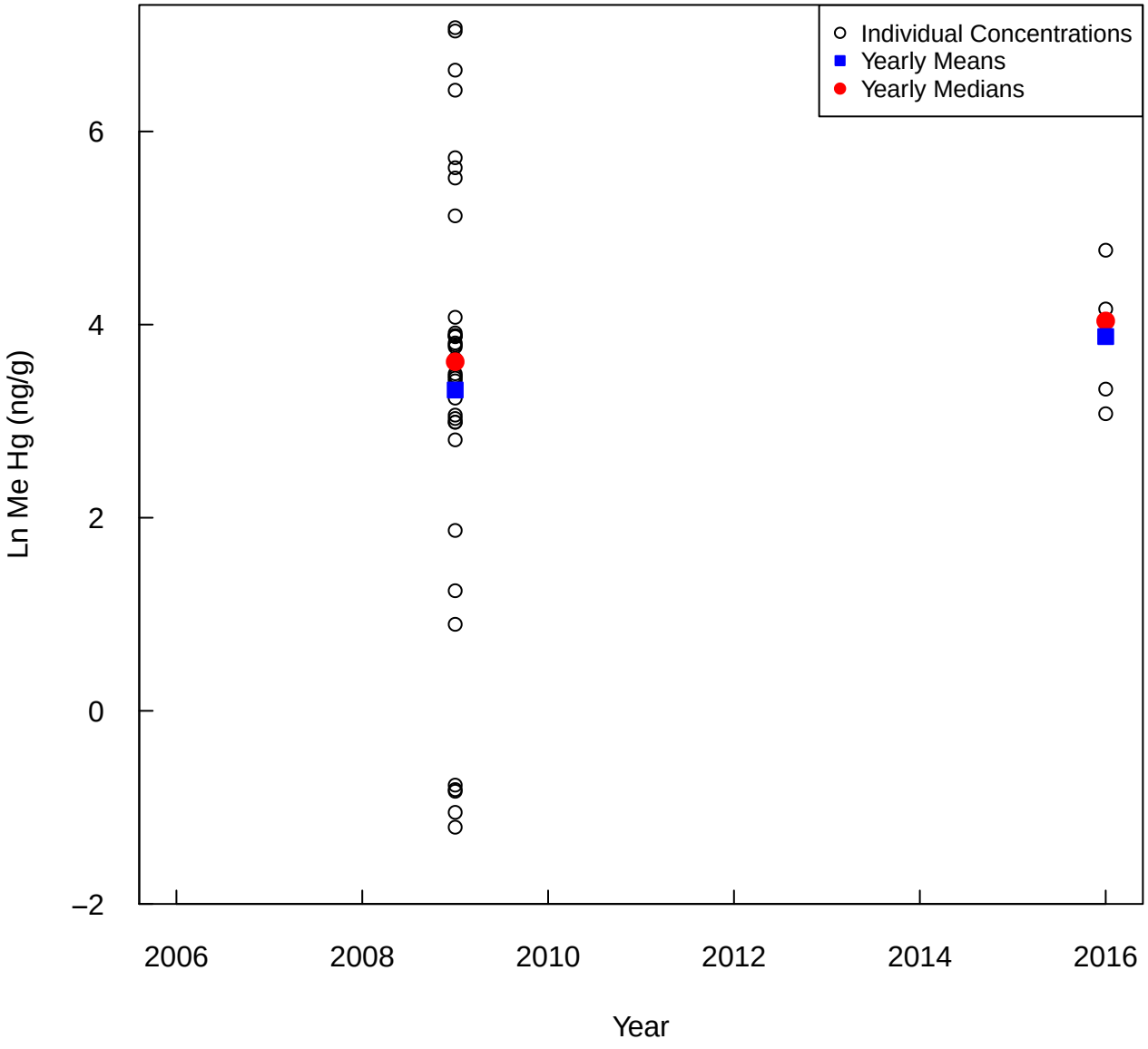


Figure 4–7
Terrestrial Insect – Whole River
Ln Methyl Mercury Concentrations



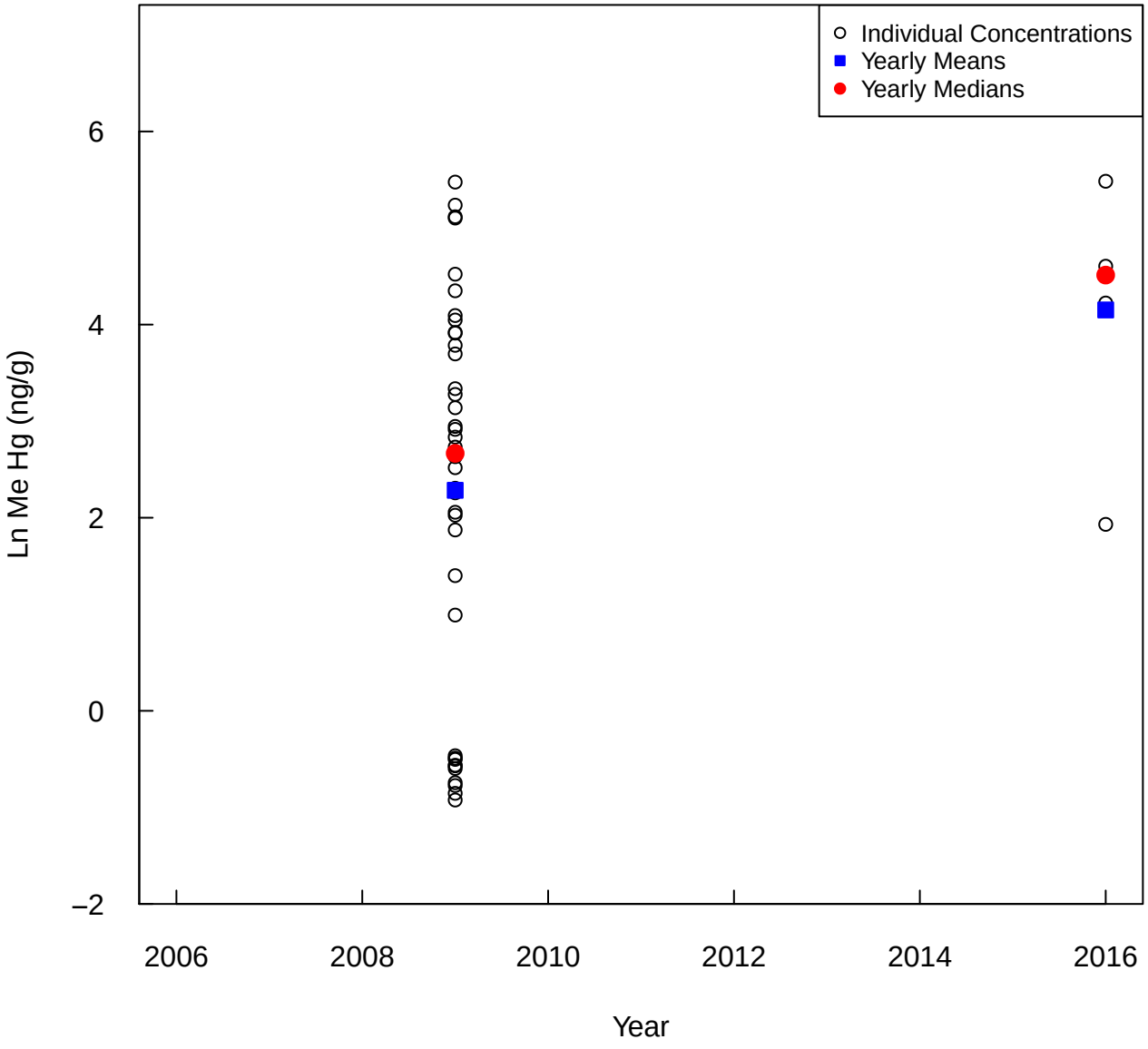
Includes Terrestrial Insects sampled at W–17–N, MM–SE, and MM–SW

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



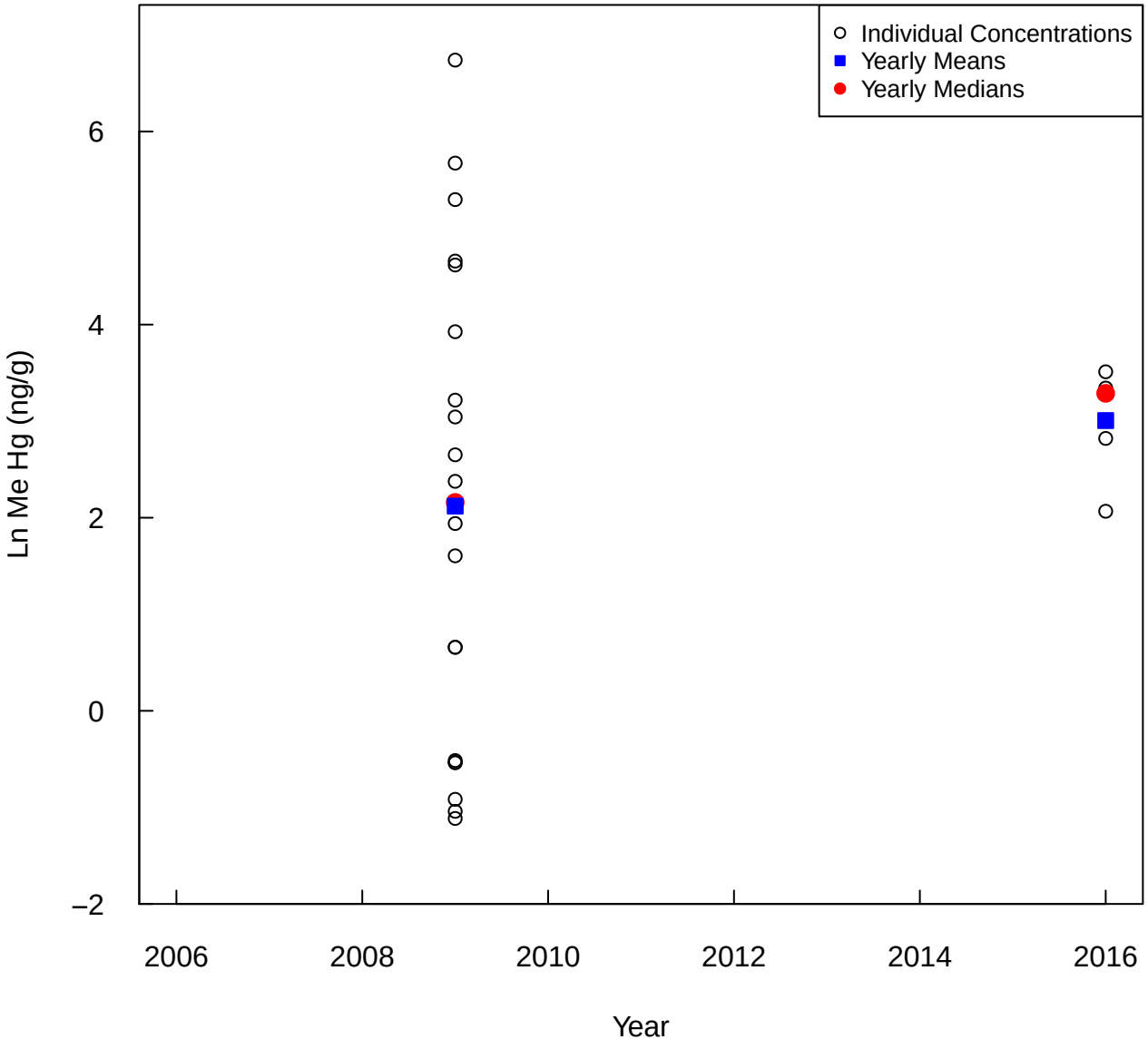
One sample collected in 2009 was non–detect and is included on this figure using the detection limit.

Figure 4–9
Terrestrial Insect – Mendall Marsh 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 – Mendall Marsh 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

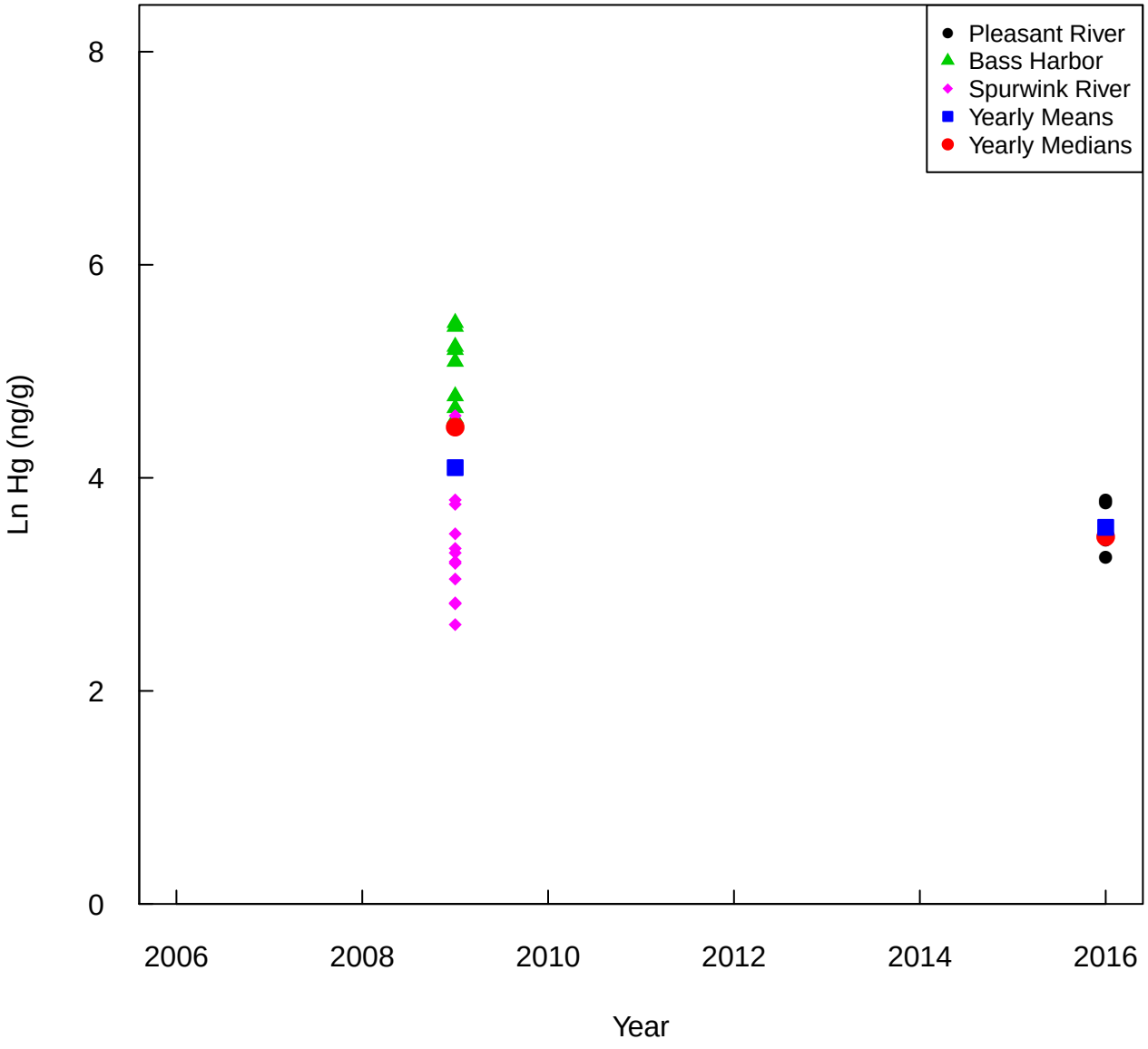


Figure 4–12
Spider – Reference Locations
Ln Methyl Mercury Concentrations

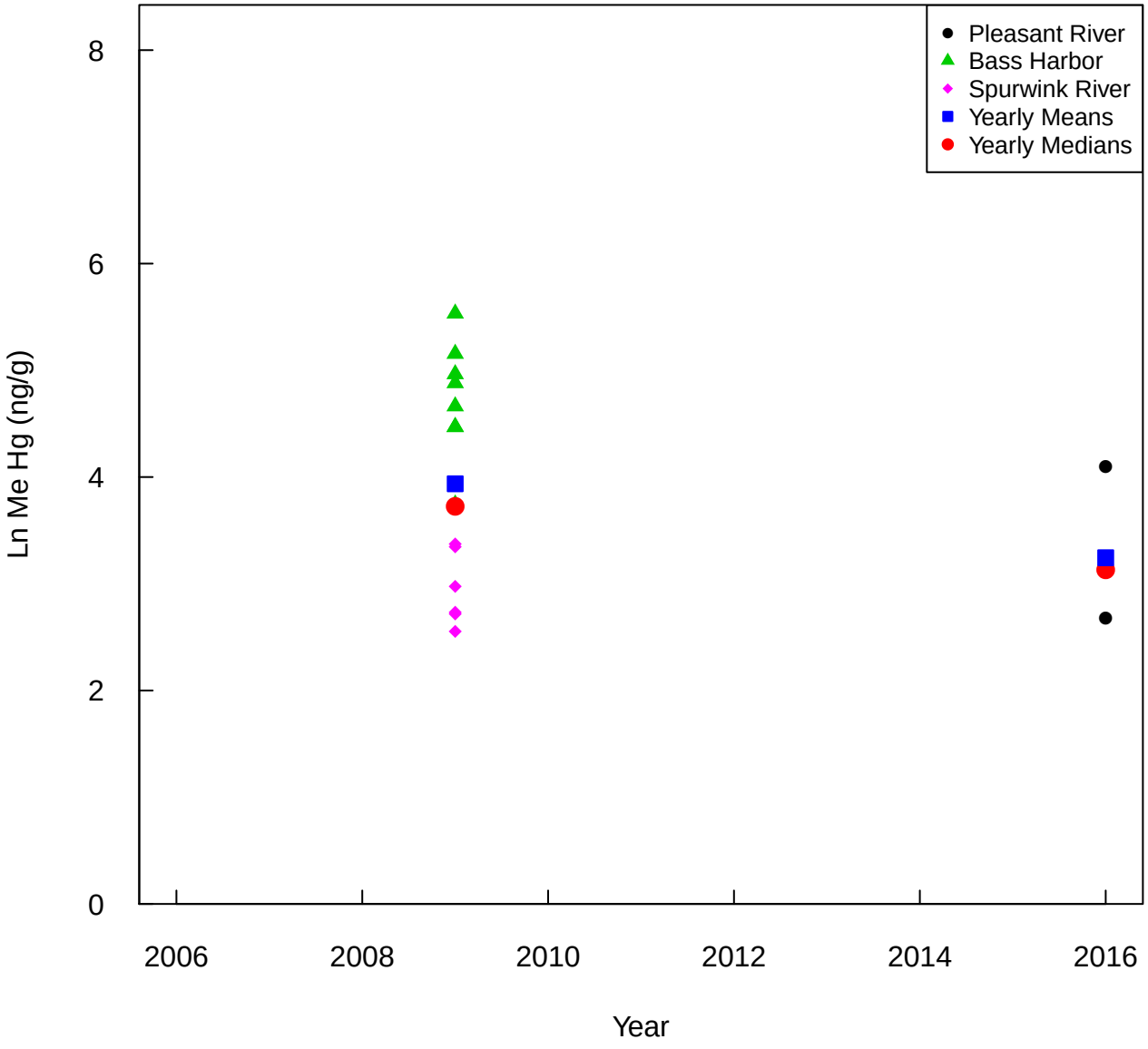
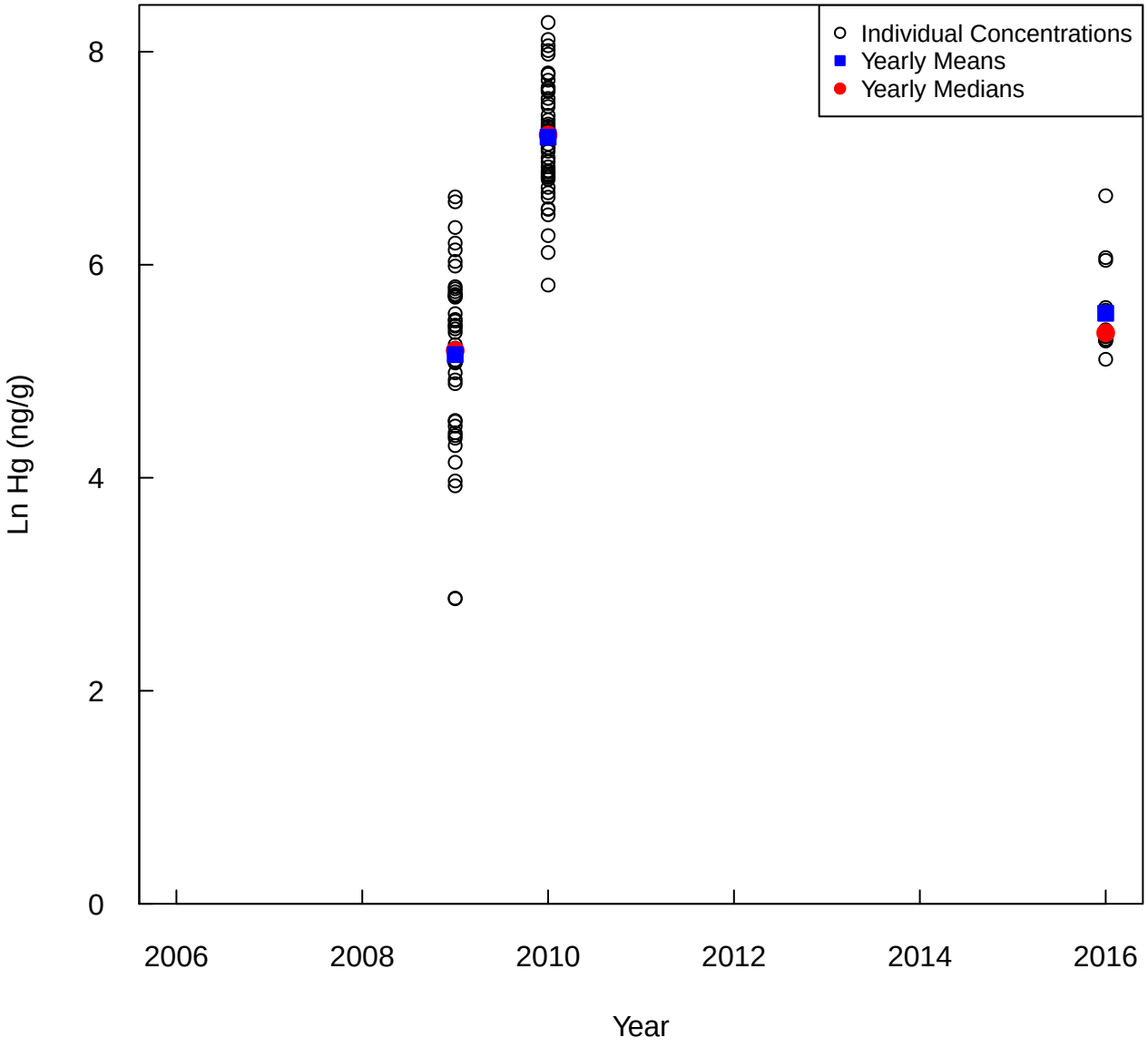


Figure 4–13
Spider – Whole River
Ln Mercury Concentrations



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

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

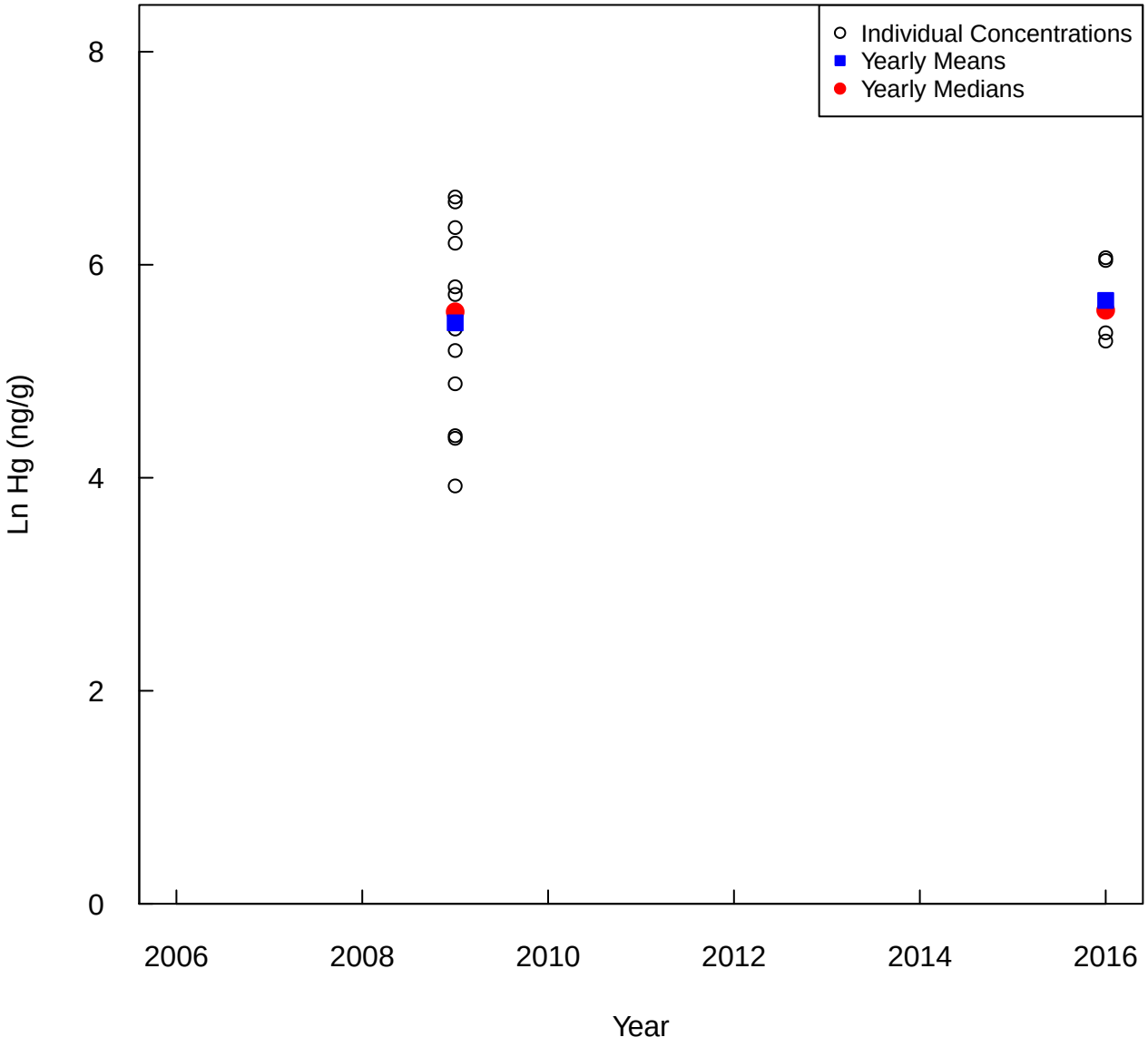


Figure 4–15
Spider – Mendall Marsh SE
Ln Mercury Concentrations

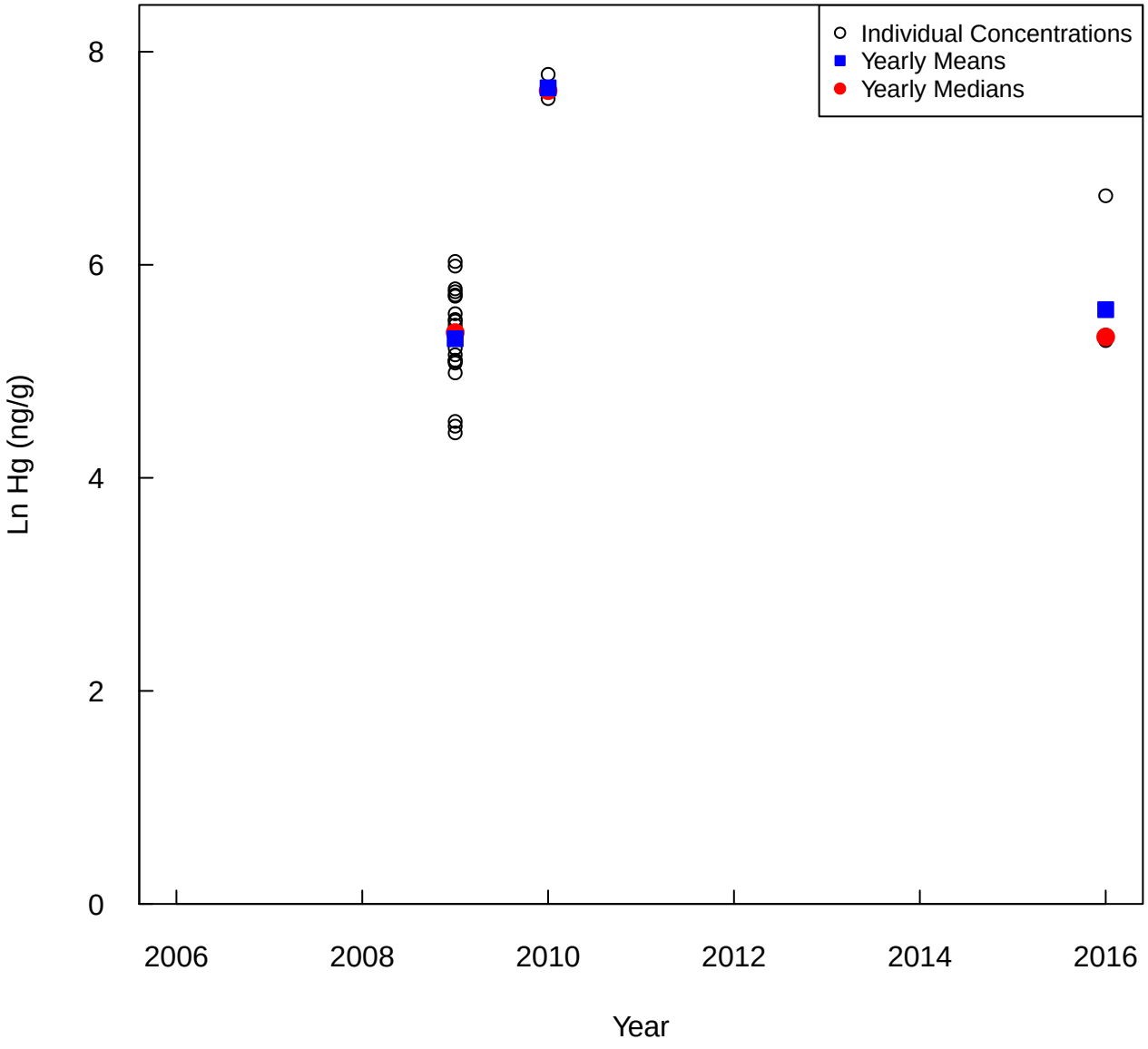


Figure 4–16
Spider – Mendall Marsh SW
Ln Mercury Concentrations

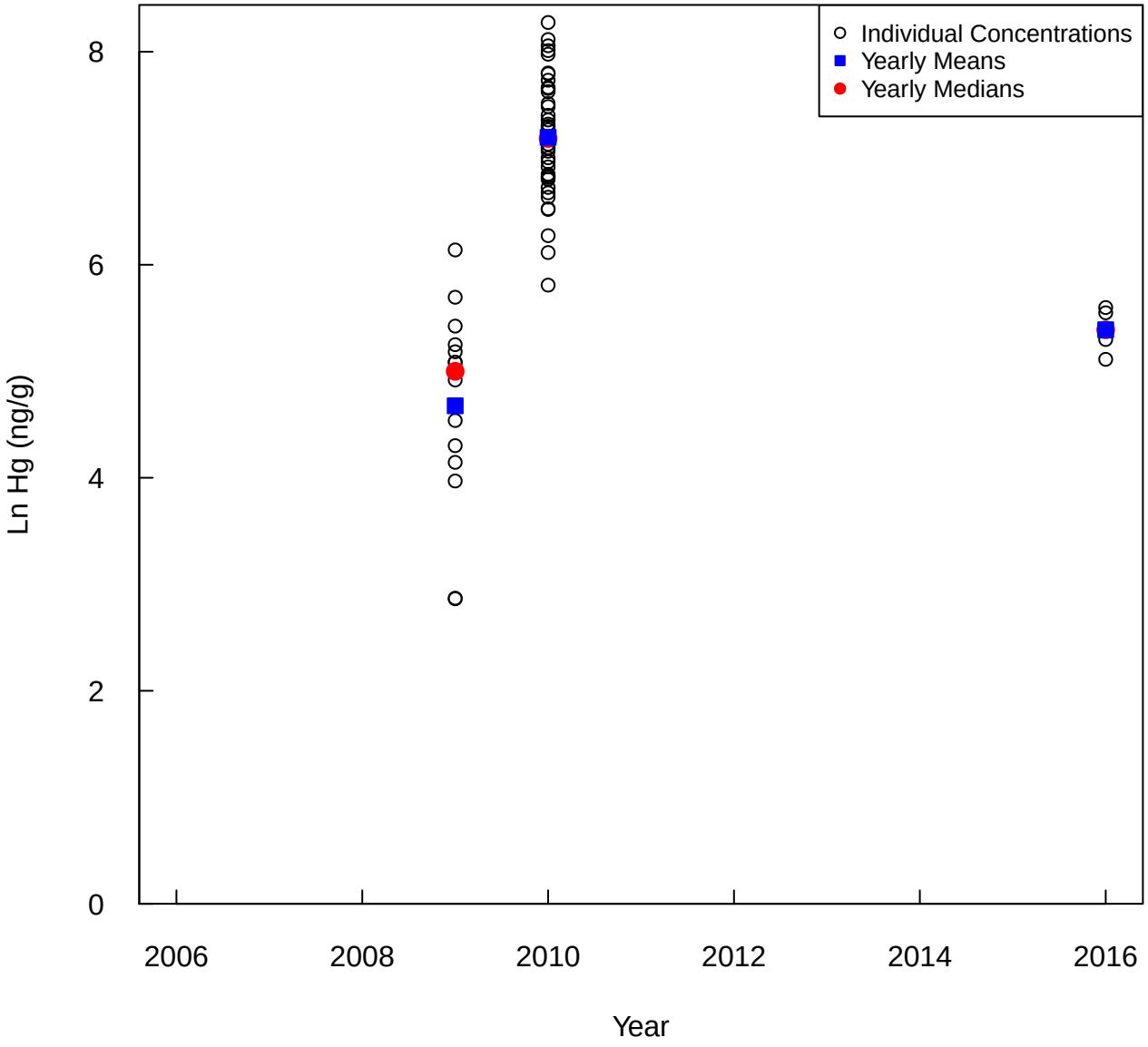
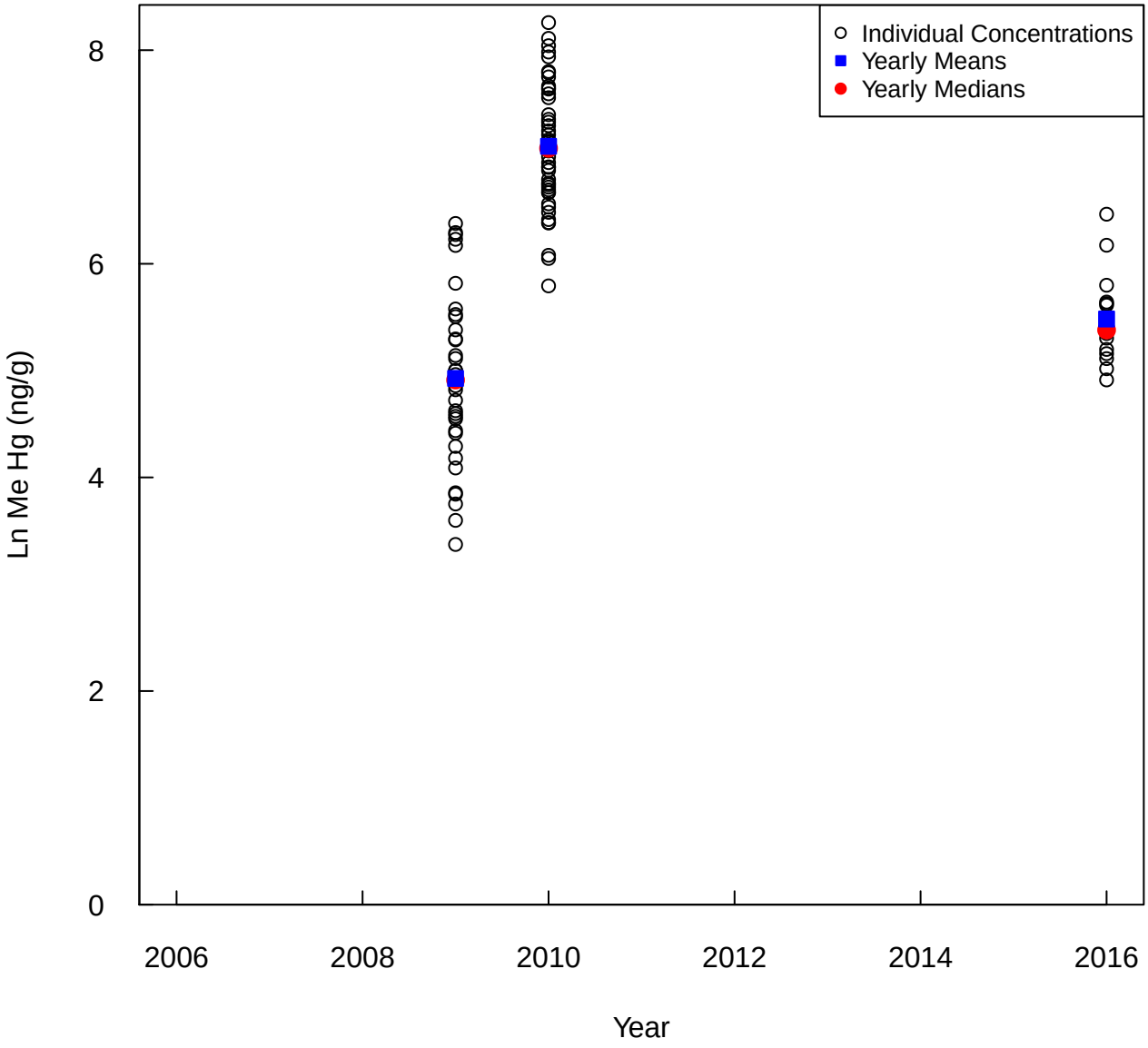


Figure 4–17
Spider – Whole River
Ln Methyl Mercury Concentrations



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

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

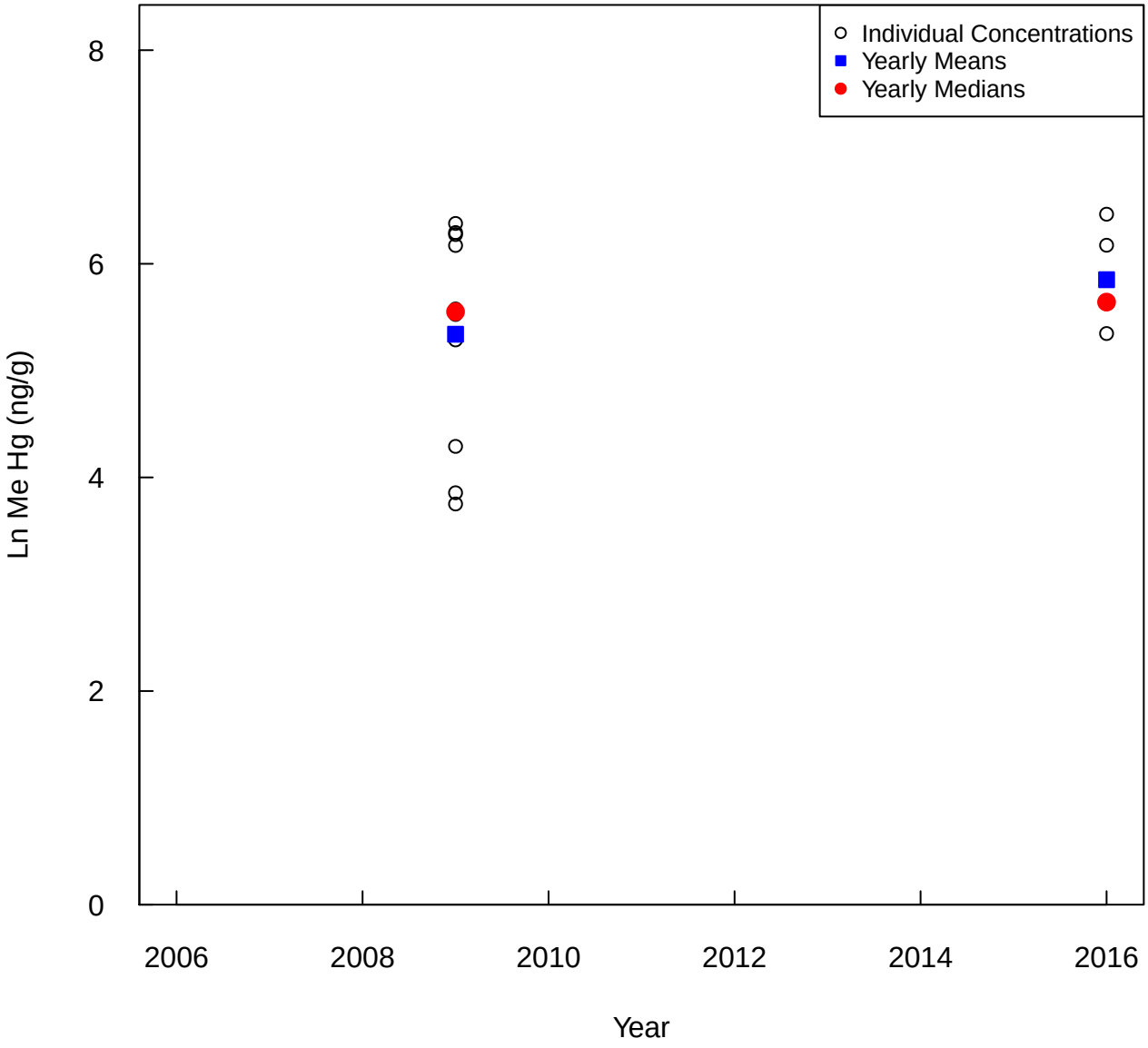


Figure 4–19
Spider – Mendall Marsh SE
Ln Methyl Mercury Concentrations

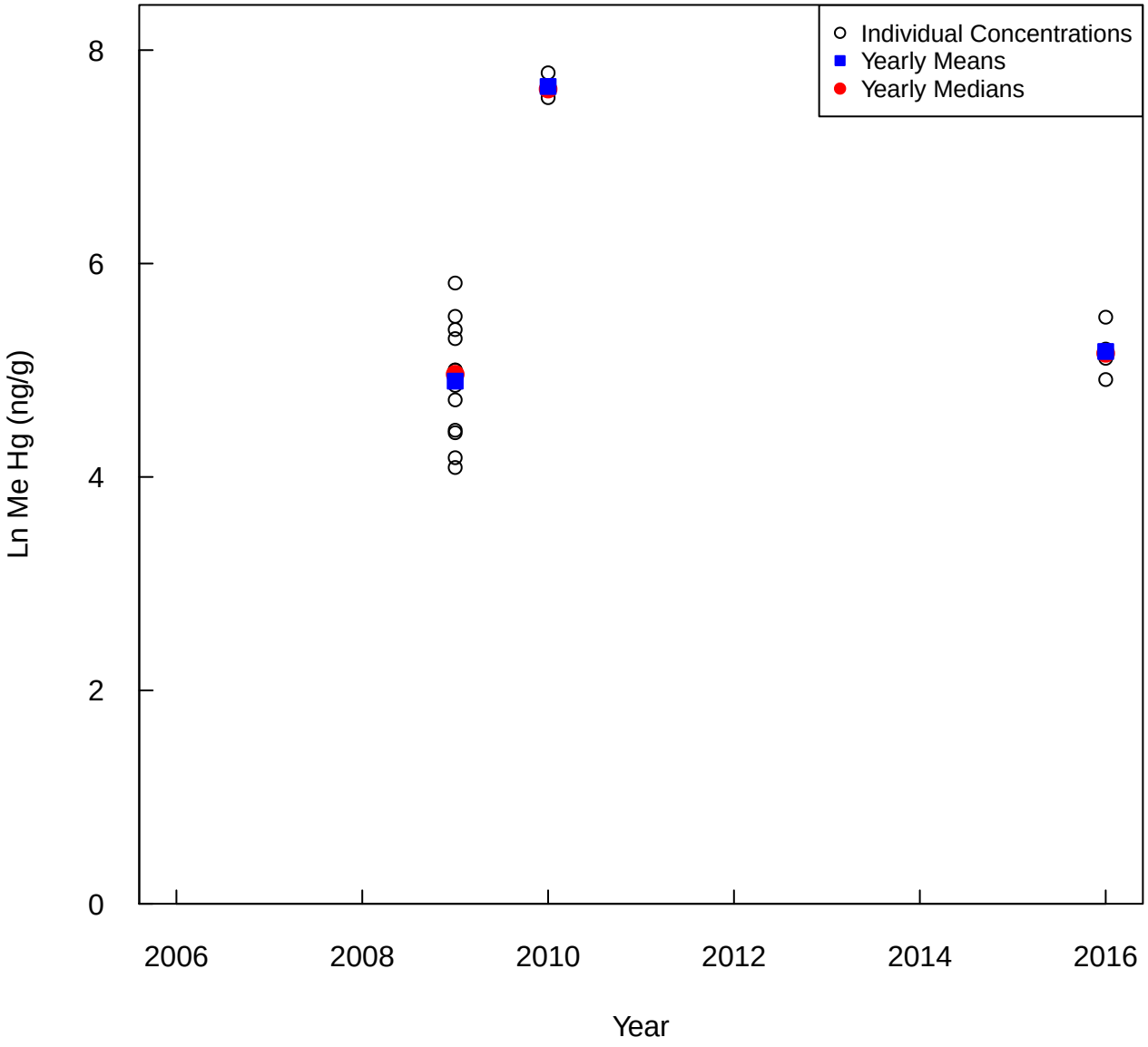


Figure 4–20
Spider – Mendall Marsh SW
Ln Methyl Mercury Concentrations

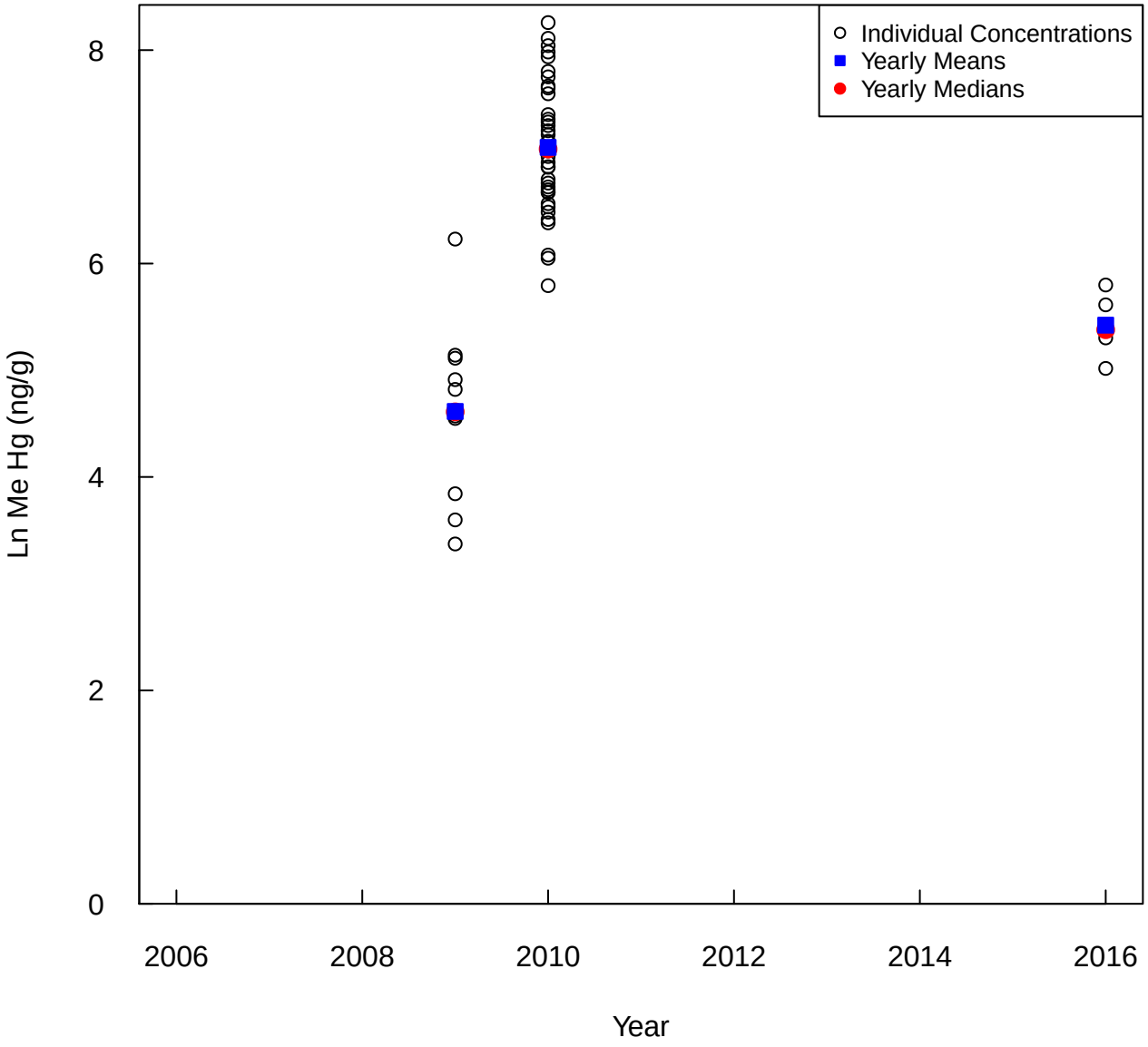
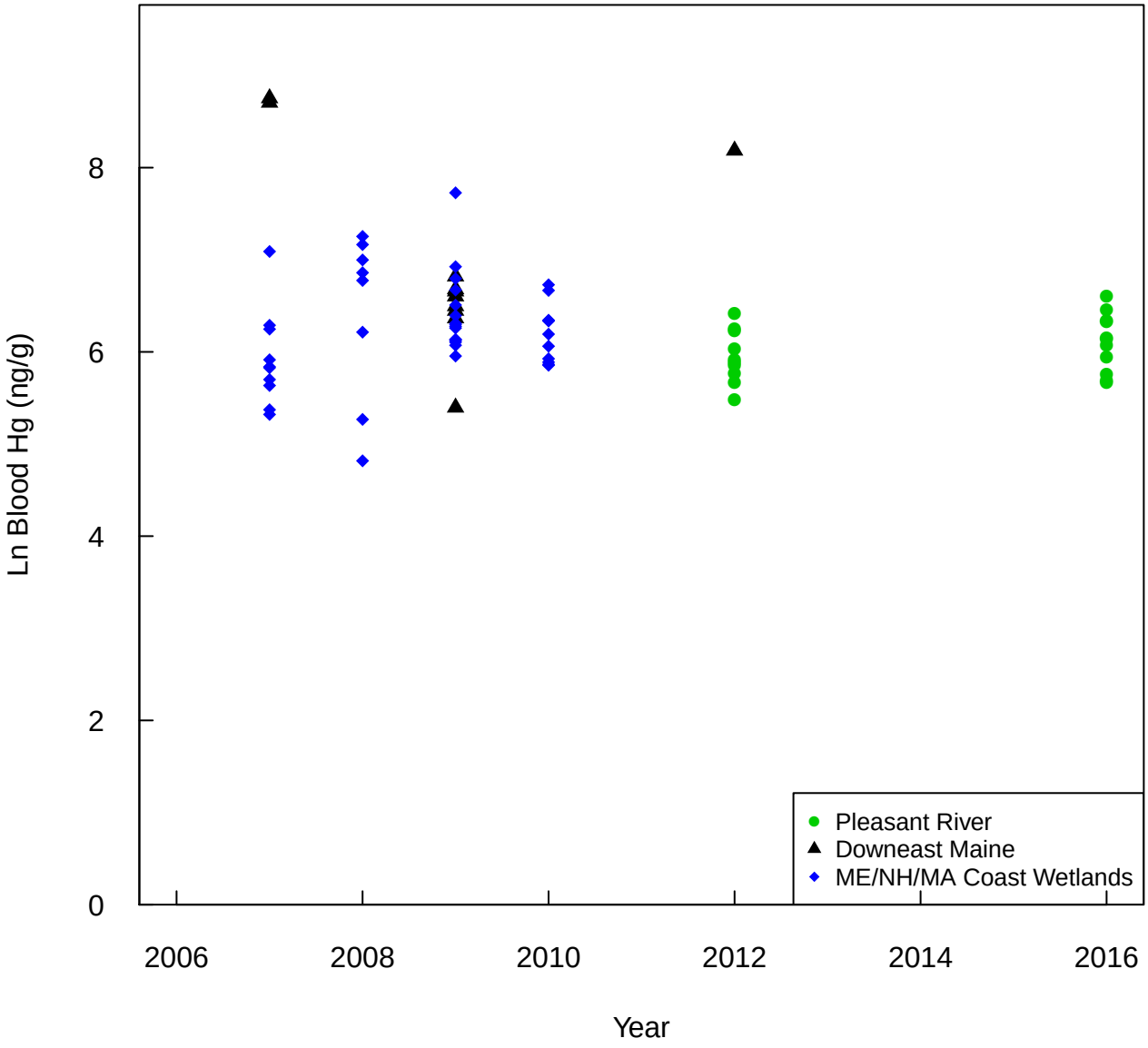
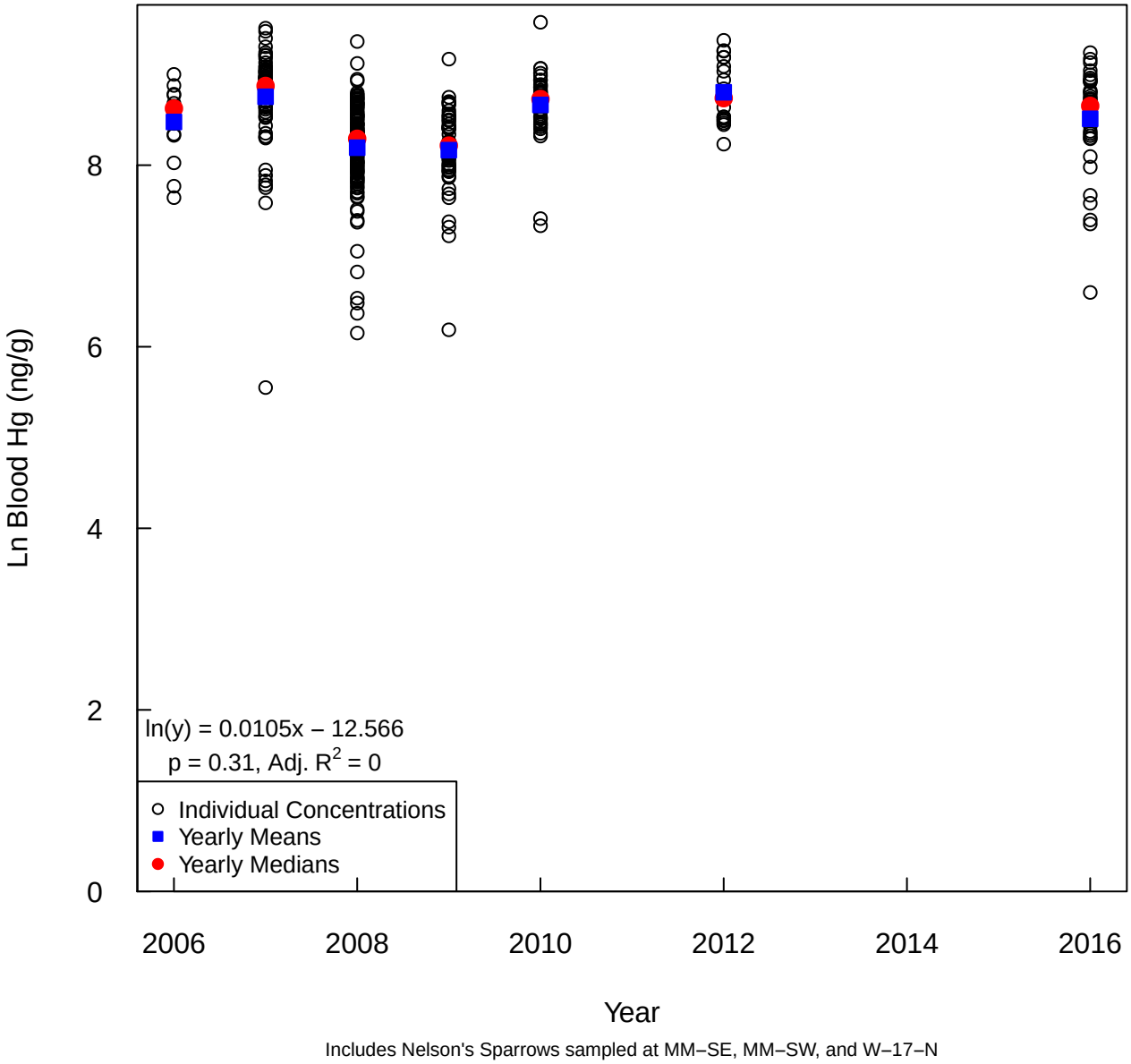


Figure 4–21
Nelson's Sparrow Blood – Reference Locations
Ln Mercury Concentrations



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

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



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

Figure 4–23
Nelson's Sparrow Blood – Mendall Marsh SE
Loglinear Regression

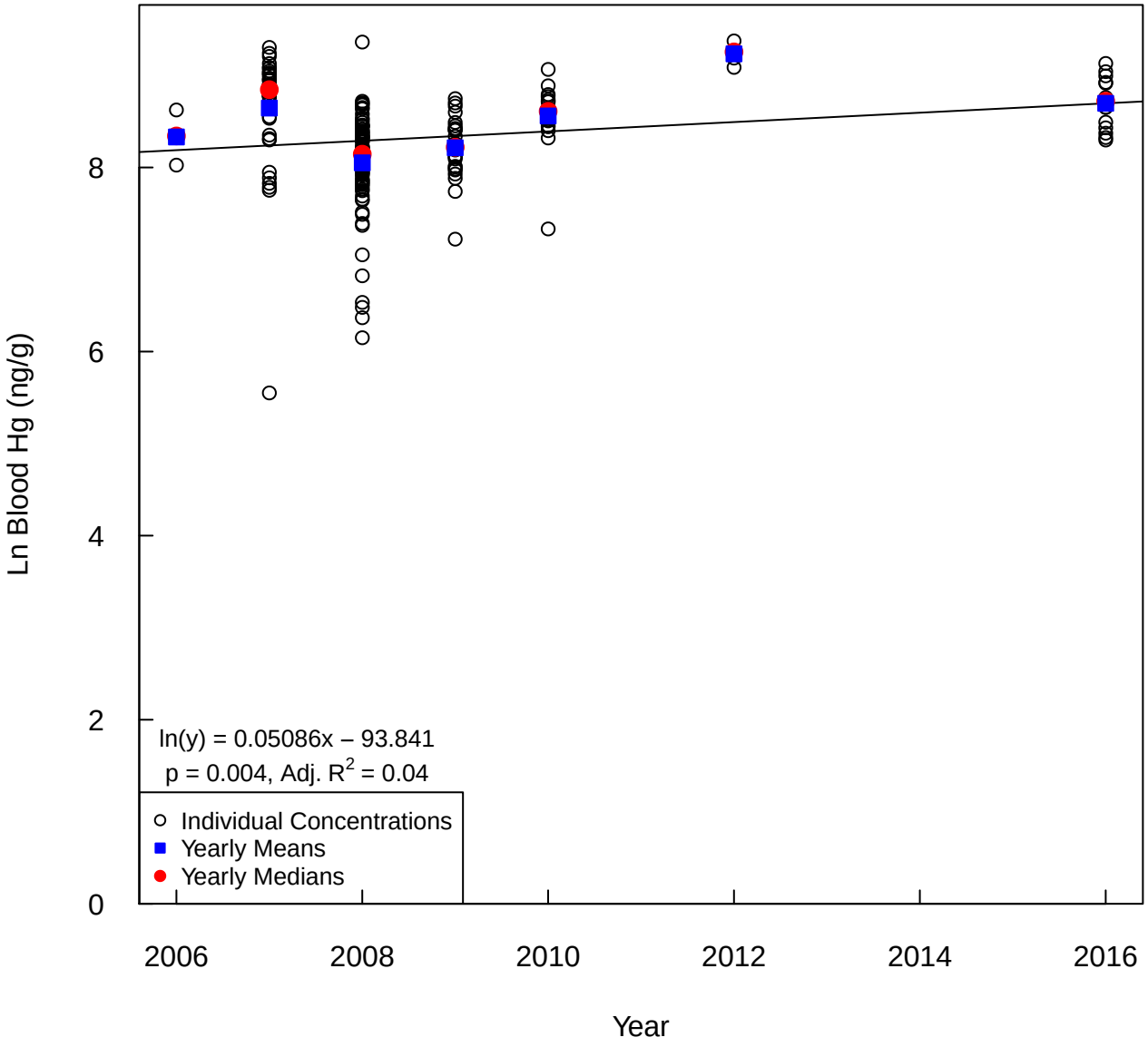


Figure 4–24
Nelson's Sparrow Blood – Mendall Marsh SW
Loglinear Regression

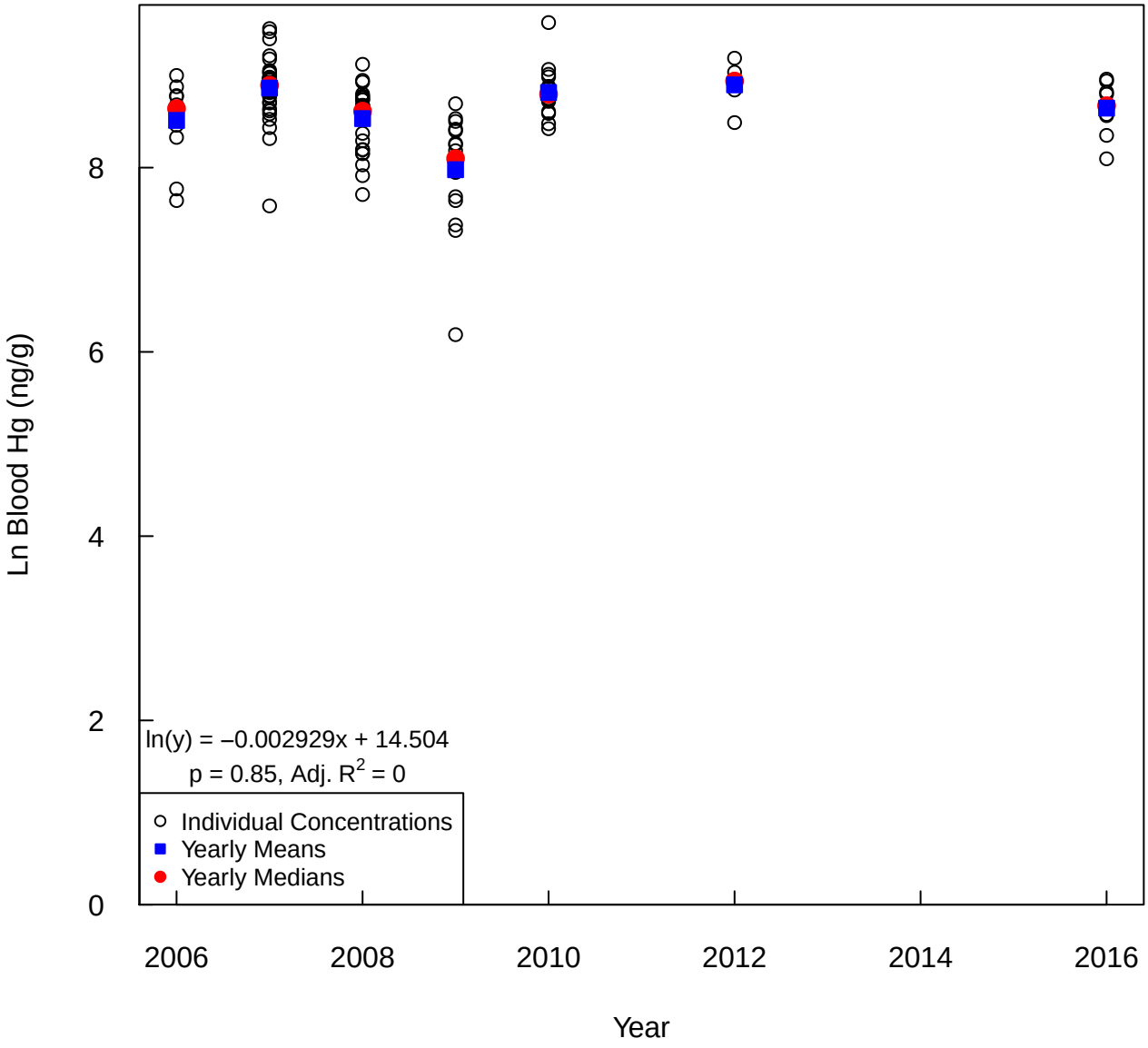


Figure 4–25
Nelson's Sparrow Blood – W–17–N
Loglinear Regression

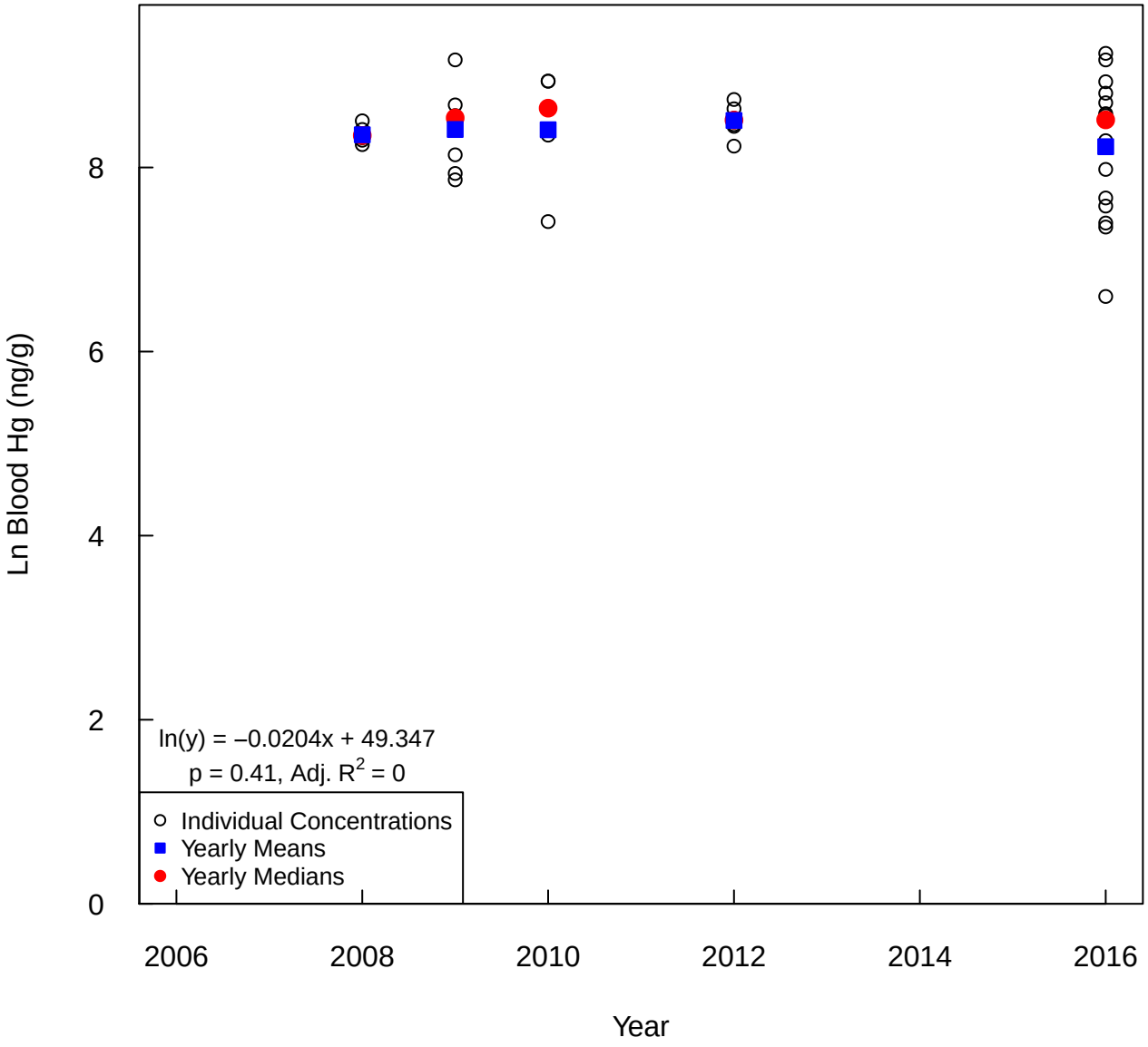
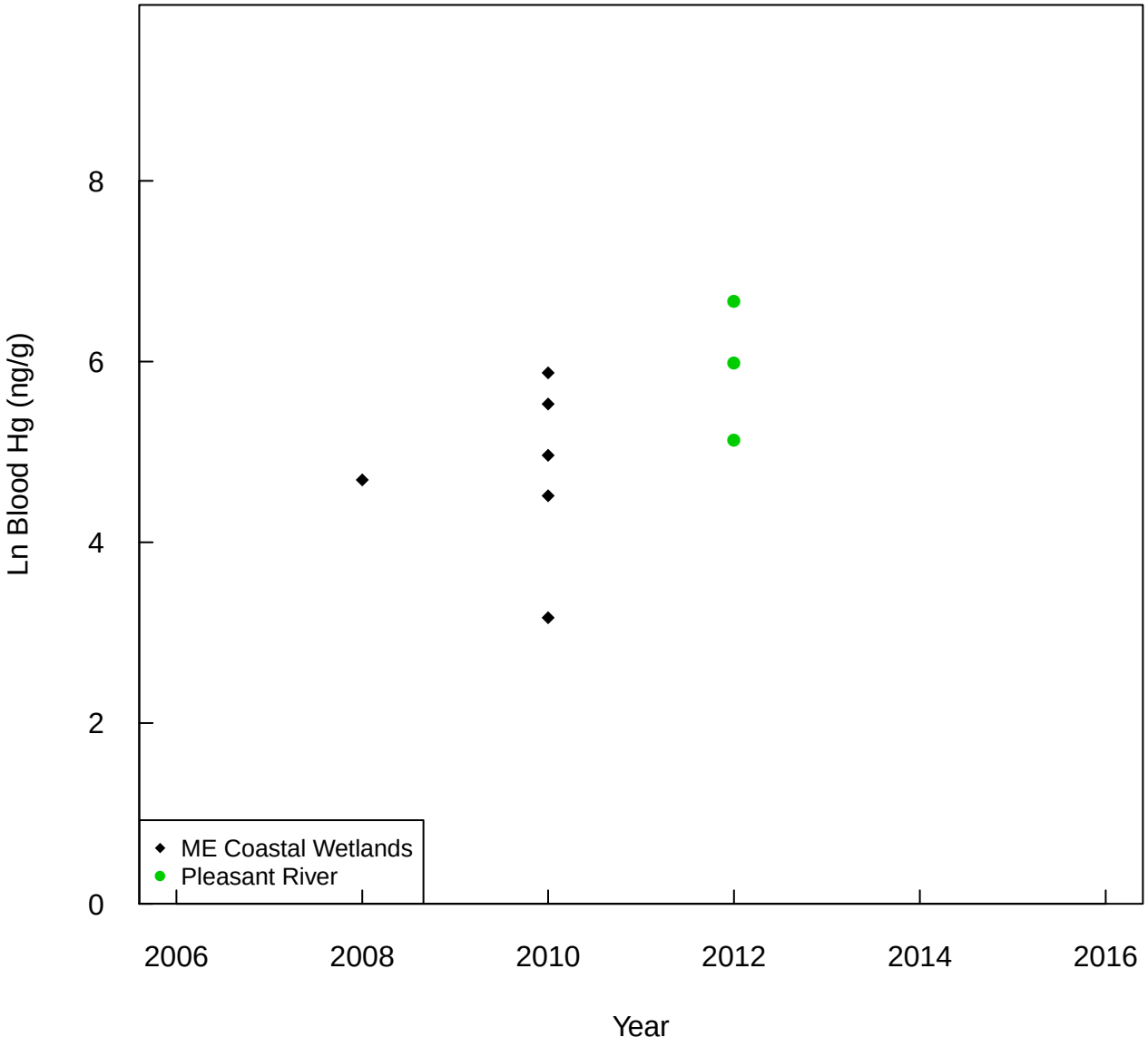


Figure 4–26
Red–winged Blackbird Blood – Reference Locations
Ln Mercury Concentrations



ME Coastal Wetlands includes: Spurwink River and Scarborough River areas

Figure 4–27
Red–winged Blackbird Blood – Mendall Marsh SE
Loglinear Regression

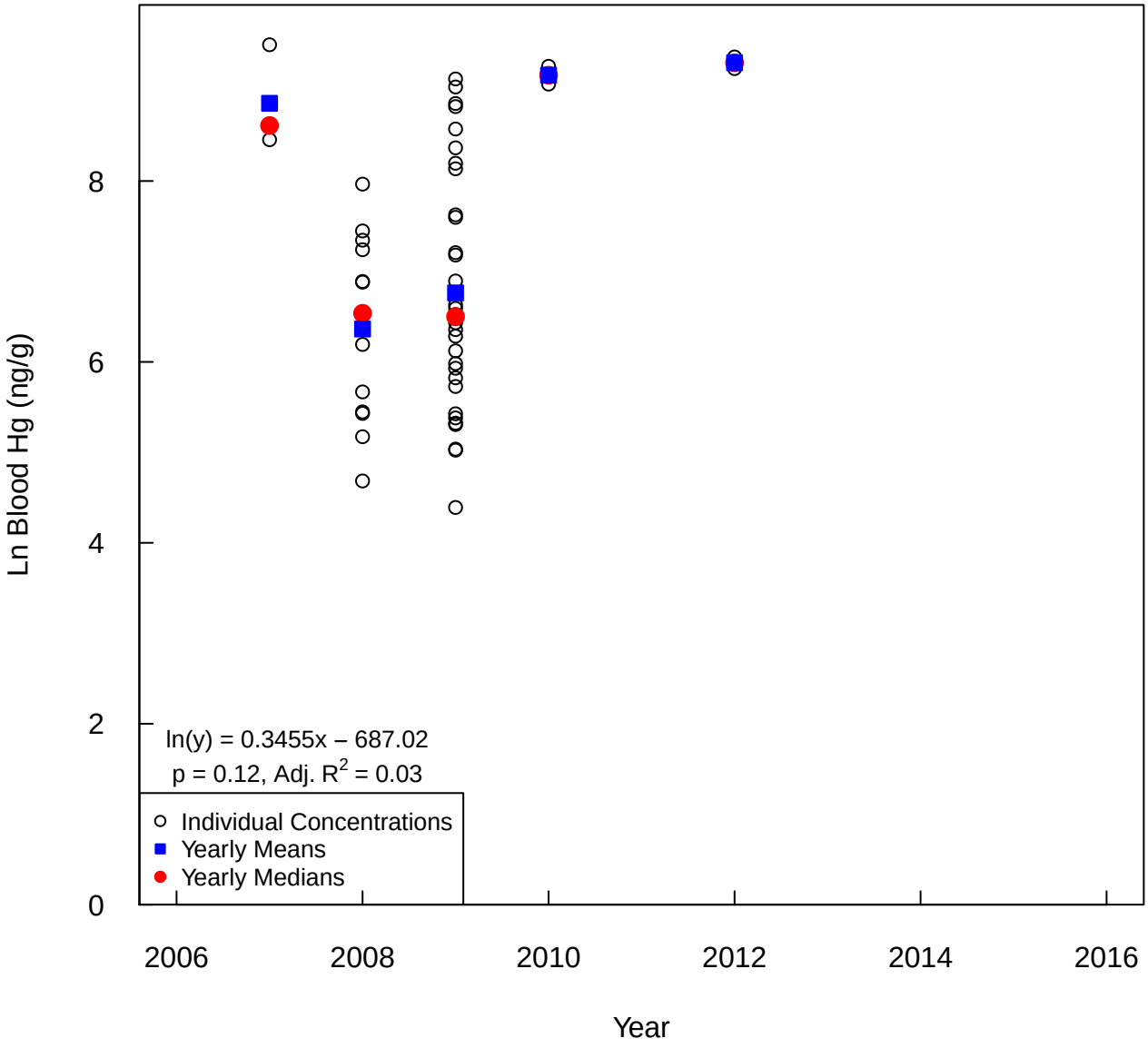


Figure 4–28
Red–winged Blackbird Blood – Mendall Marsh SW
Loglinear Regression

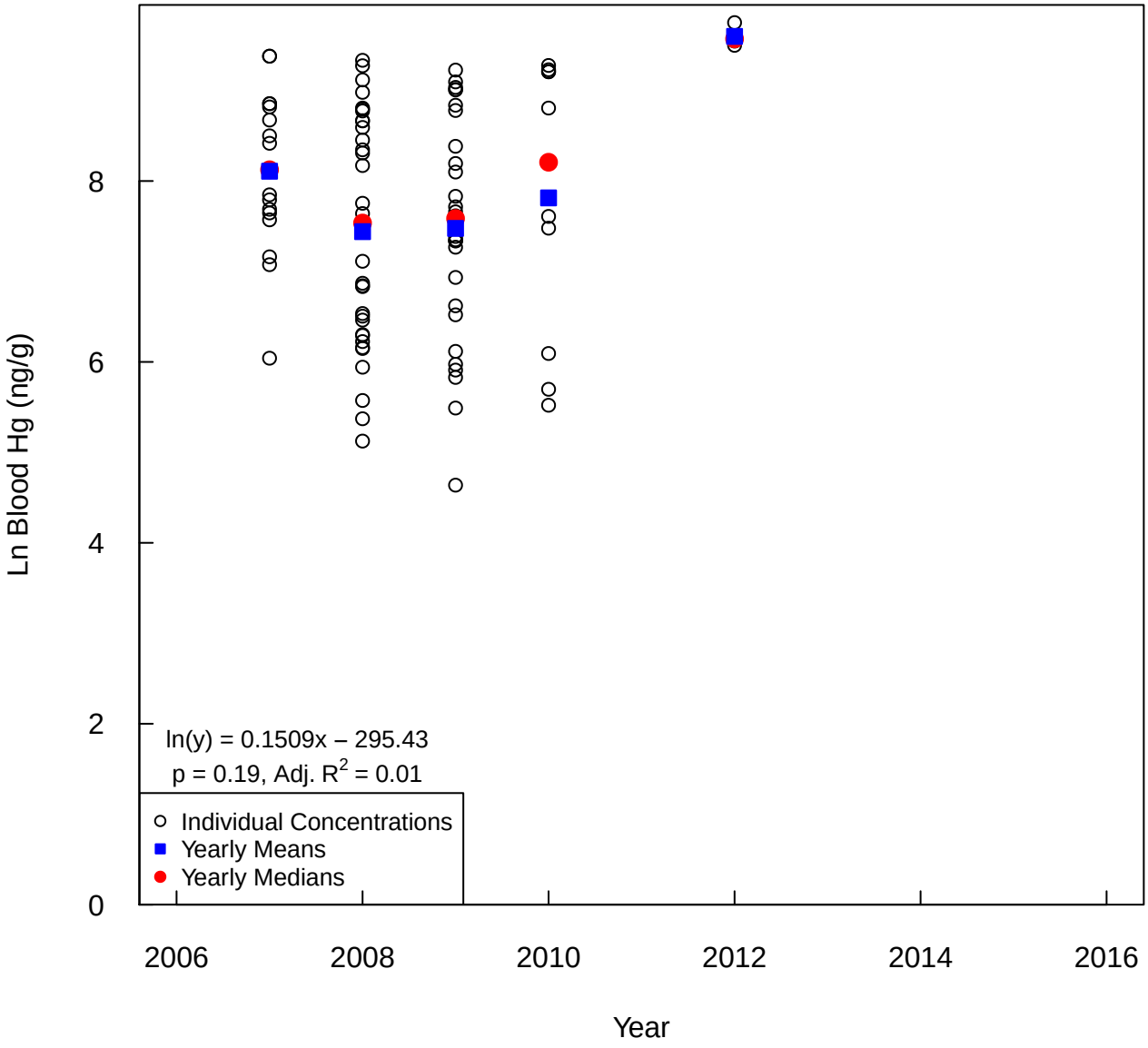


Figure 4–29
Red–winged Blackbird Blood – W–17–N
Loglinear Regression

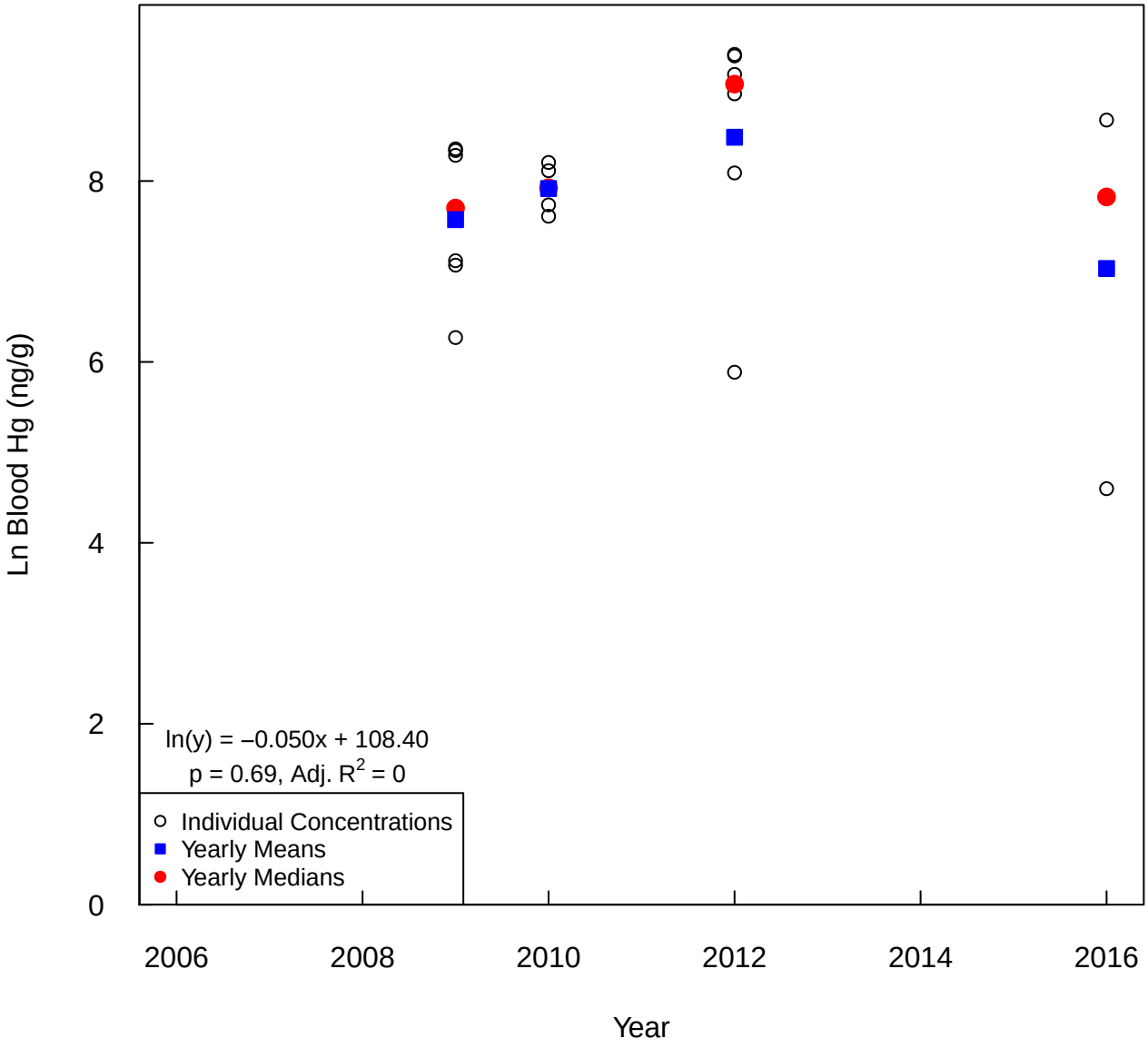


Figure 4–30
American Black Duck Blood – Frenchman Bay (Reference)
Loglinear Regression

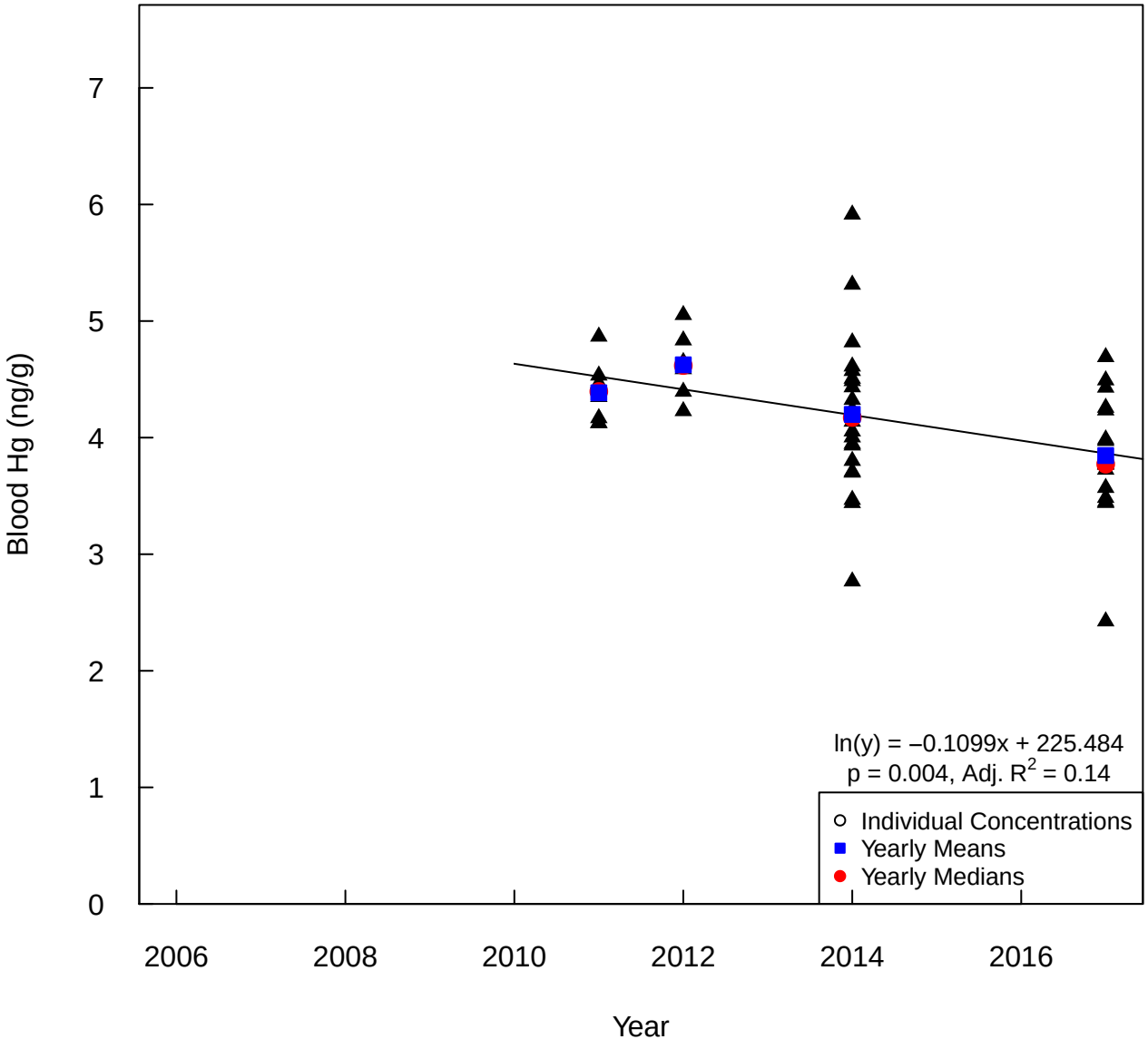
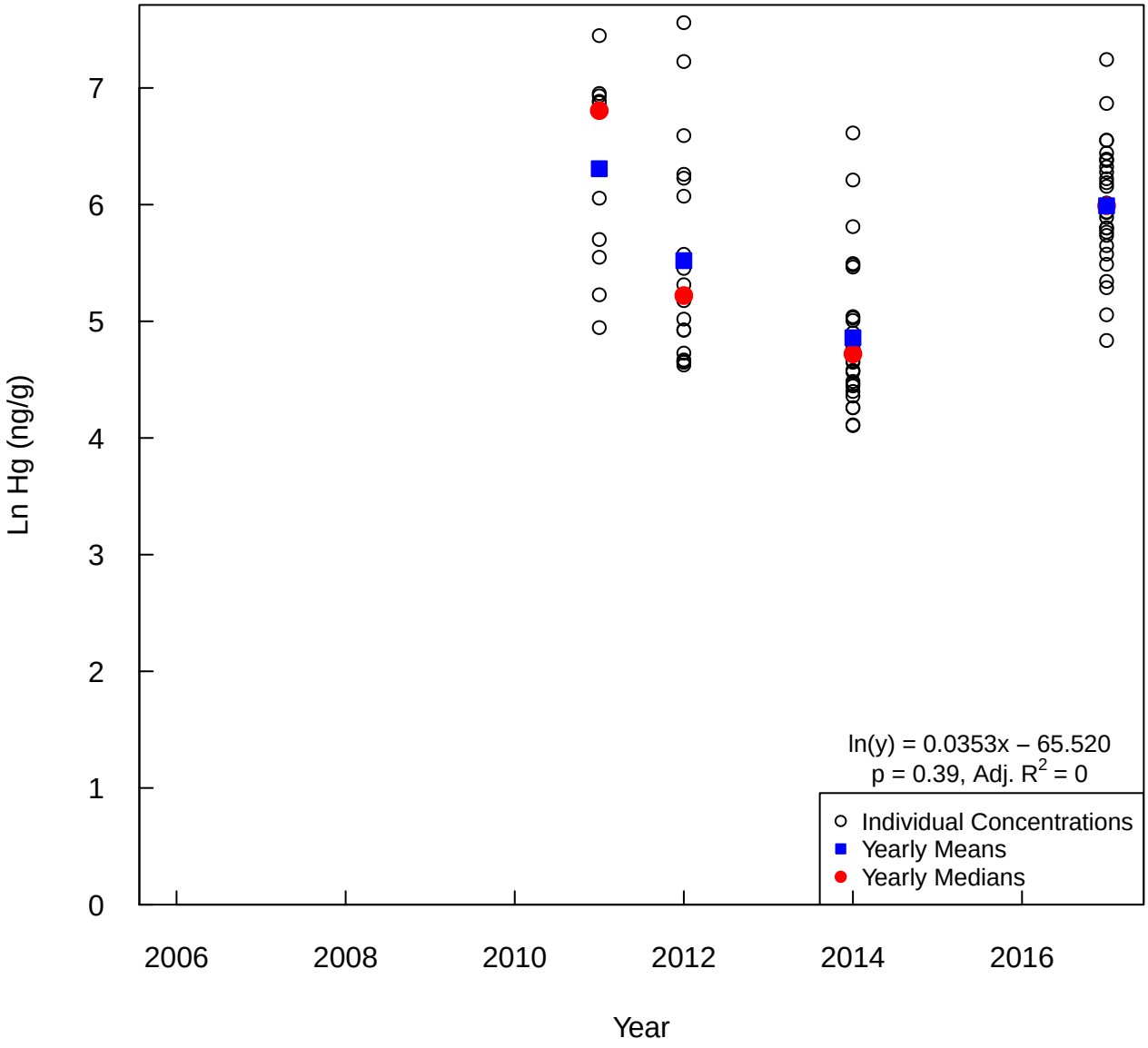


Figure 4–31
American Black Duck Blood – Whole River
Loglinear Regression



Includes American Black Ducks sampled at Mendall Marsh and South Verona

Figure 4–32
American Black Duck Blood – Mendall Marsh
Loglinear Regression

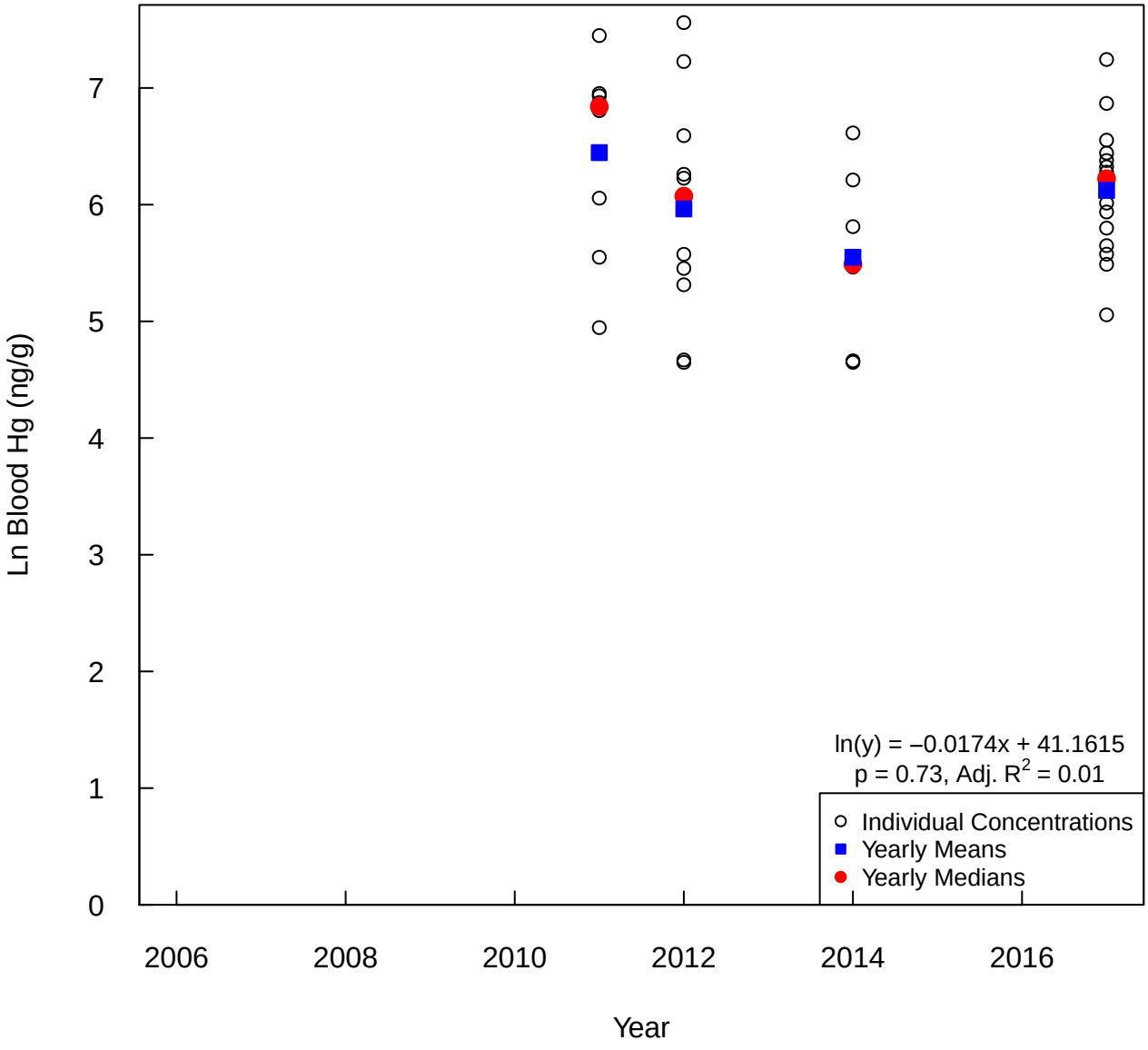


Figure 4–33
American Black Duck Blood – South Verona
Loglinear Regression

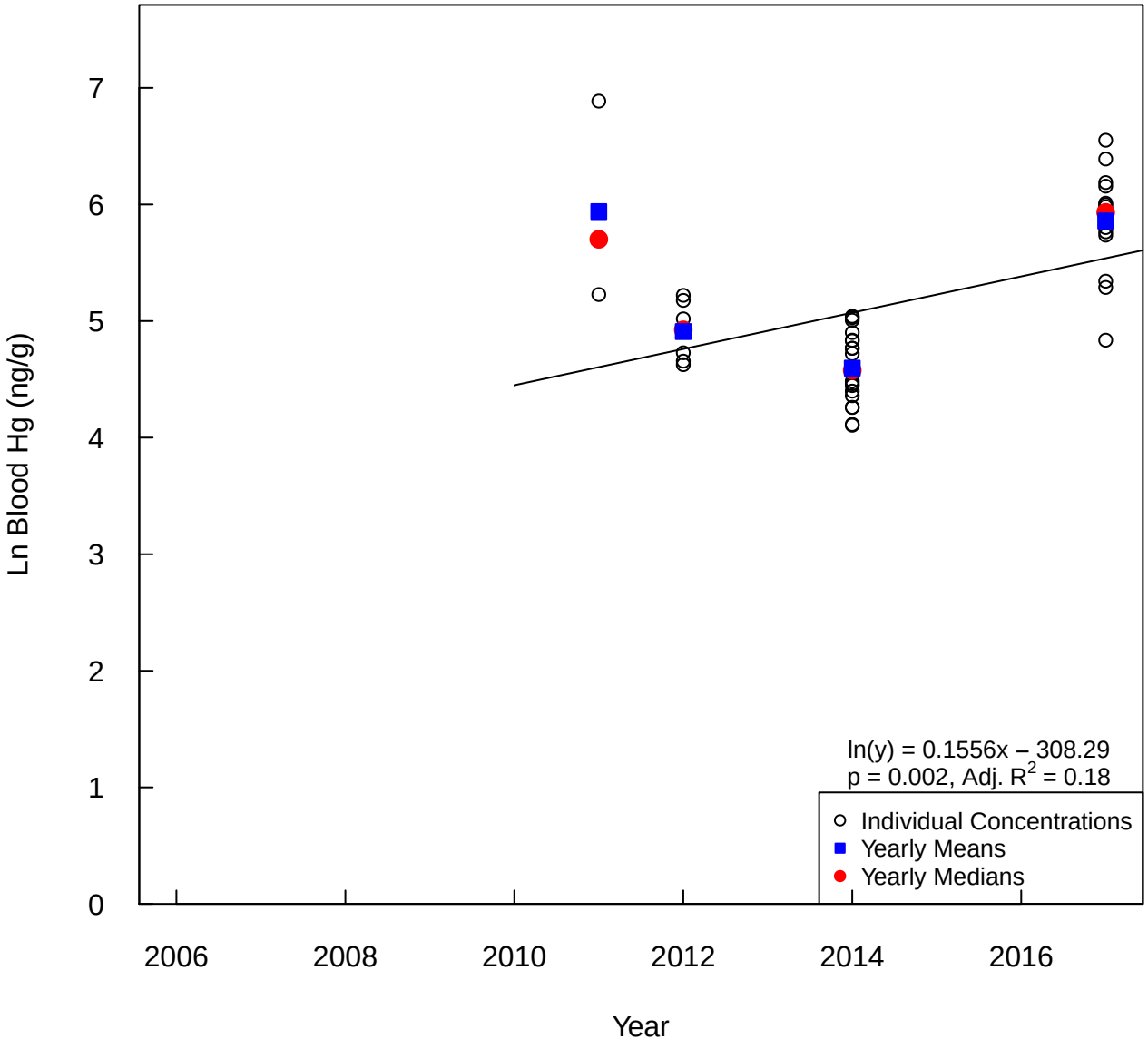


Figure 4–34
American Black Duck Muscle – Frenchman Bay (Reference)
Ln Mercury Concentrations

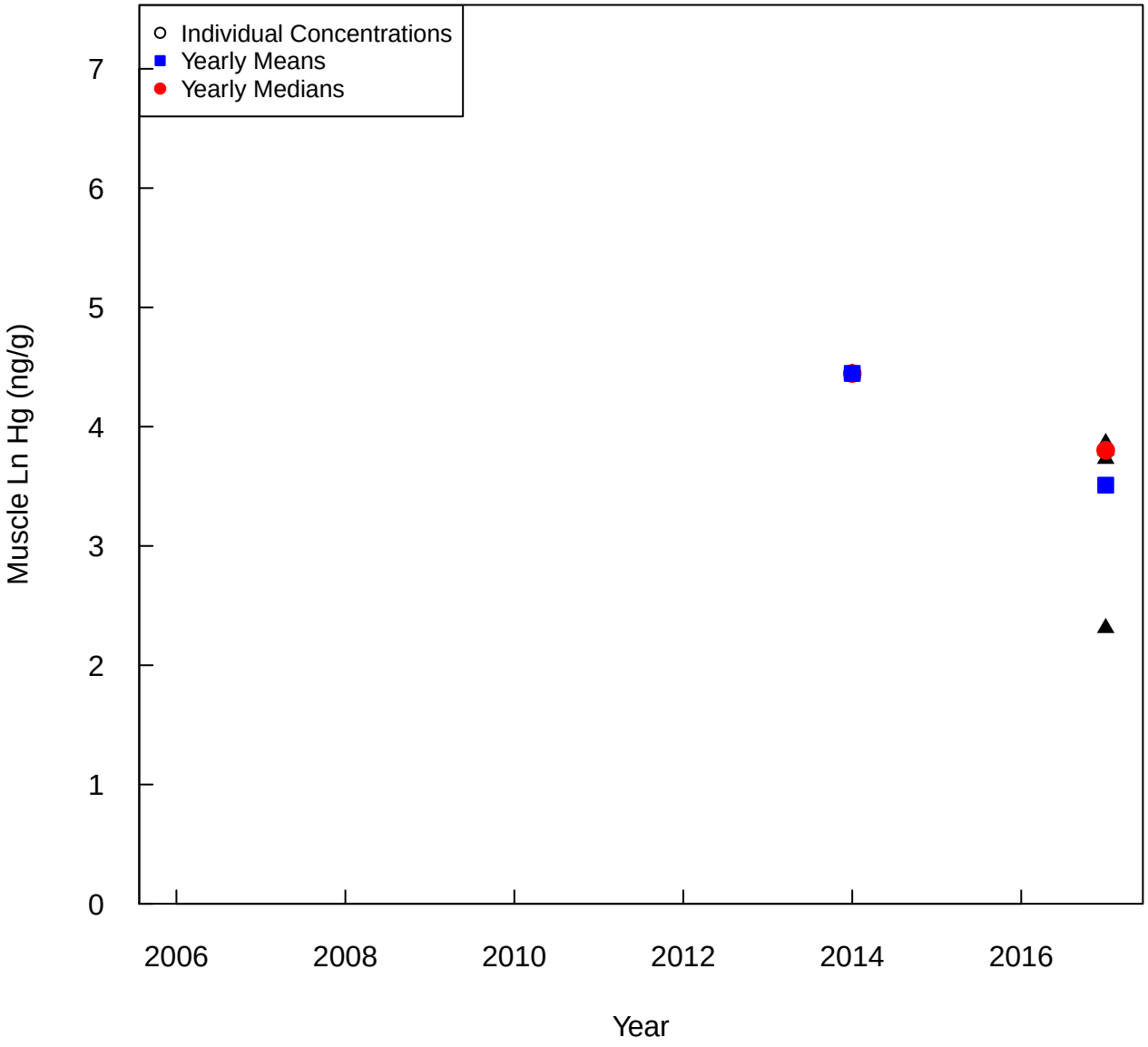


Figure 4–35
American Black Duck Muscle – Mendall Marsh
Loglinear Regression

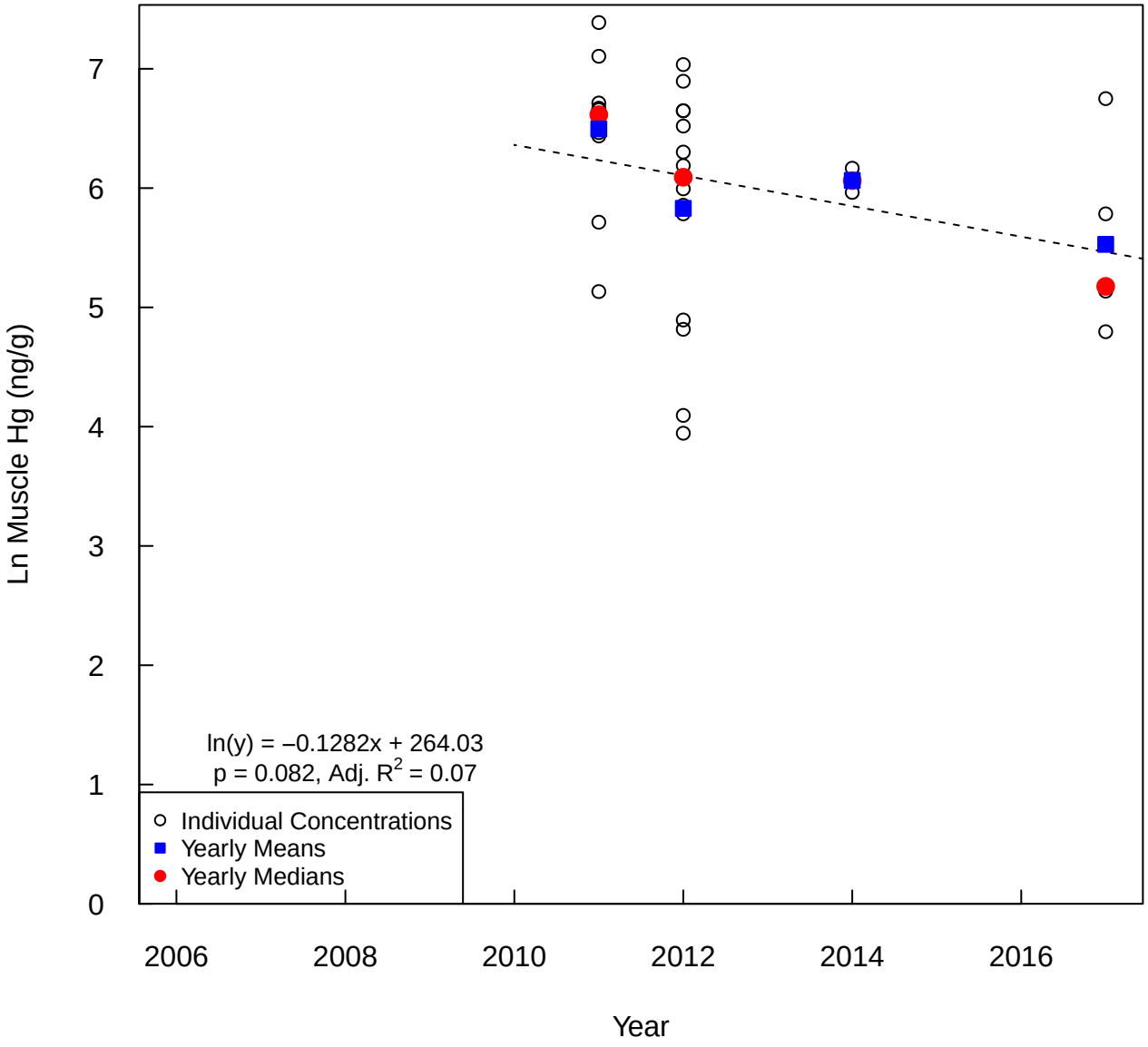


Figure 4–36
American Black Duck Muscle – South Verona
Ln Mercury Concentrations

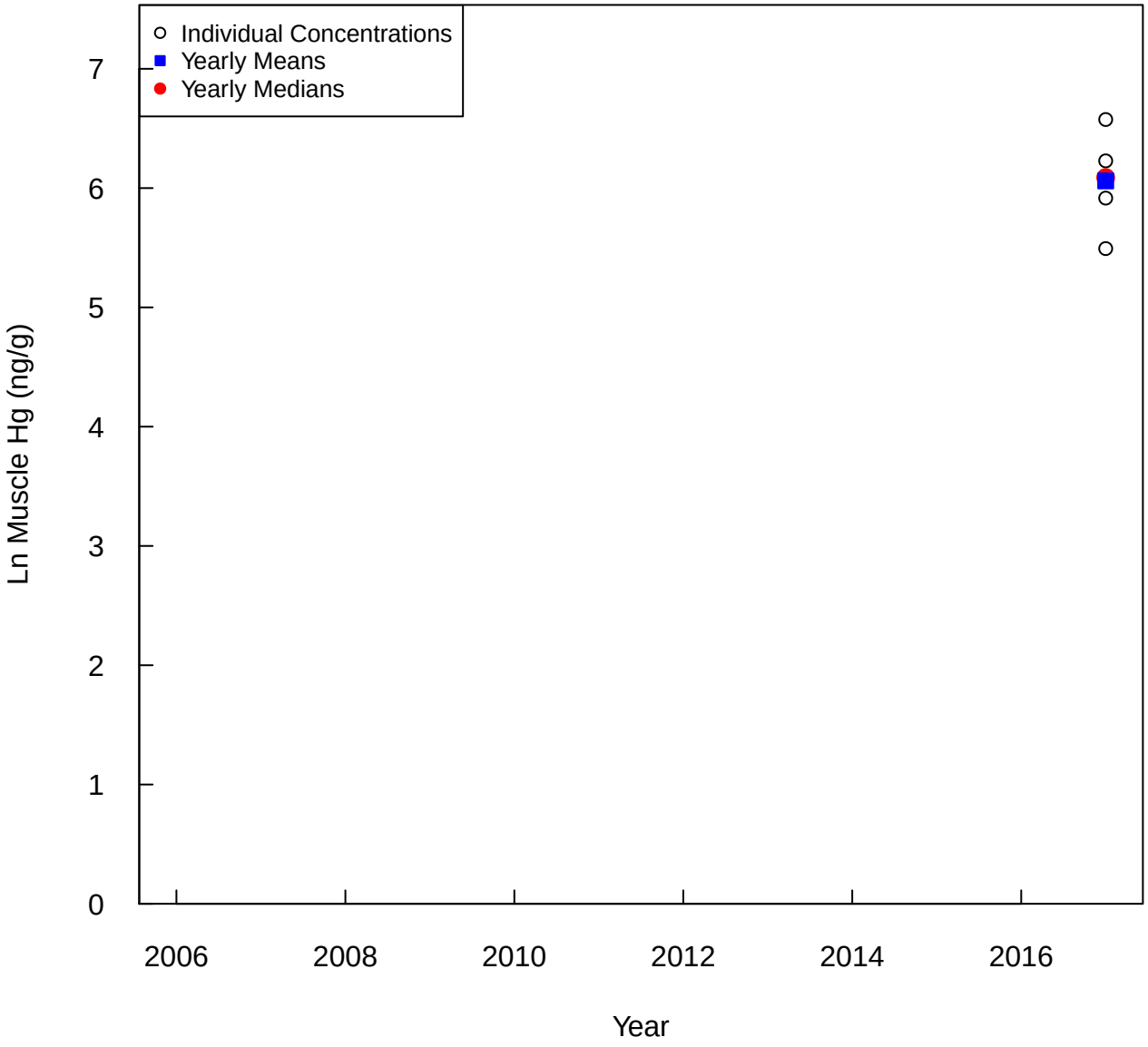


Figure 4–37
Comparison of American Black Duck Blood and Breast Muscle Mercury Results

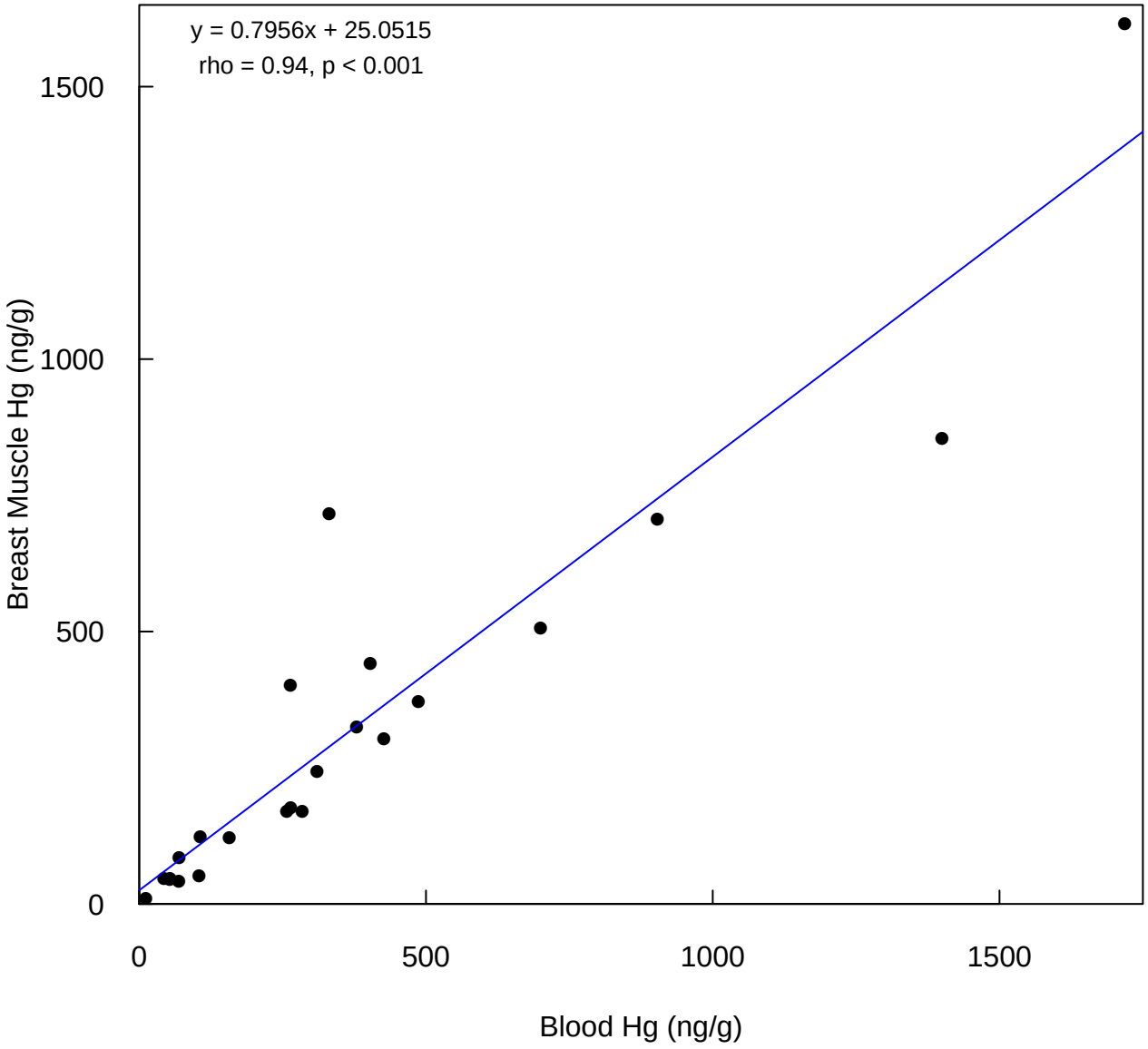


Figure 4–38
Polychaetes – Reference Locations
Ln Mercury Concentrations

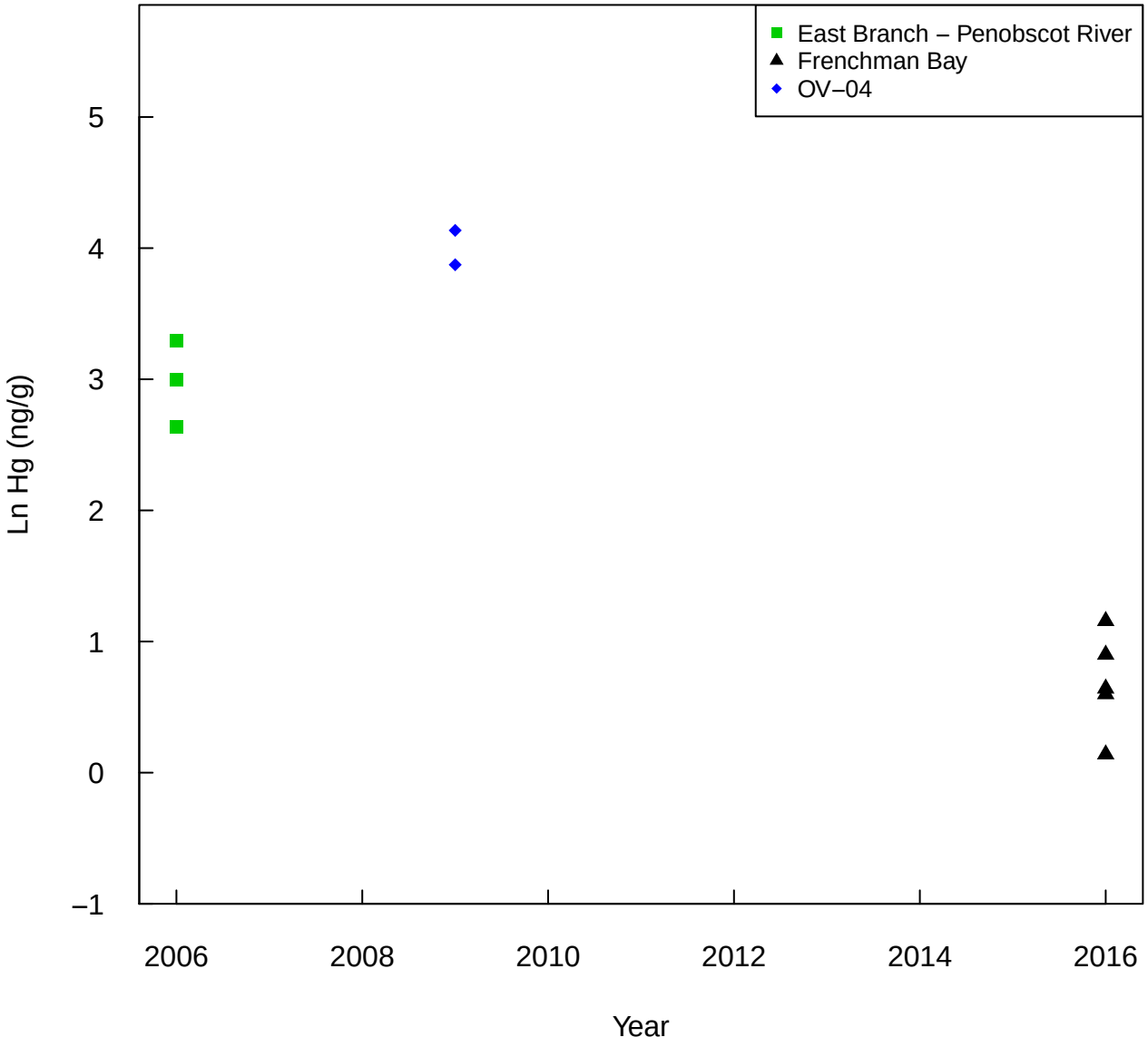
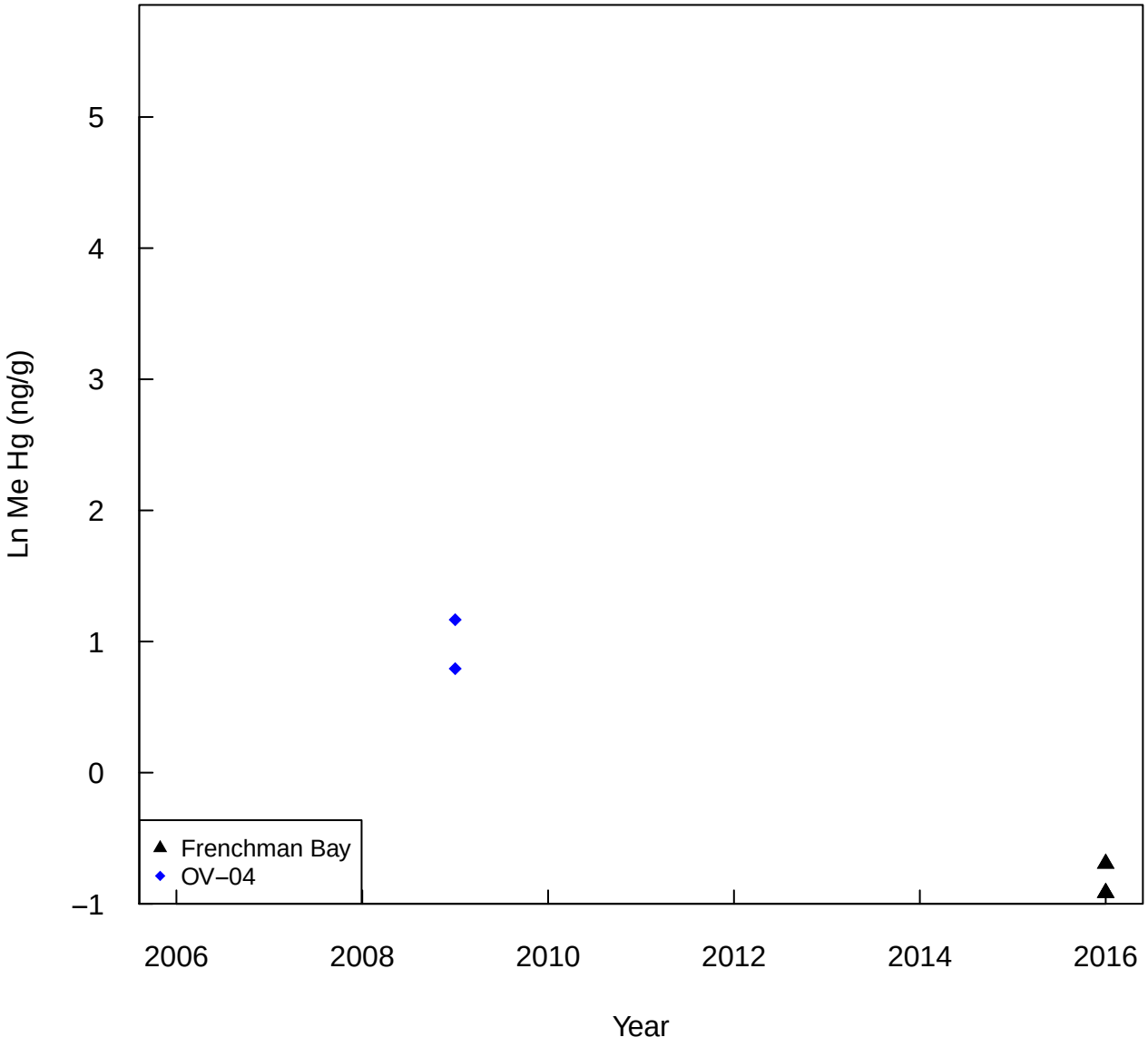
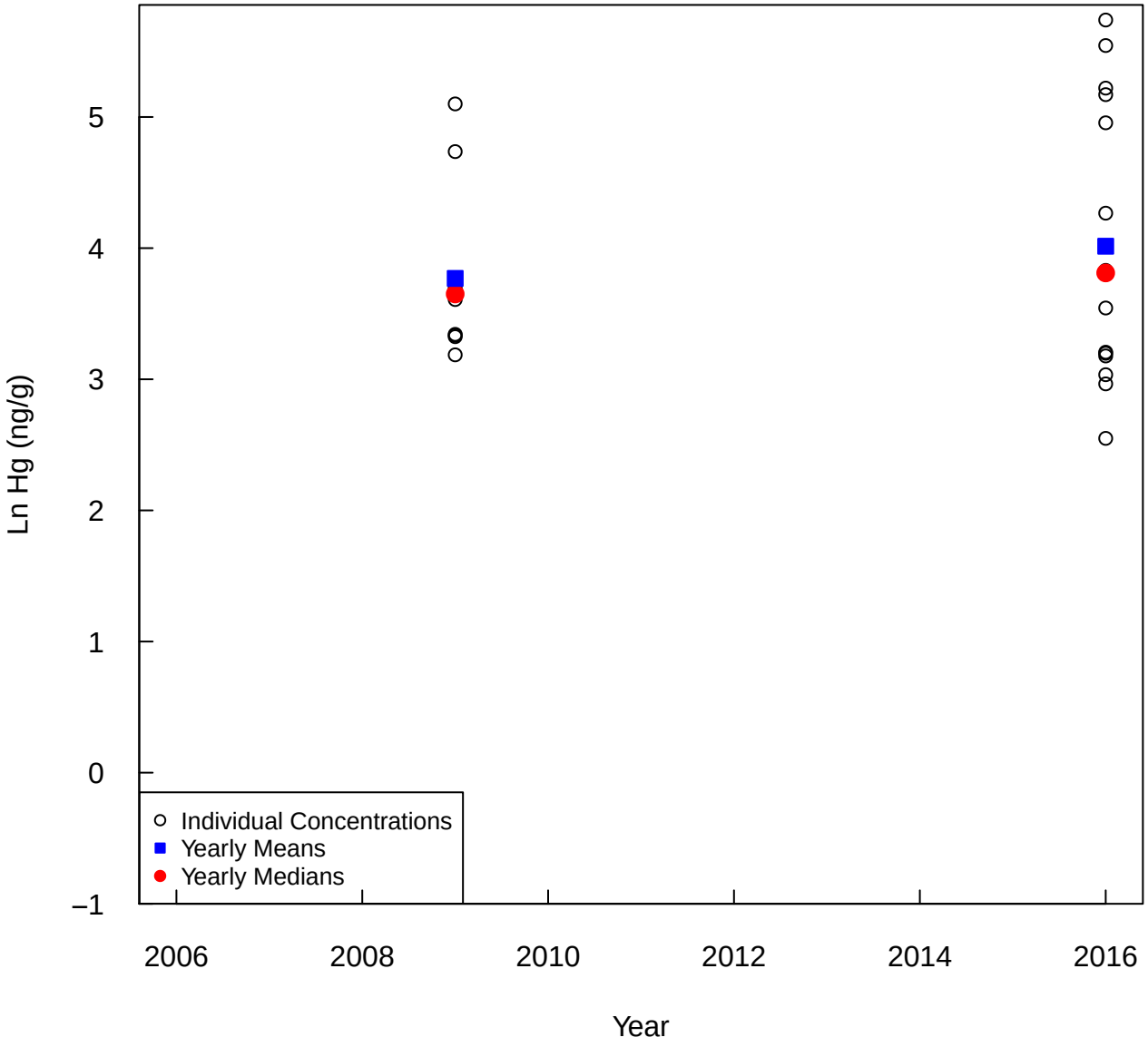


Figure 4–39
Polychaetes – Reference Locations
Ln Methyl Mercury Concentrations



Samples collected in 2016 were non−detect.

Figure 4–40
Polychaetes – Whole River
Ln Mercury Concentrations



Includes Polychaetes sampled at BO–04, ES–13, and ES–FP

Figure 4–41
Polychaetes – BO–04
Ln Mercury Concentrations

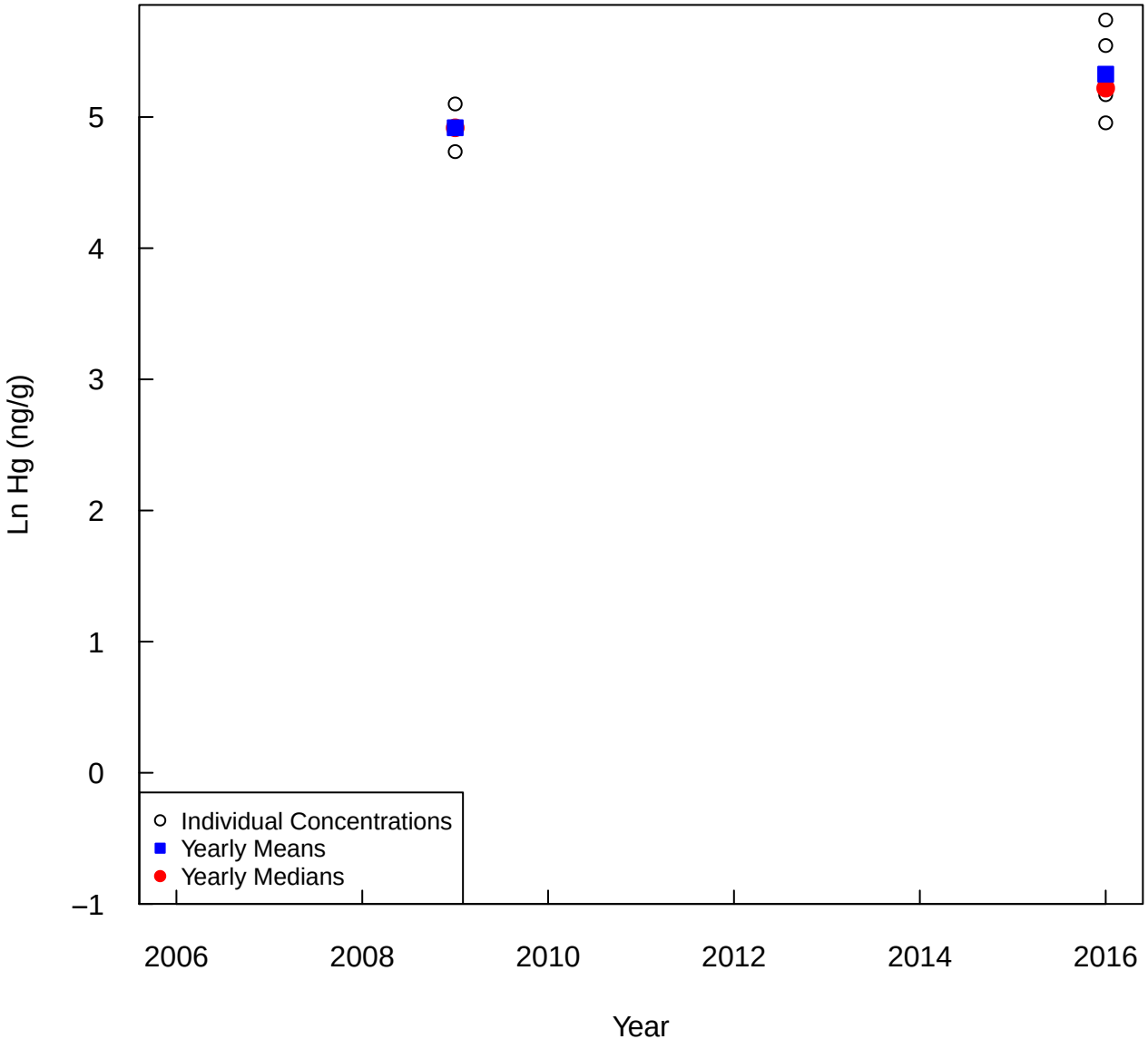


Figure 4–42
Polychaetes – OB–05
Ln Mercury Concentrations

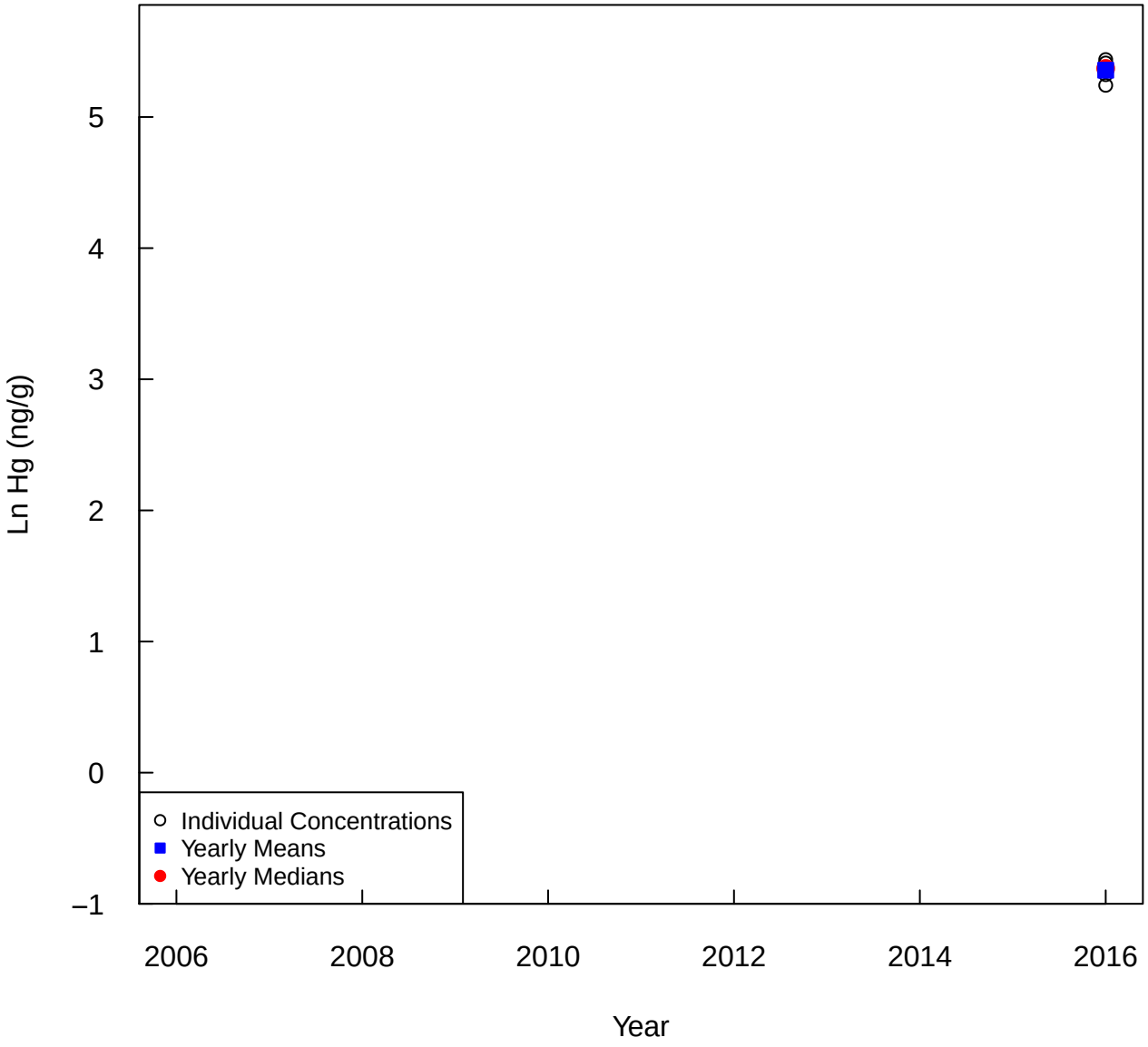


Figure 4–43
Polychaetes – Mendall Marsh
Ln Mercury Concentrations

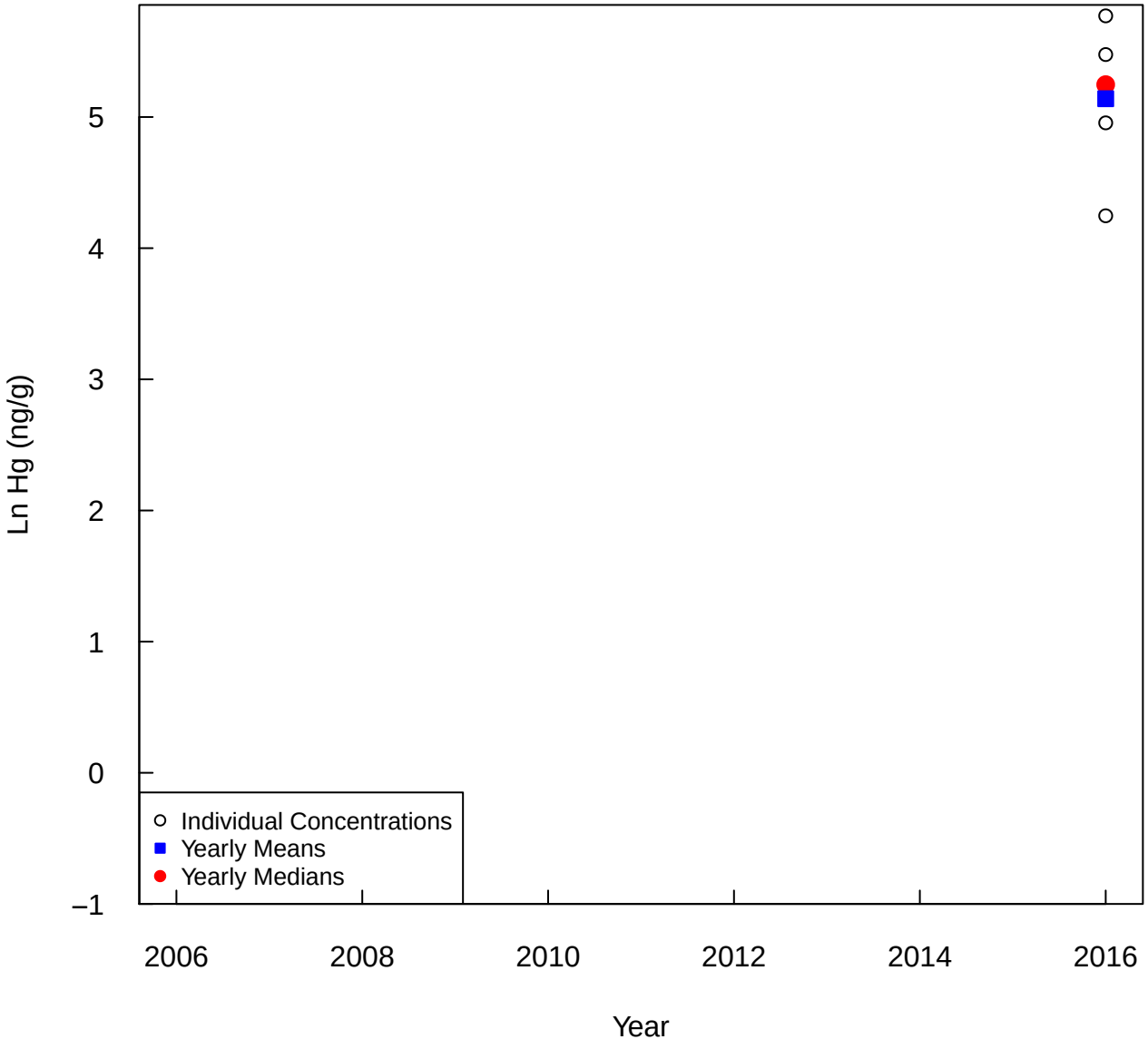


Figure 4–44
Polychaetes – ES–13
Ln Mercury Concentrations

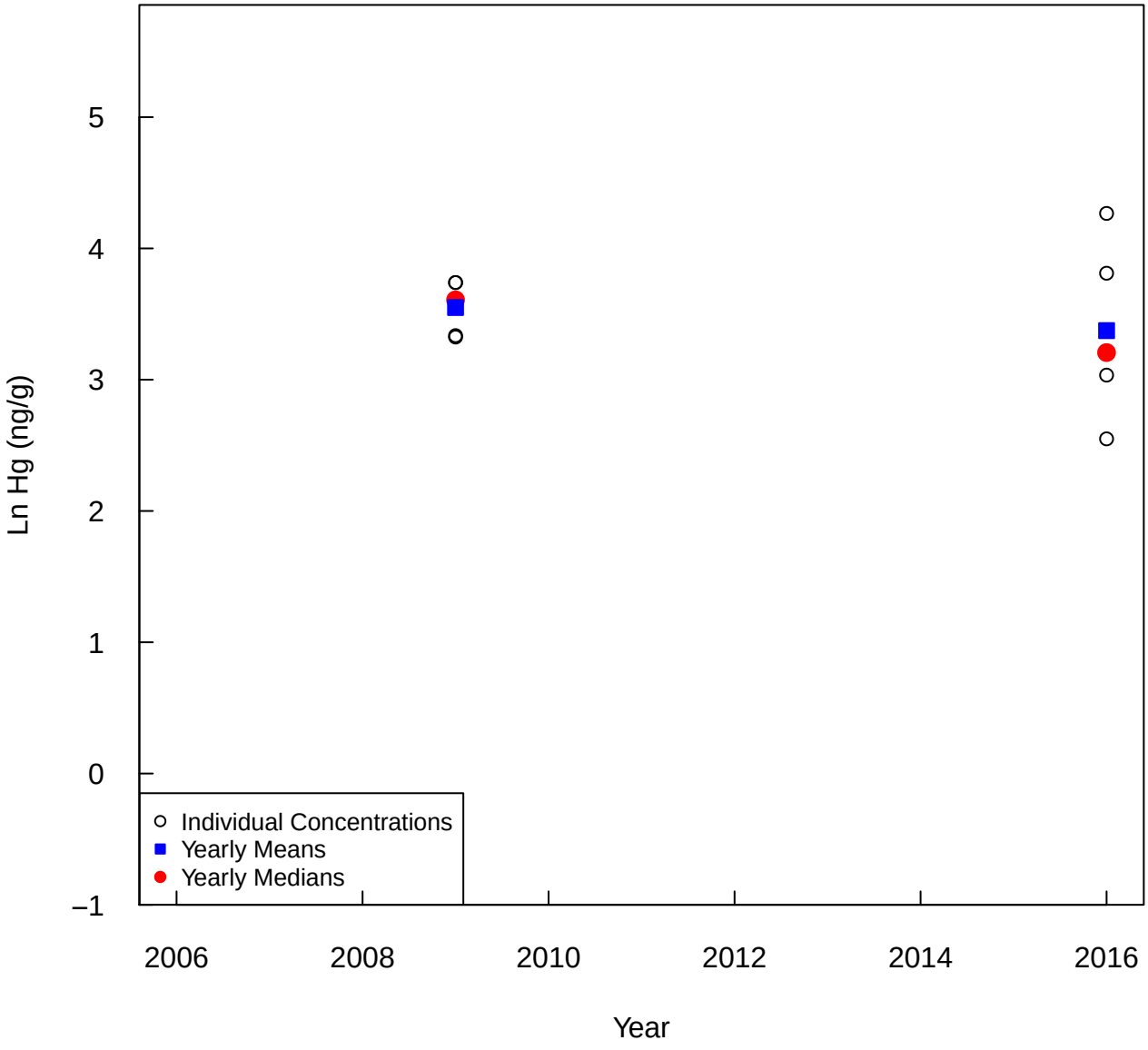


Figure 4–45
Polychaetes – ES–FP
Ln Mercury Concentrations

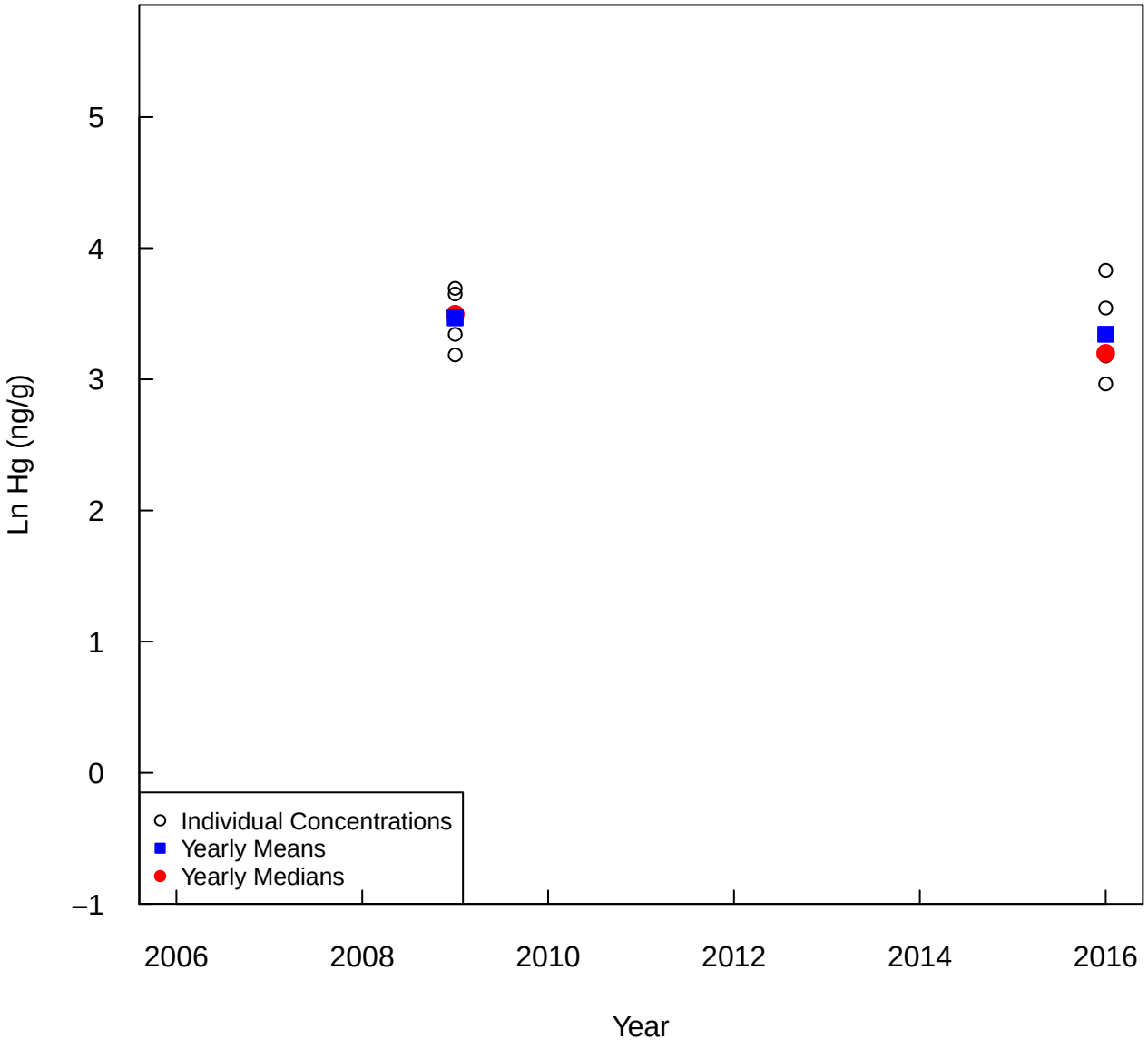
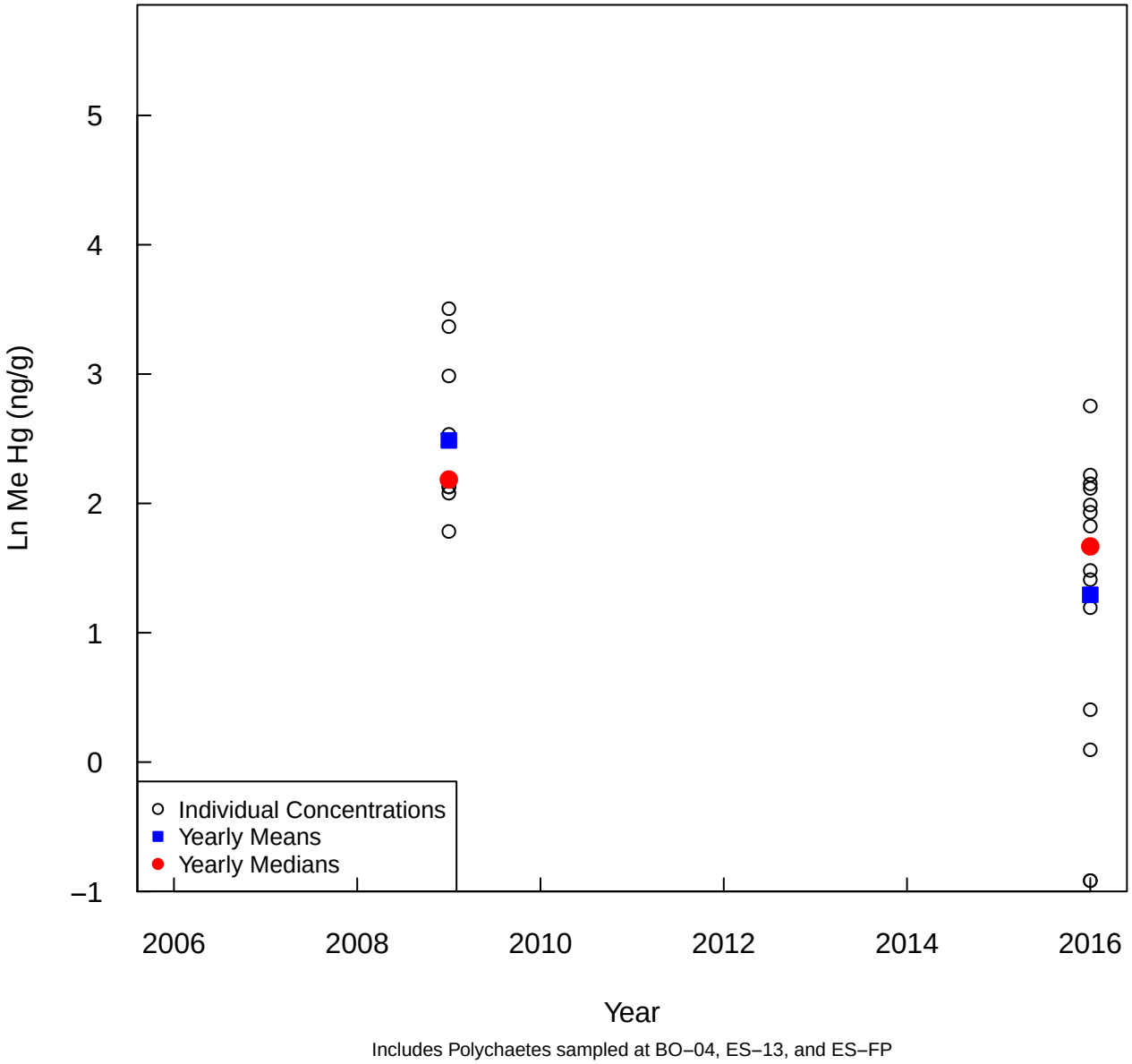


Figure 4–46
Polychaetes – Whole River
Ln Methyl Mercury Concentrations



Includes Polychaetes sampled at BO–04, ES–13, and ES–FP

Figure 4–47
Polychaetes – BO–04
Ln Methyl Mercury Concentrations

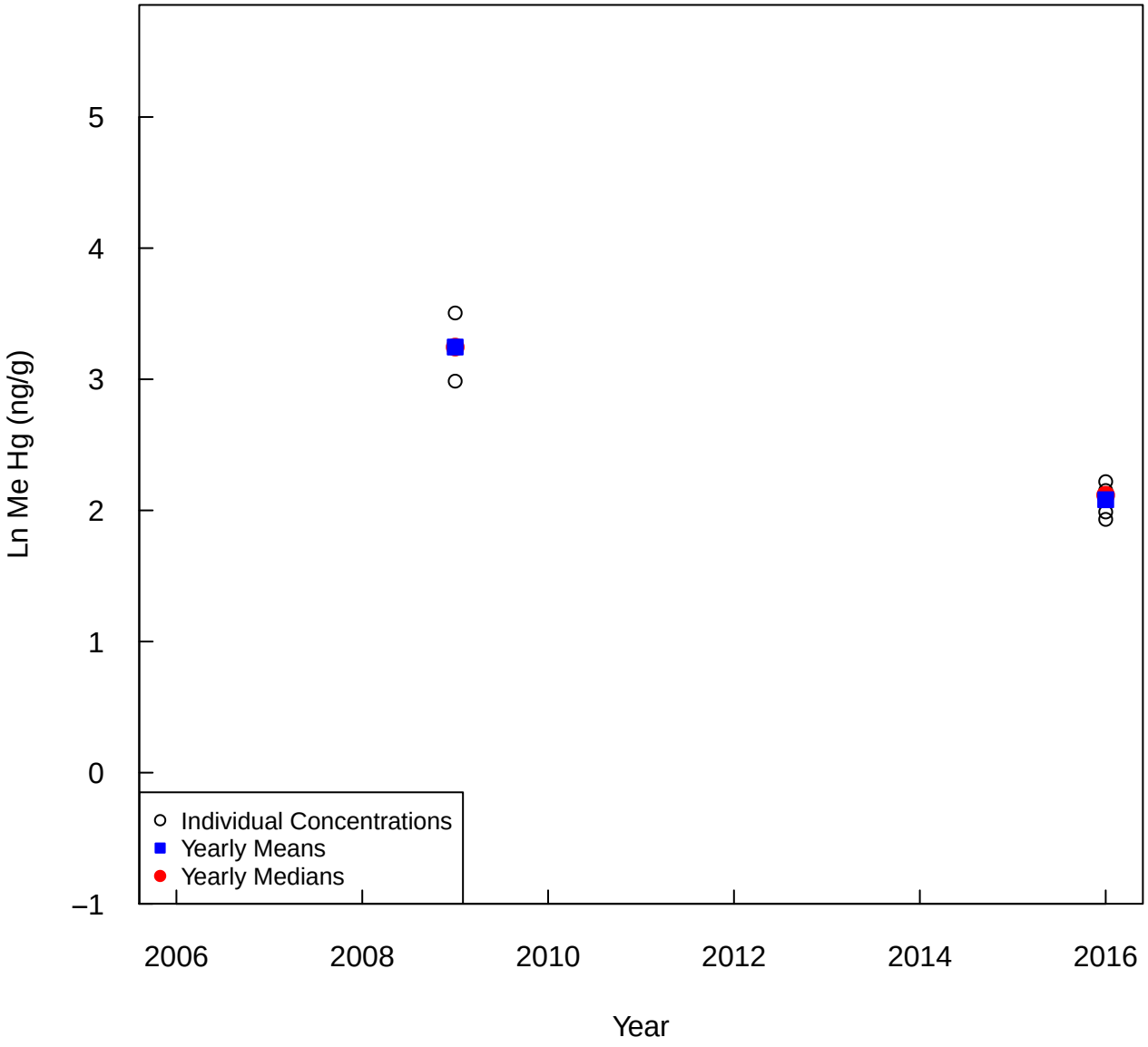


Figure 4–48
Polychaetes – OB–05
Ln Methyl Mercury Concentrations

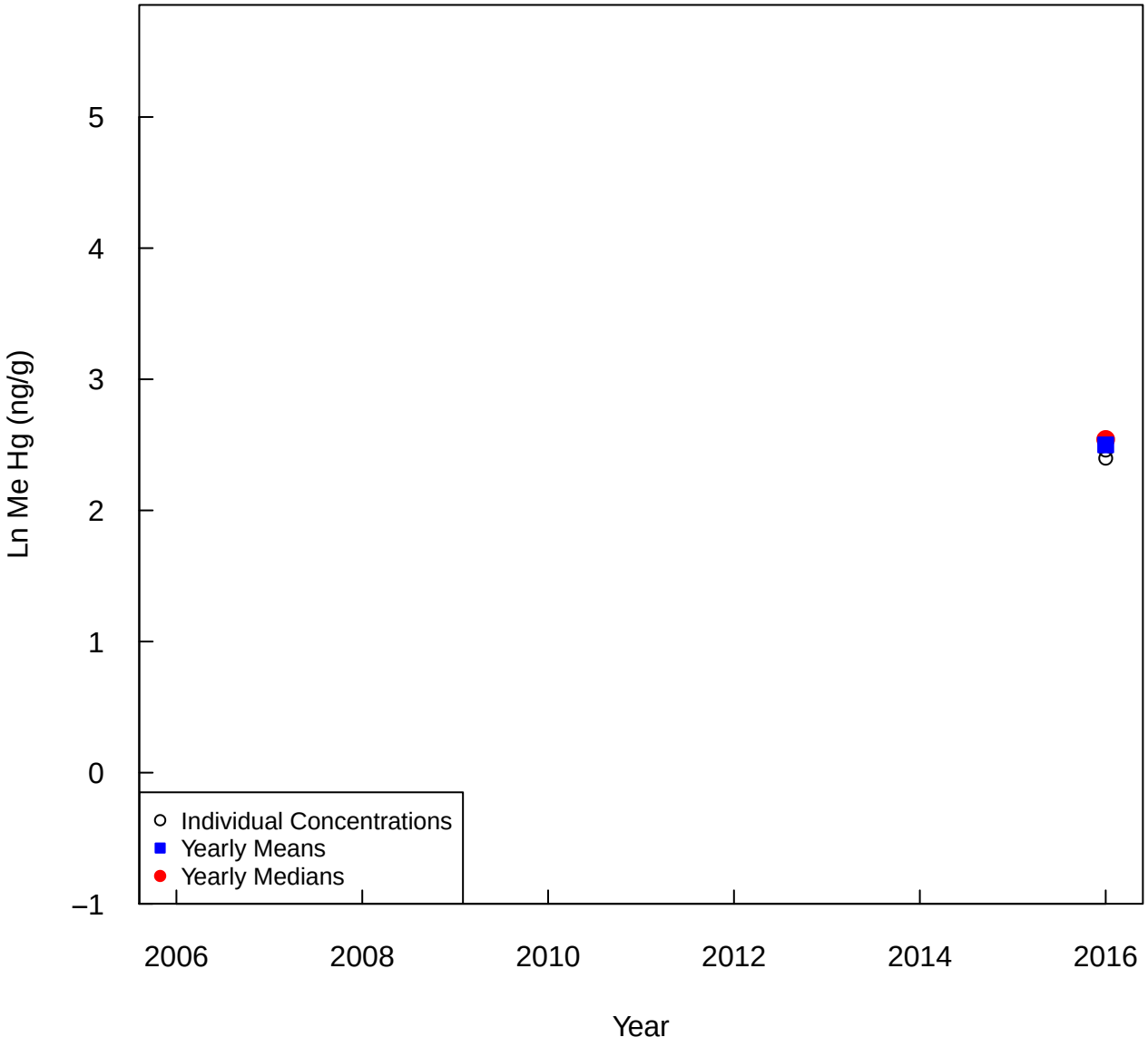


Figure 4–49
Polychaetes – Mendall Marsh
Ln Methyl Mercury Concentrations

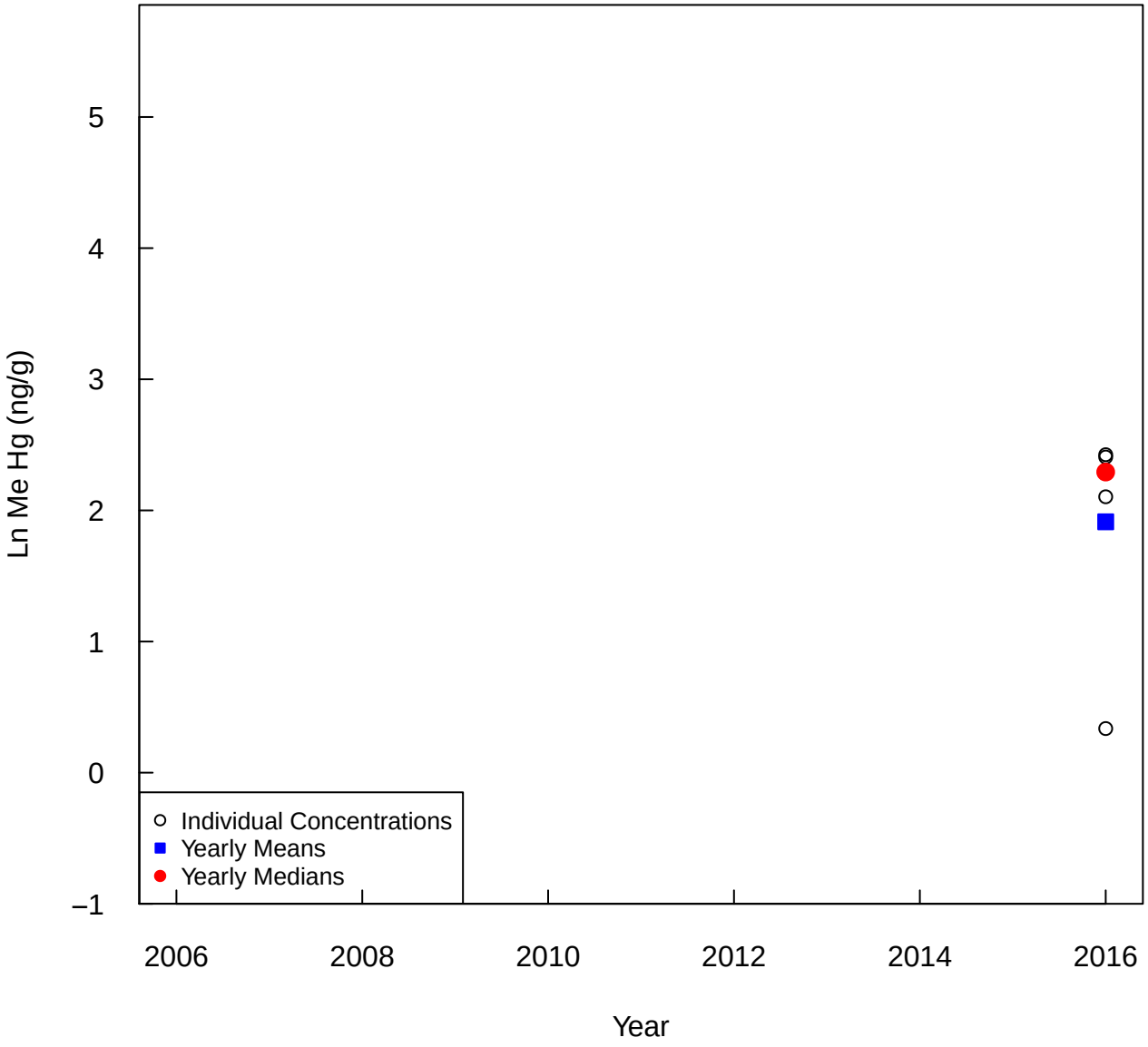


Figure 4–50
Polychaetes – ES–13
Ln Methyl Mercury Concentrations

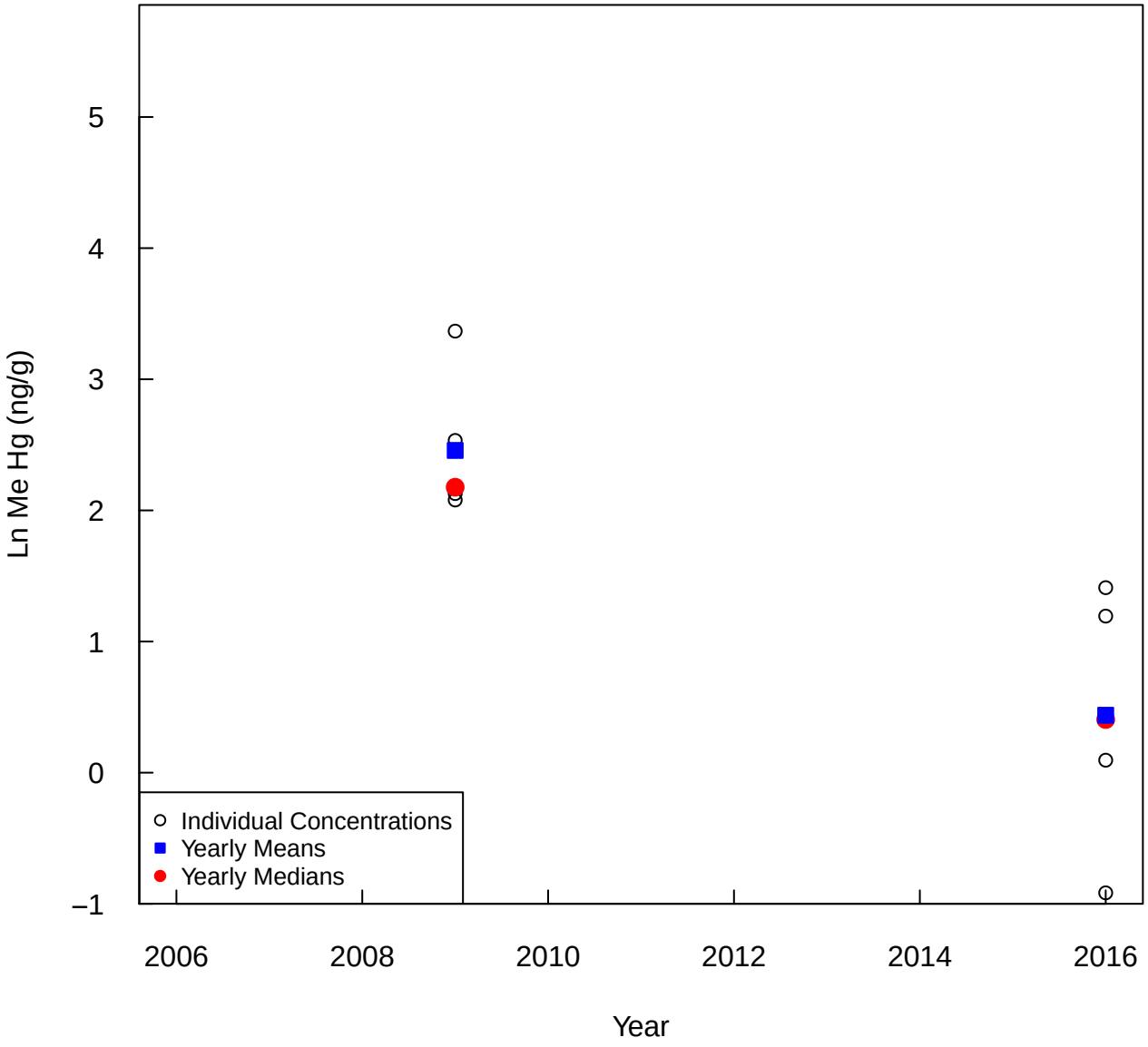


Figure 4–51
Polychaetes – ES–FP
Ln Methyl Mercury Concentrations

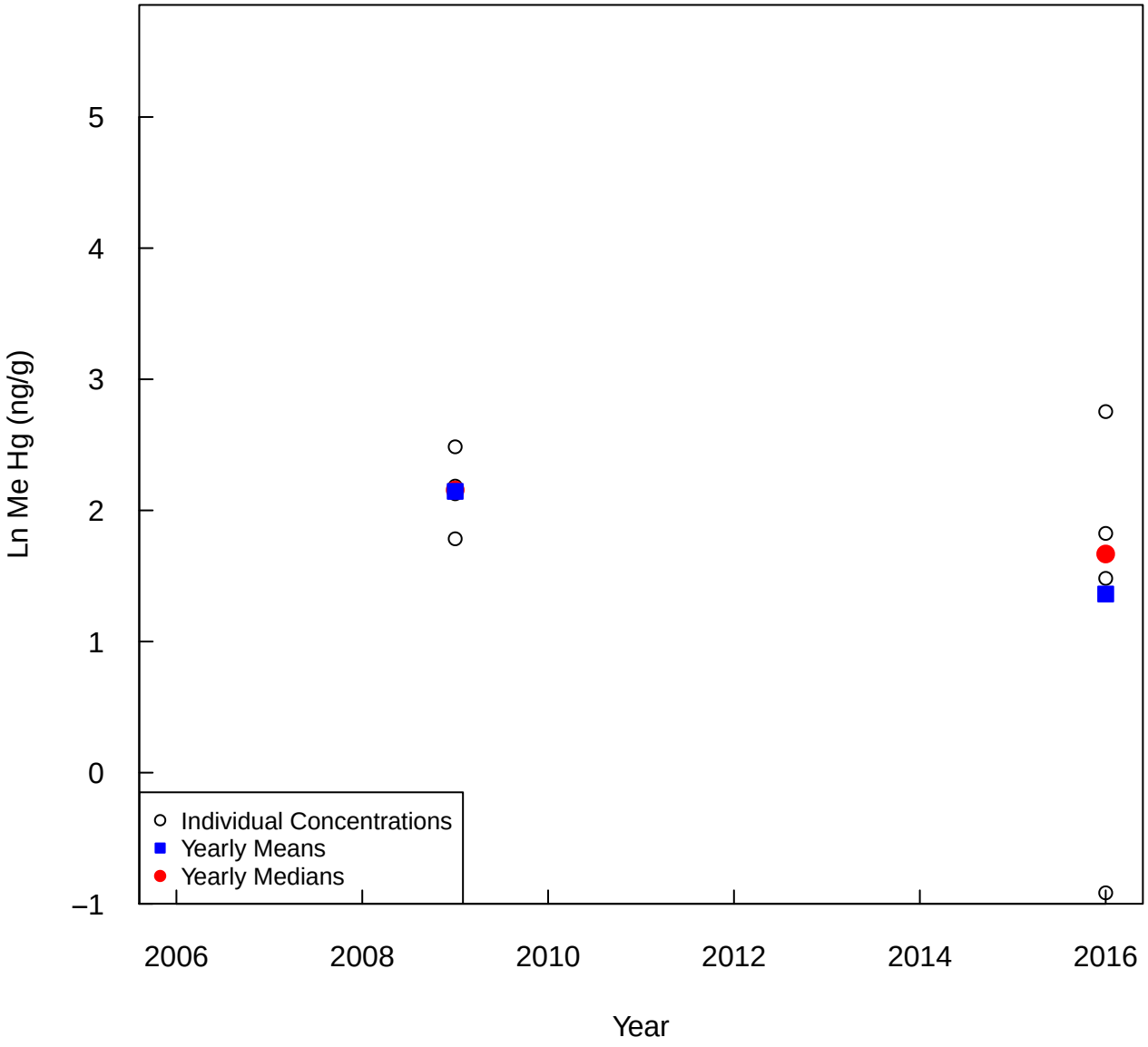


Figure 4–52
Blue Mussel – Reference Locations
Ln Mercury Concentrations

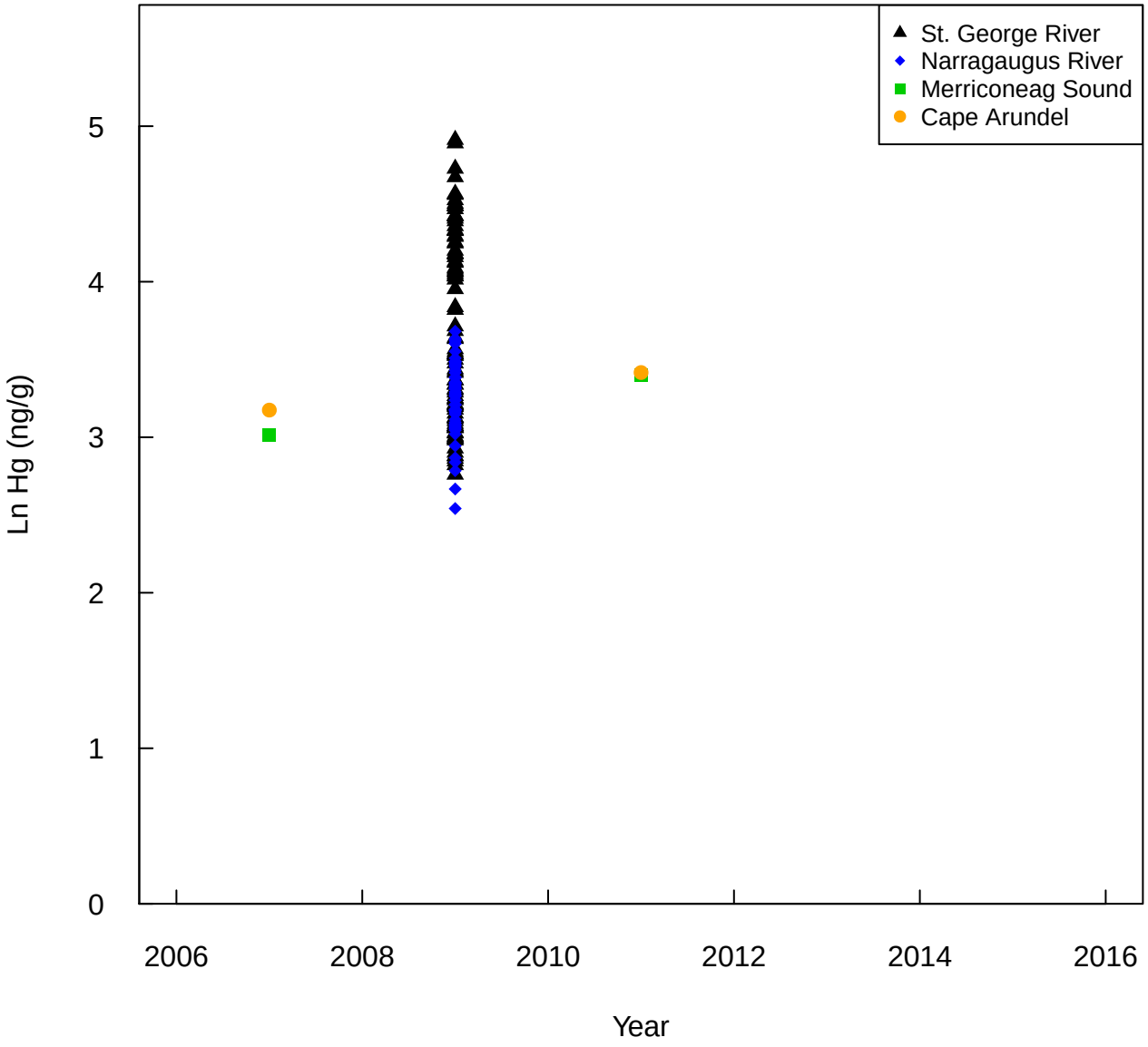
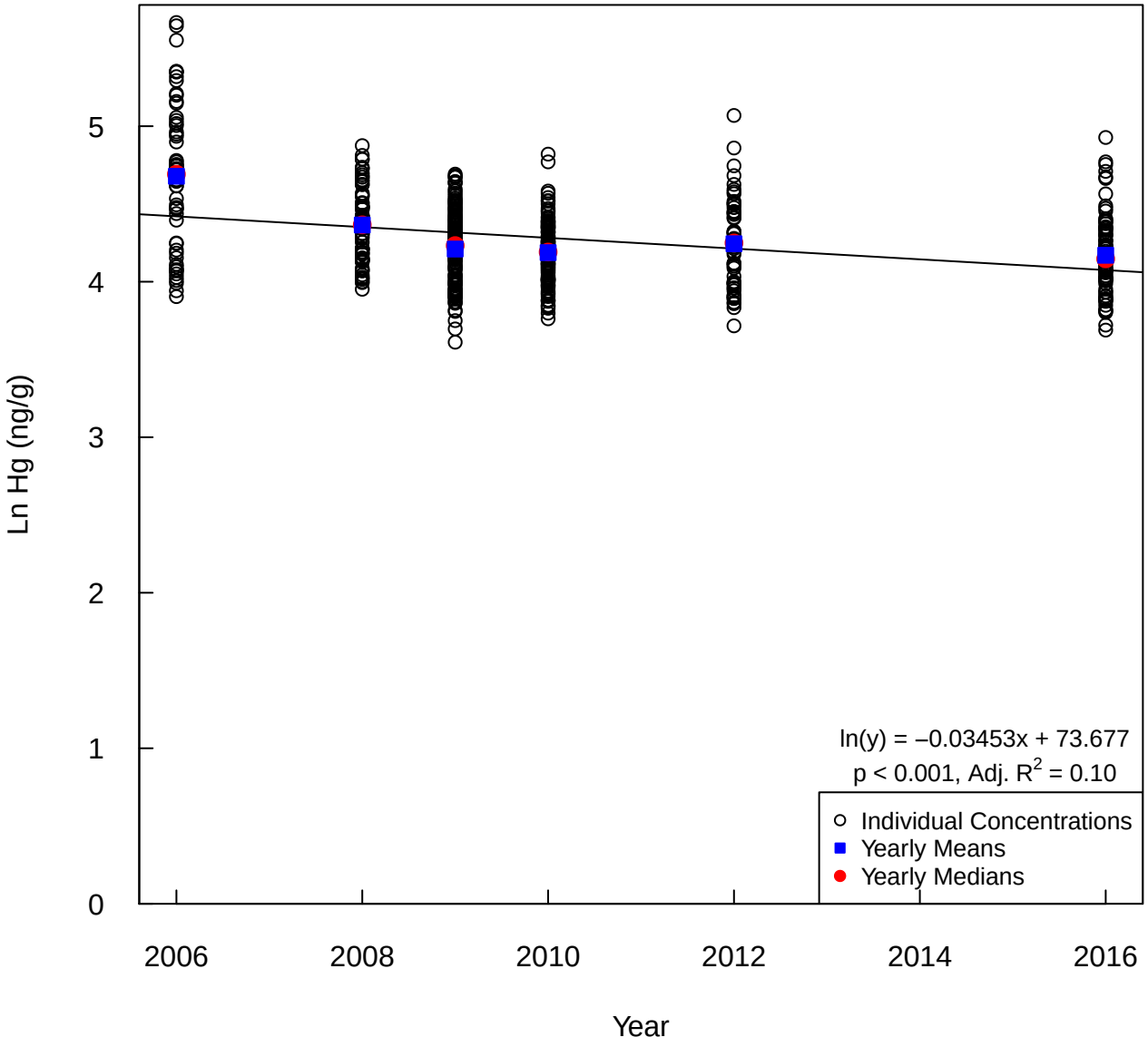


Figure 4–53
Blue Mussel – Whole River
Loglinear Regression



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

Figure 4–54
Blue Mussel – ES–15
Loglinear Regression

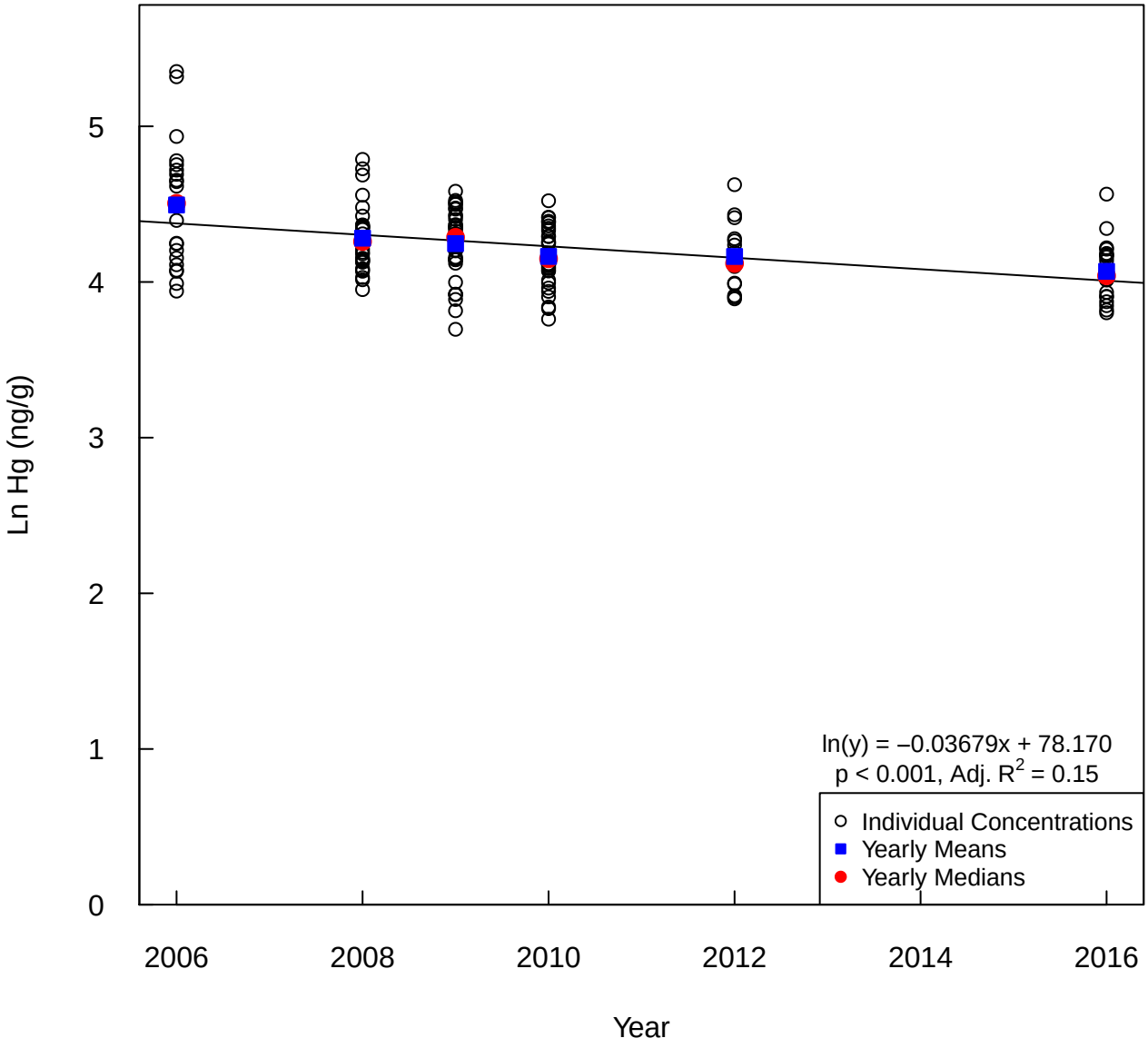


Figure 4–55
Blue Mussel – ES–13
Loglinear Regression

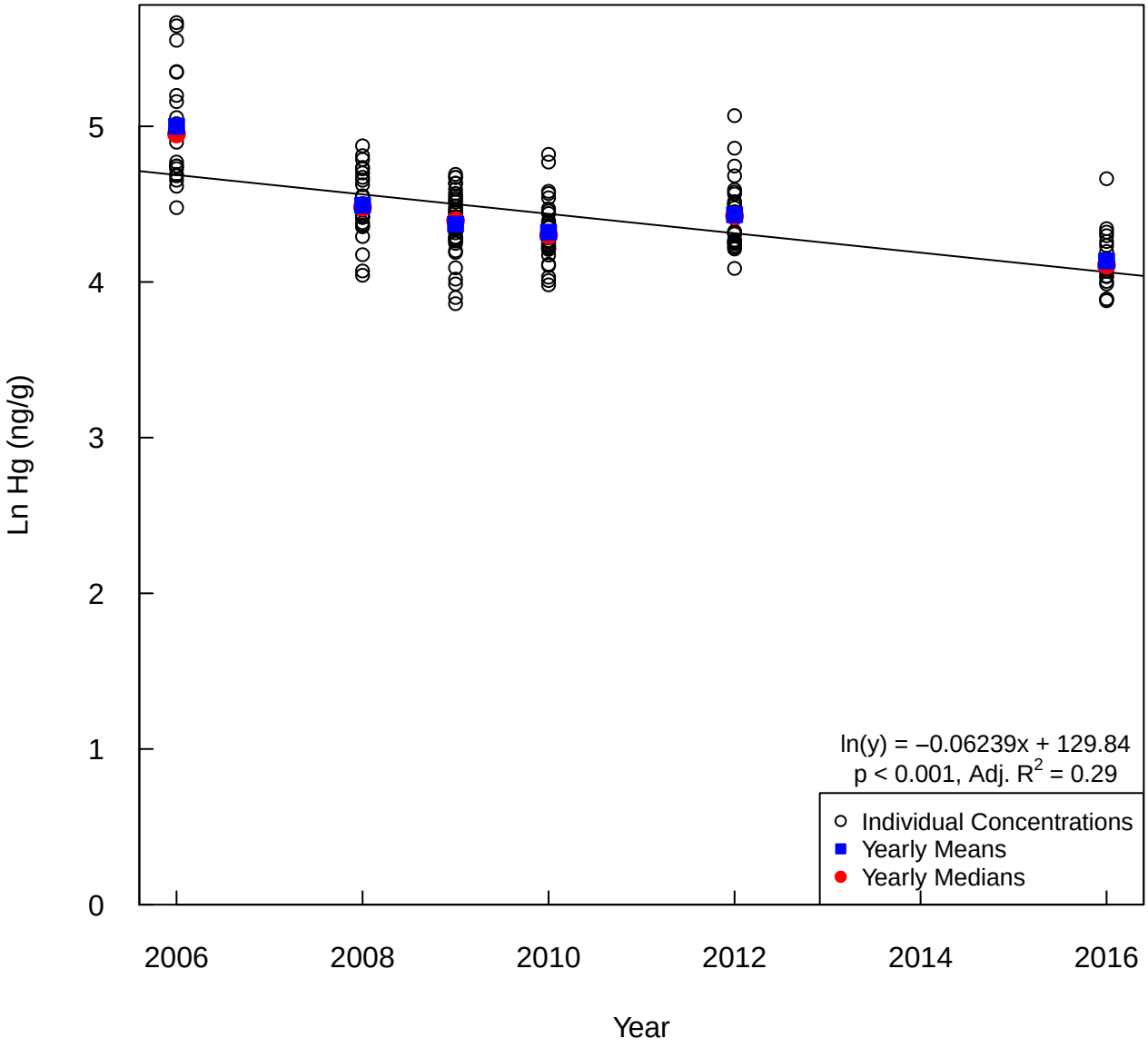


Figure 4–56
Blue Mussel – ES–03
Loglinear Regression

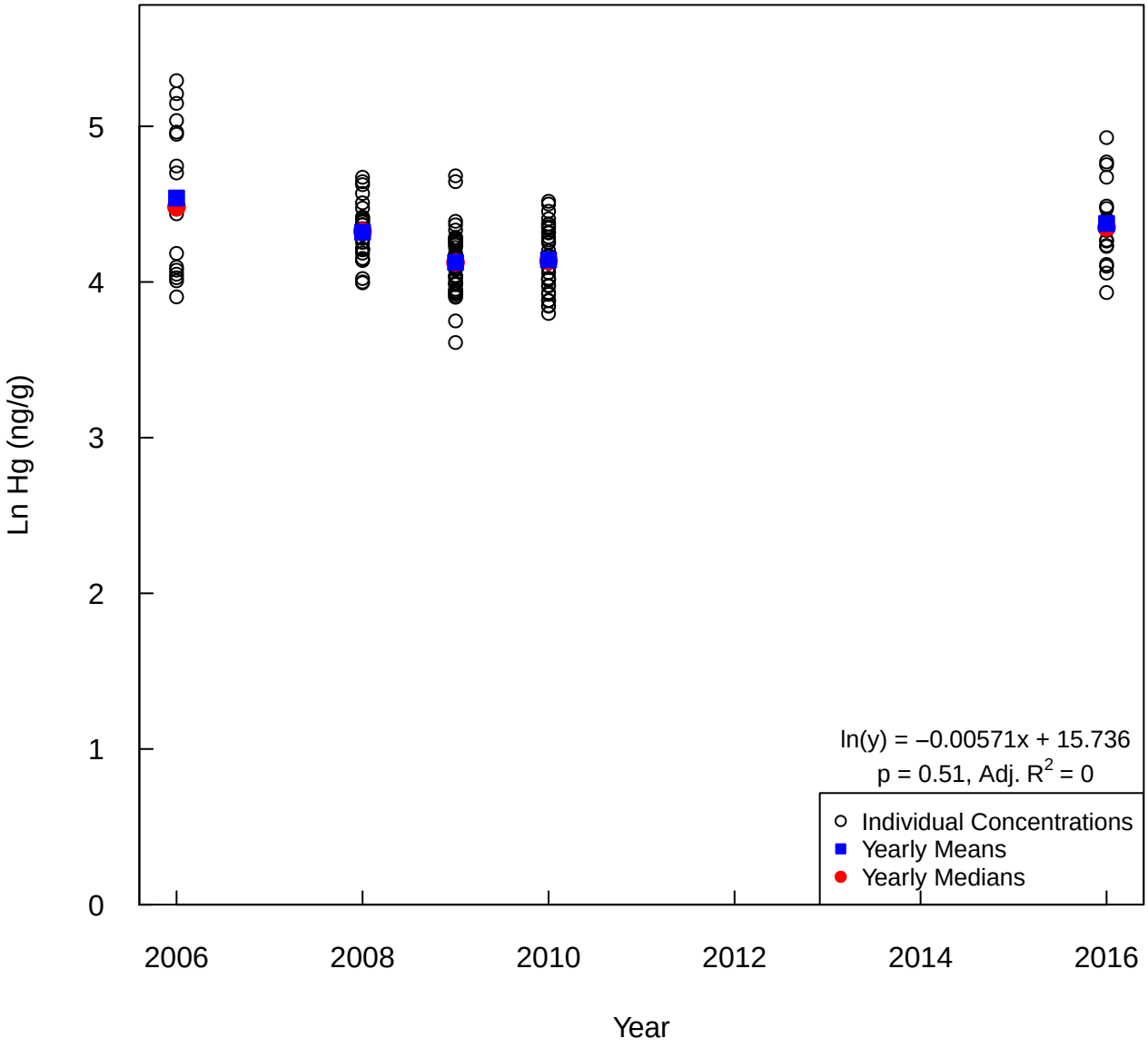


Figure 4–57
Blue Mussel – ES–FP
Loglinear Regression

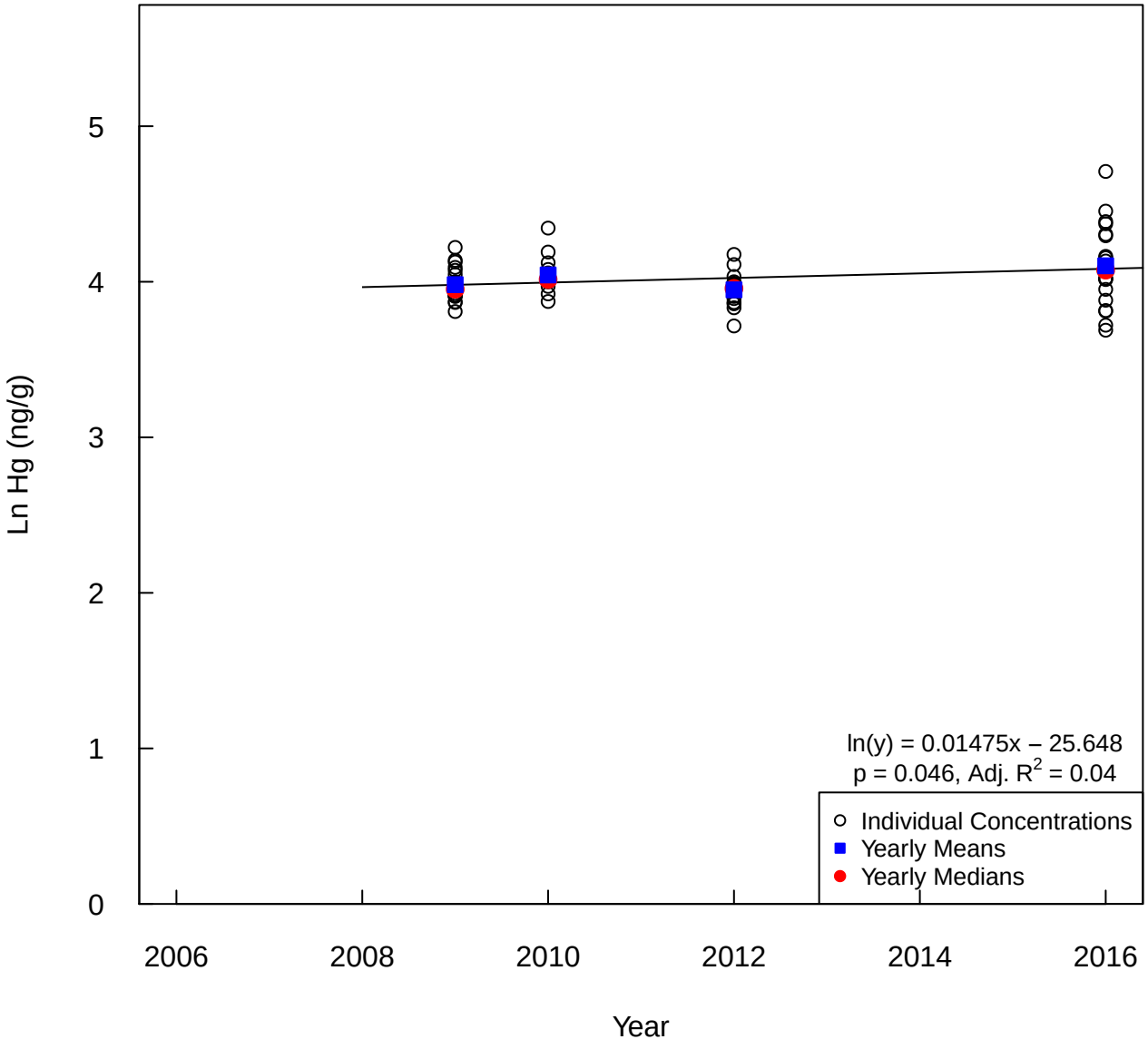
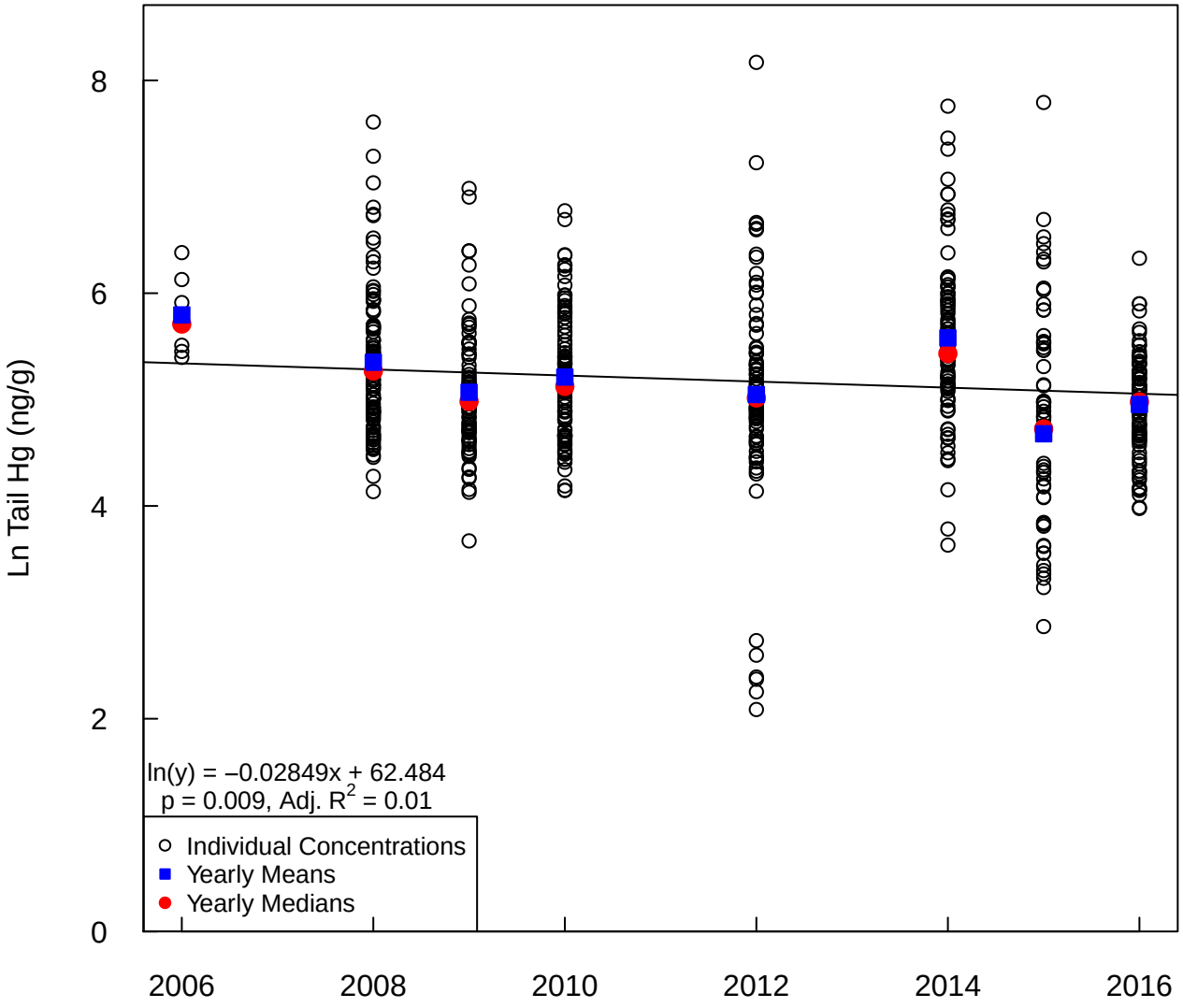


Figure 4–58
Lobster Tail – Penobscot Bay
Length Adjusted Loglinear Regression



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

Figure 4–59
Lobster Tail – Odom Ledge
Length Adjusted Loglinear Regression

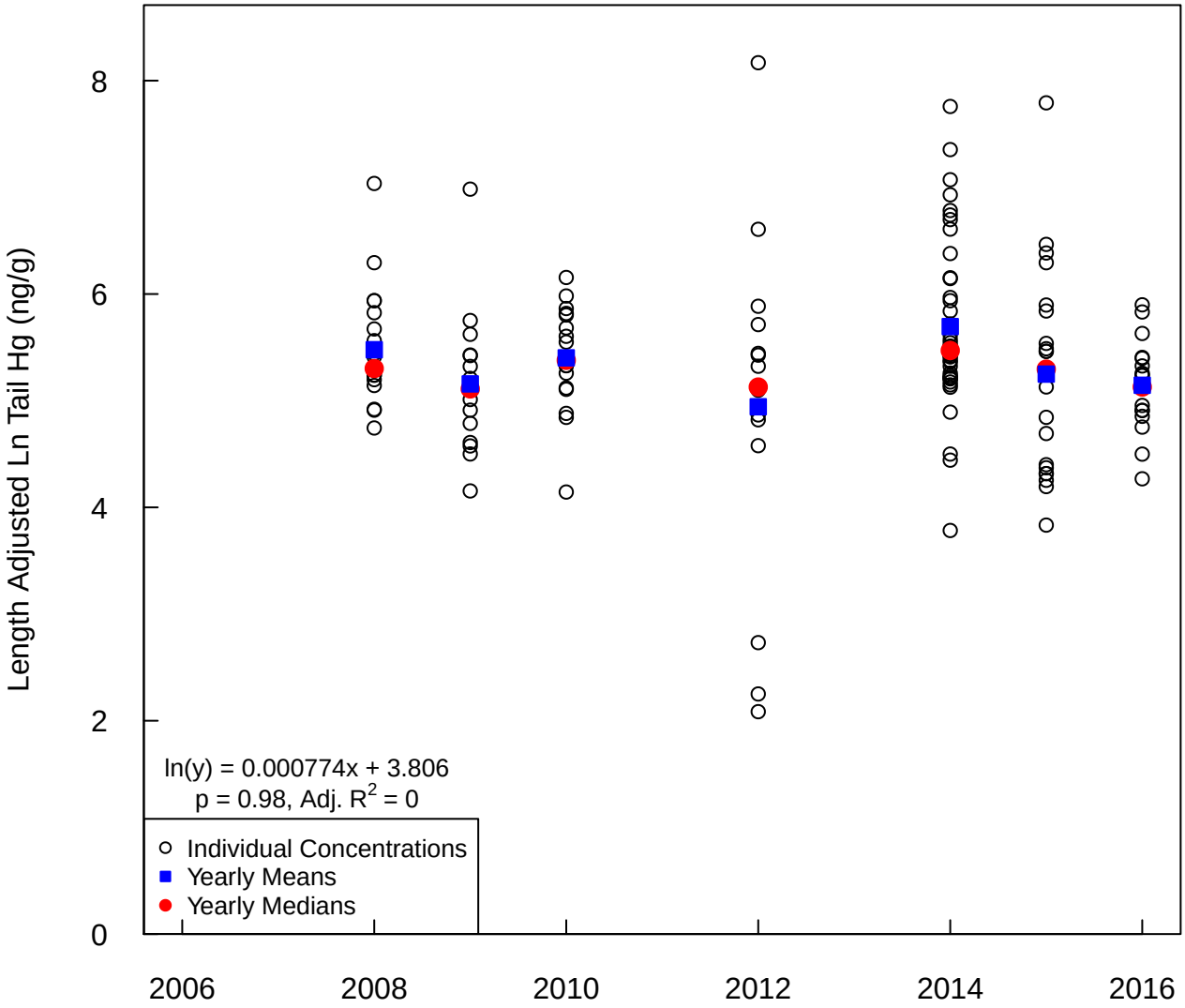


Figure 4–60
Lobster Tail – South Verona
Length Adjusted Loglinear Regression

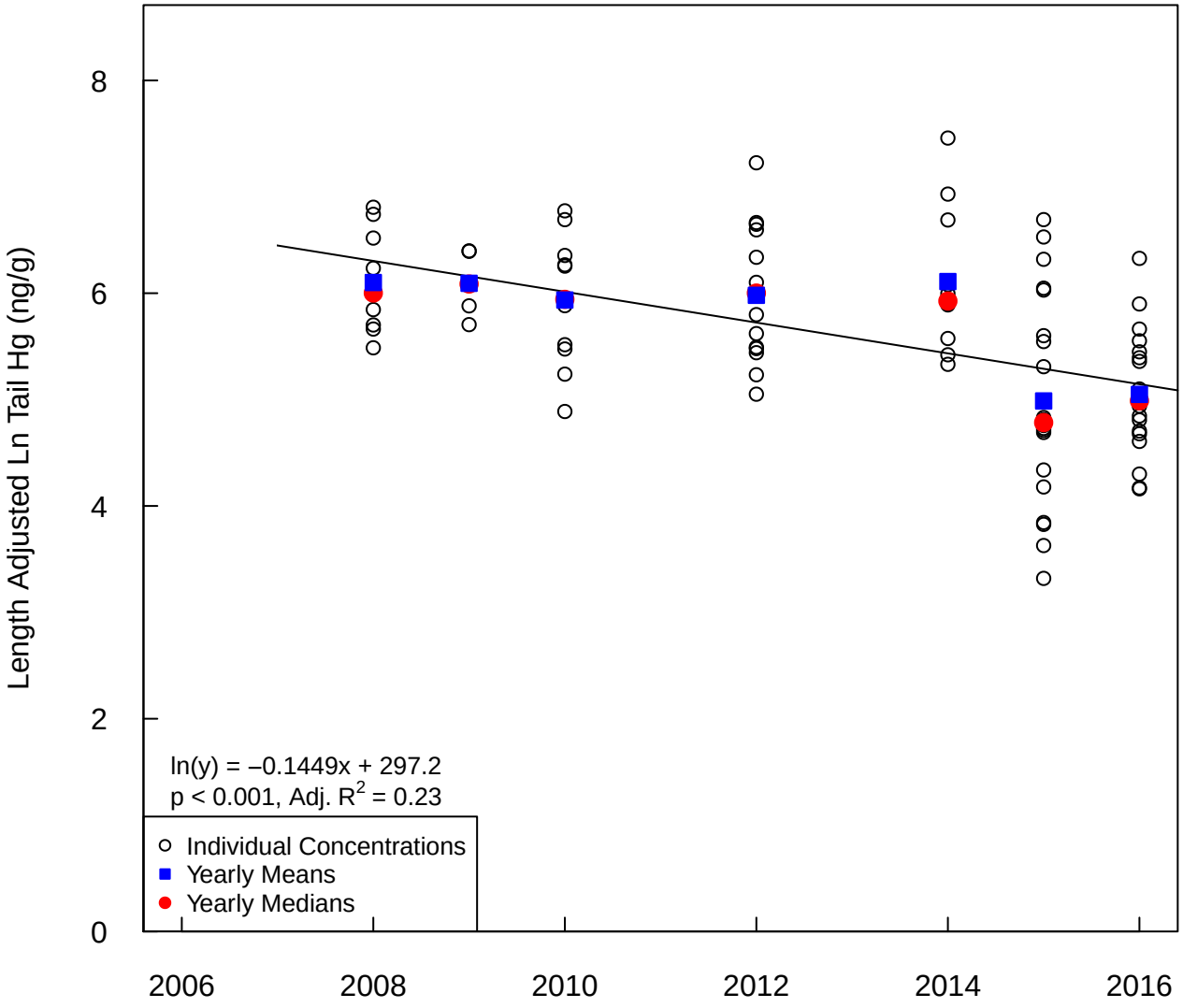


Figure 4–61
Lobster Tail – Cape Jellison
Length Adjusted Loglinear Regression

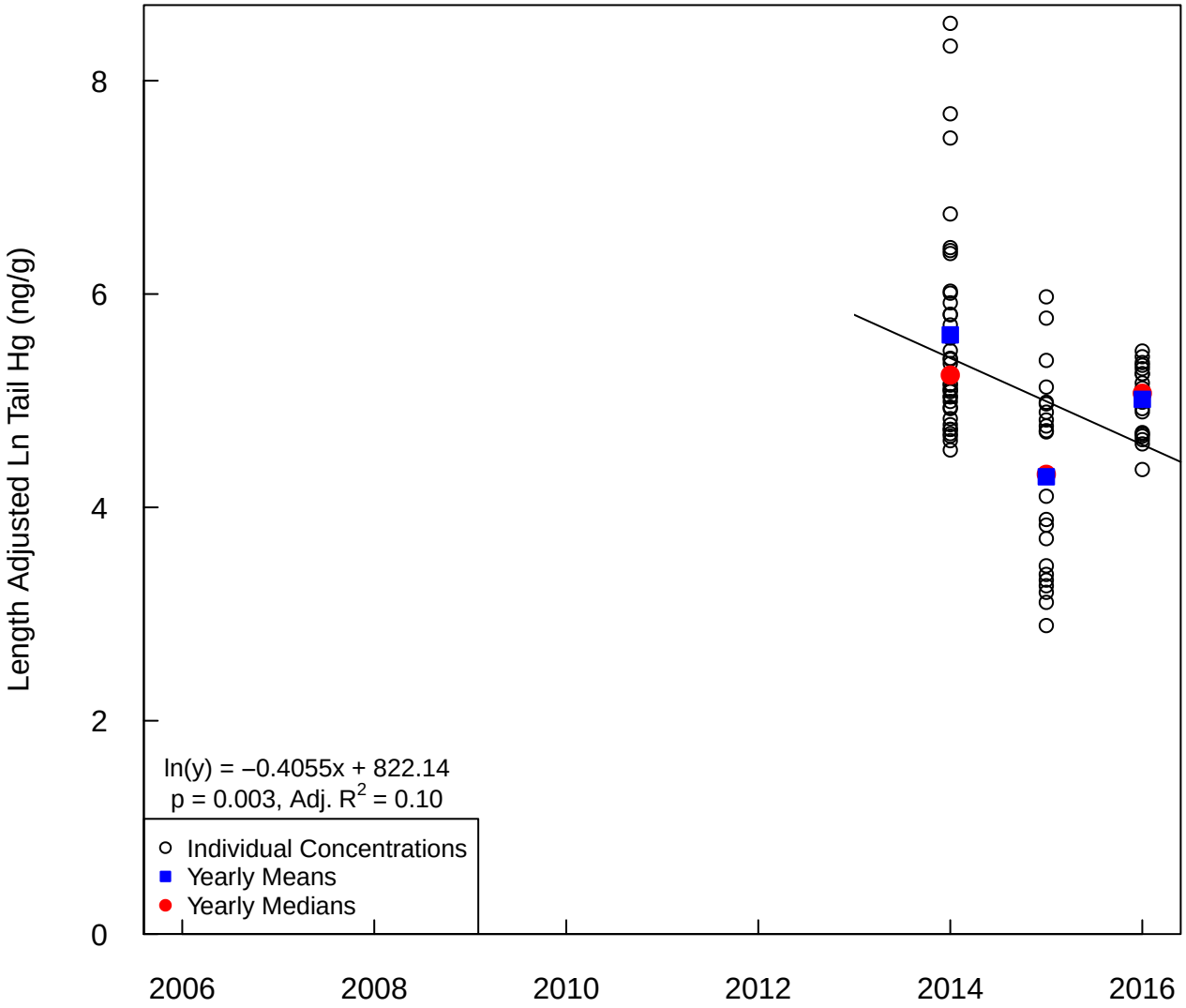


Figure 4–62
Lobster Tail – Turner Point
Length Adjusted Loglinear Regression

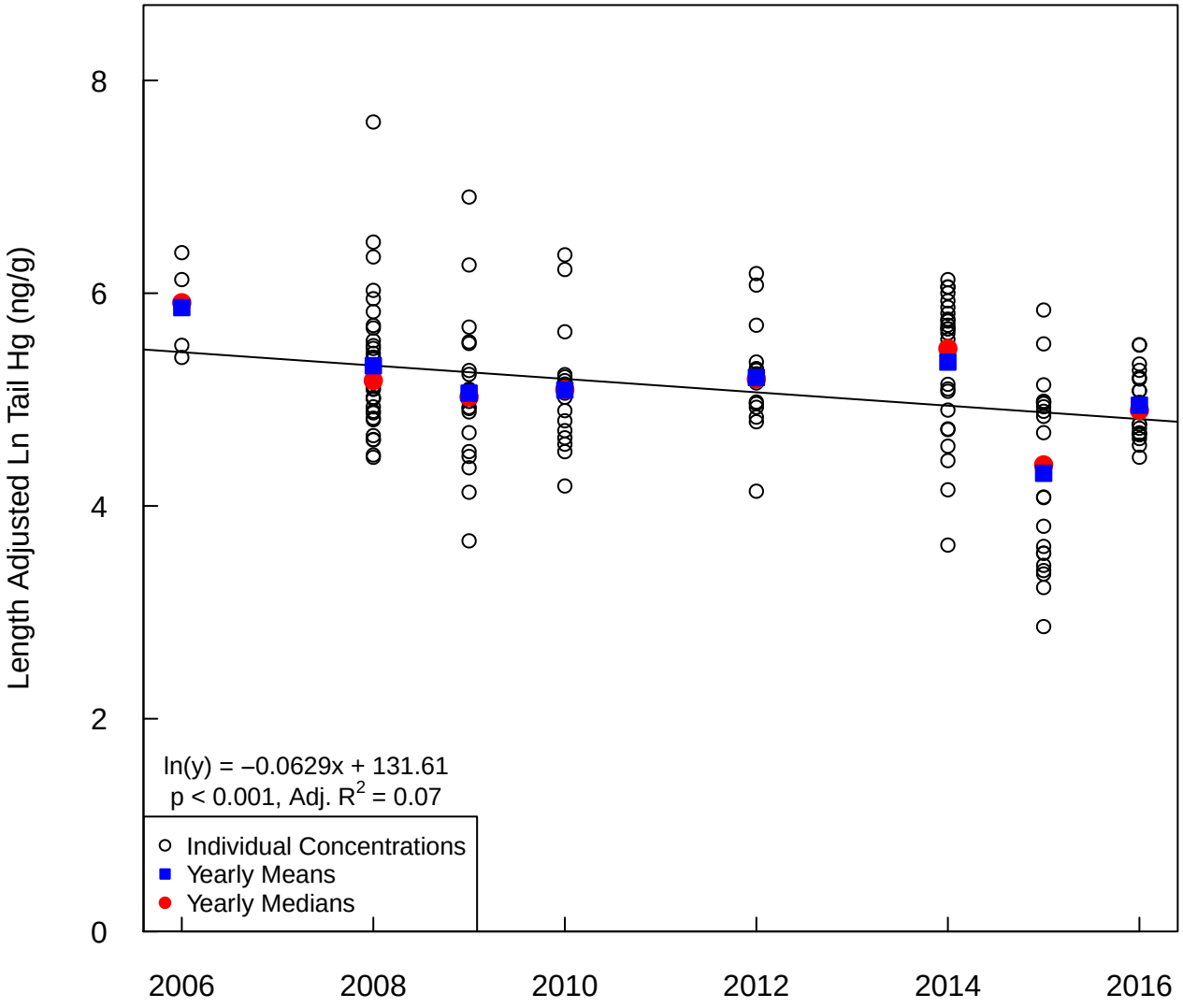


Figure 4–63
Lobster Tail – Harborside
Length Adjusted Loglinear Regression

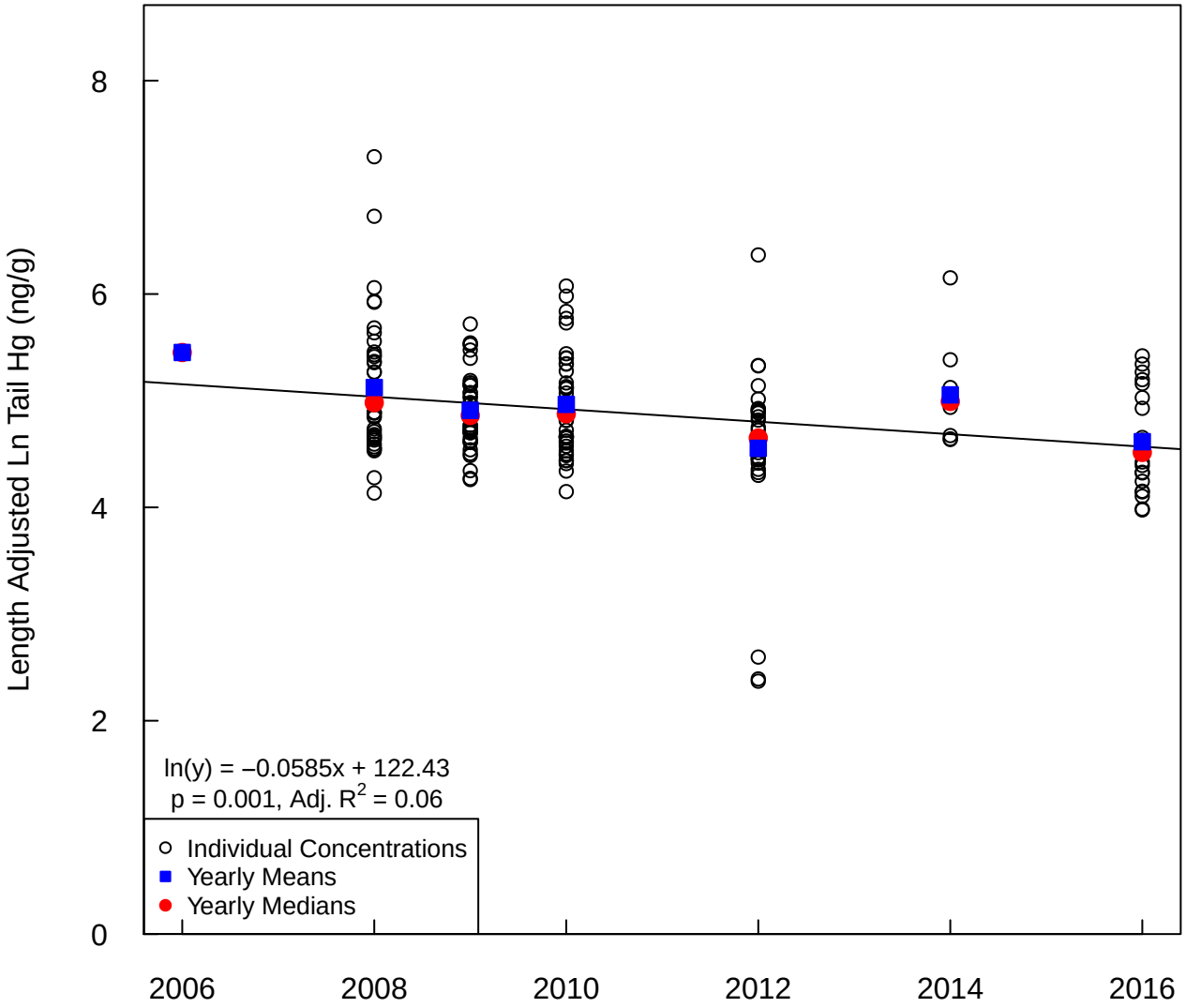


Figure 4–64
Comparison of Lobster Claw and Tail Mercury Results

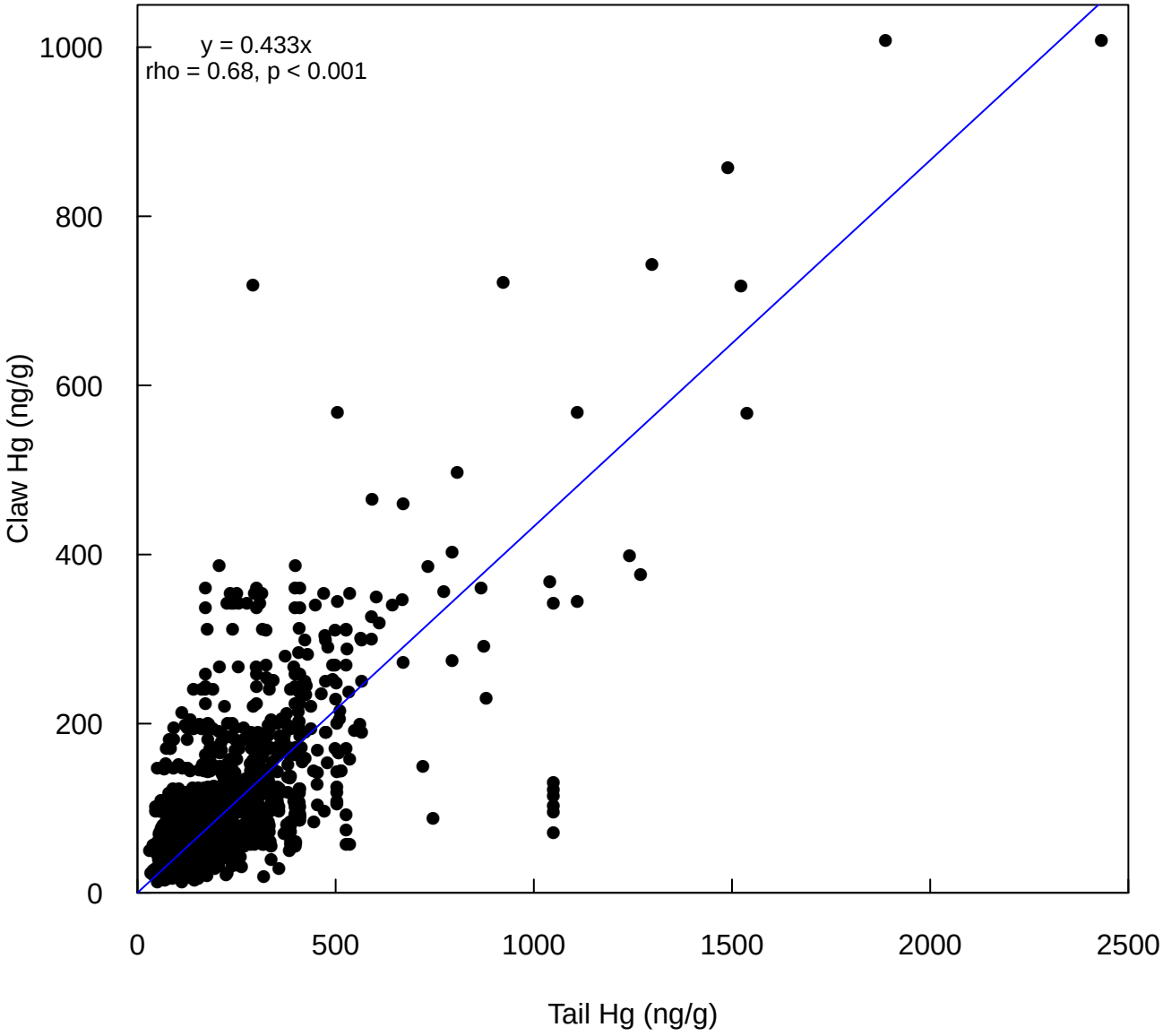
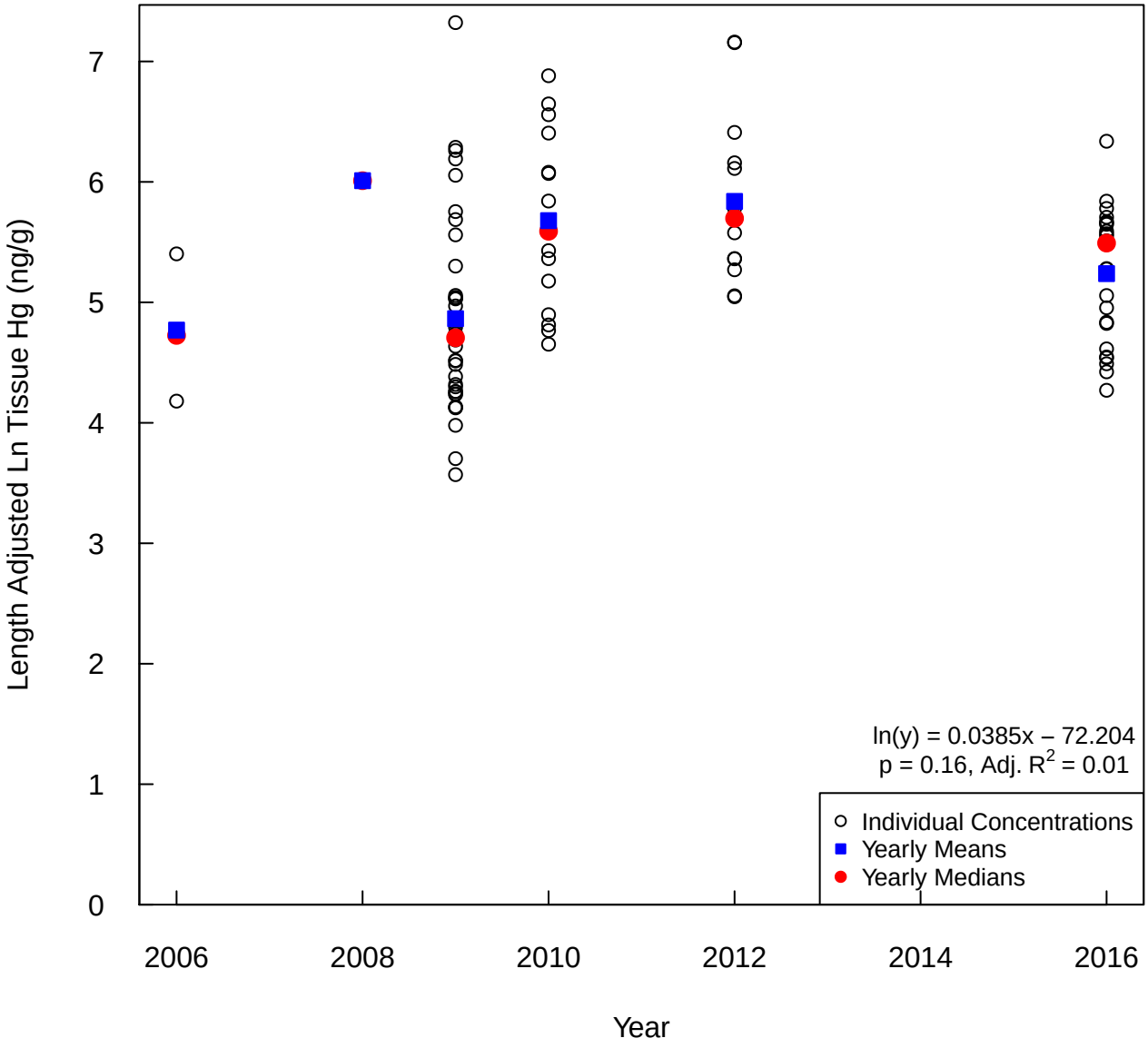


Figure 4–65
Mummichog – Whole River
Length Adjusted Loglinear Regression



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

Figure 4–66
Mummichog – OB–05
Length Adjusted Loglinear Regression

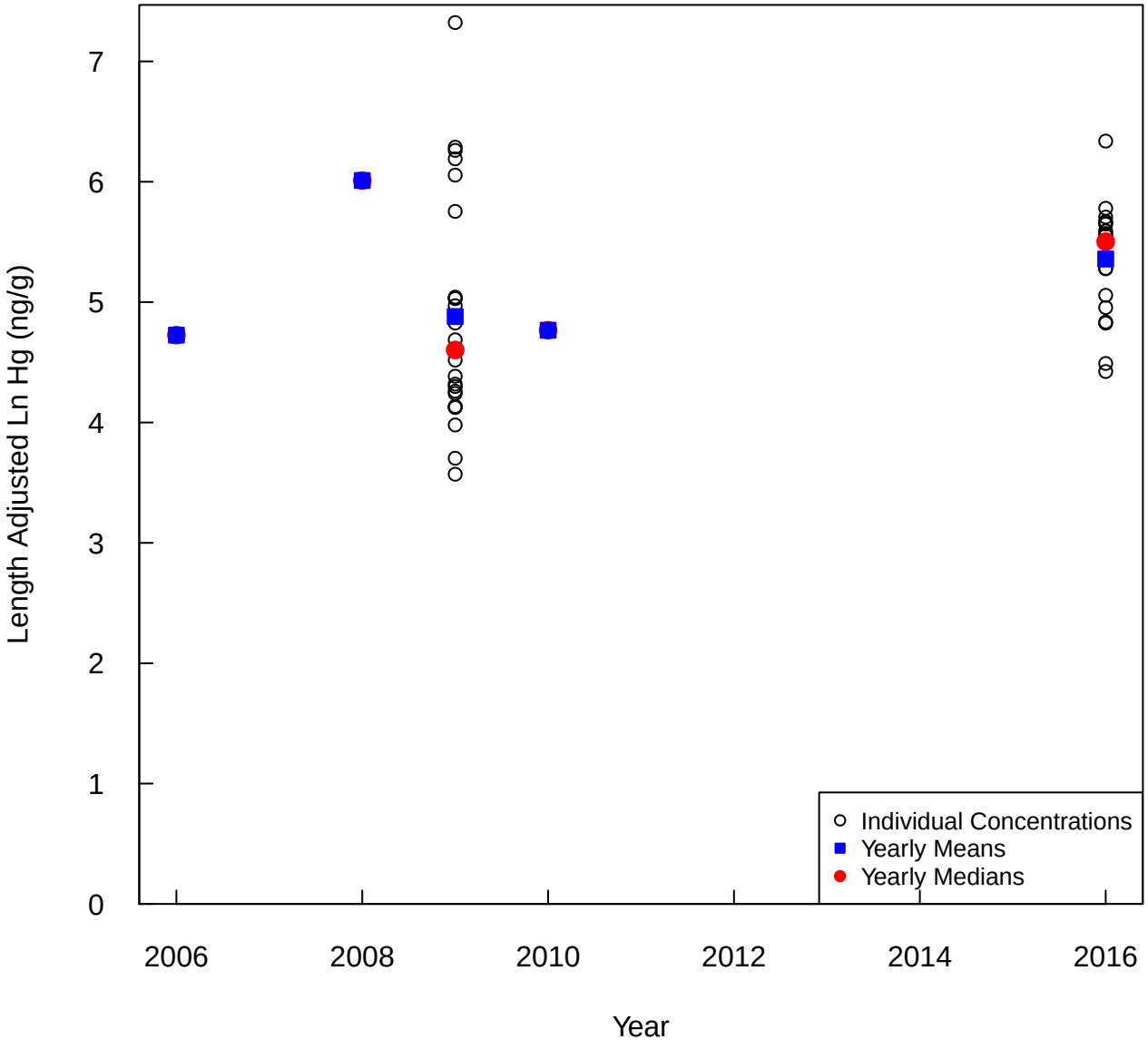
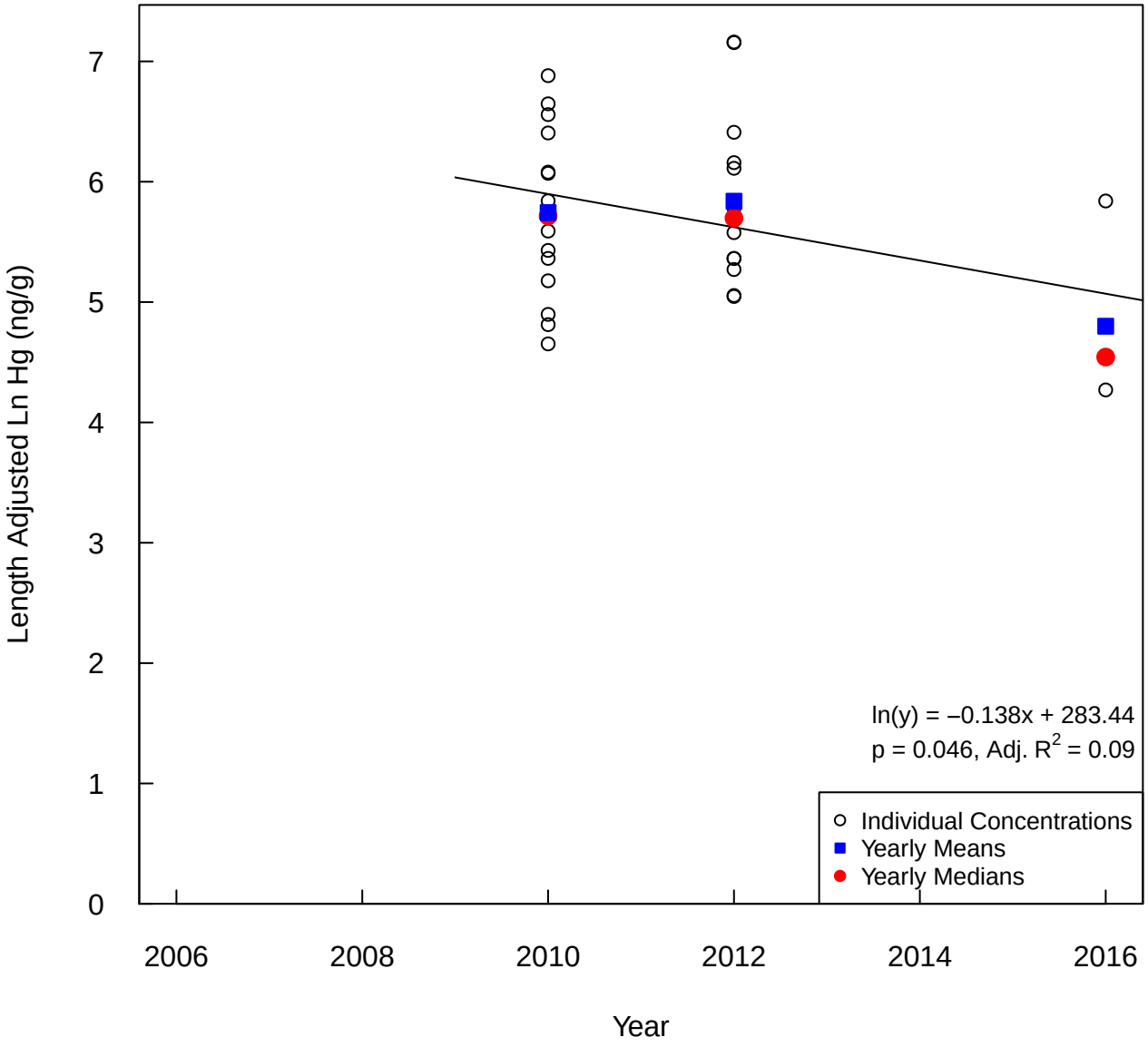


Figure 4–67
Mummichog – Mendall Marsh
Length Adjusted Loglinear Regression



Includes Mummichog sampled at MMMC–01 and W–21

Figure 4–68
Mummichog – OB–01
Length Adjusted Loglinear Regression

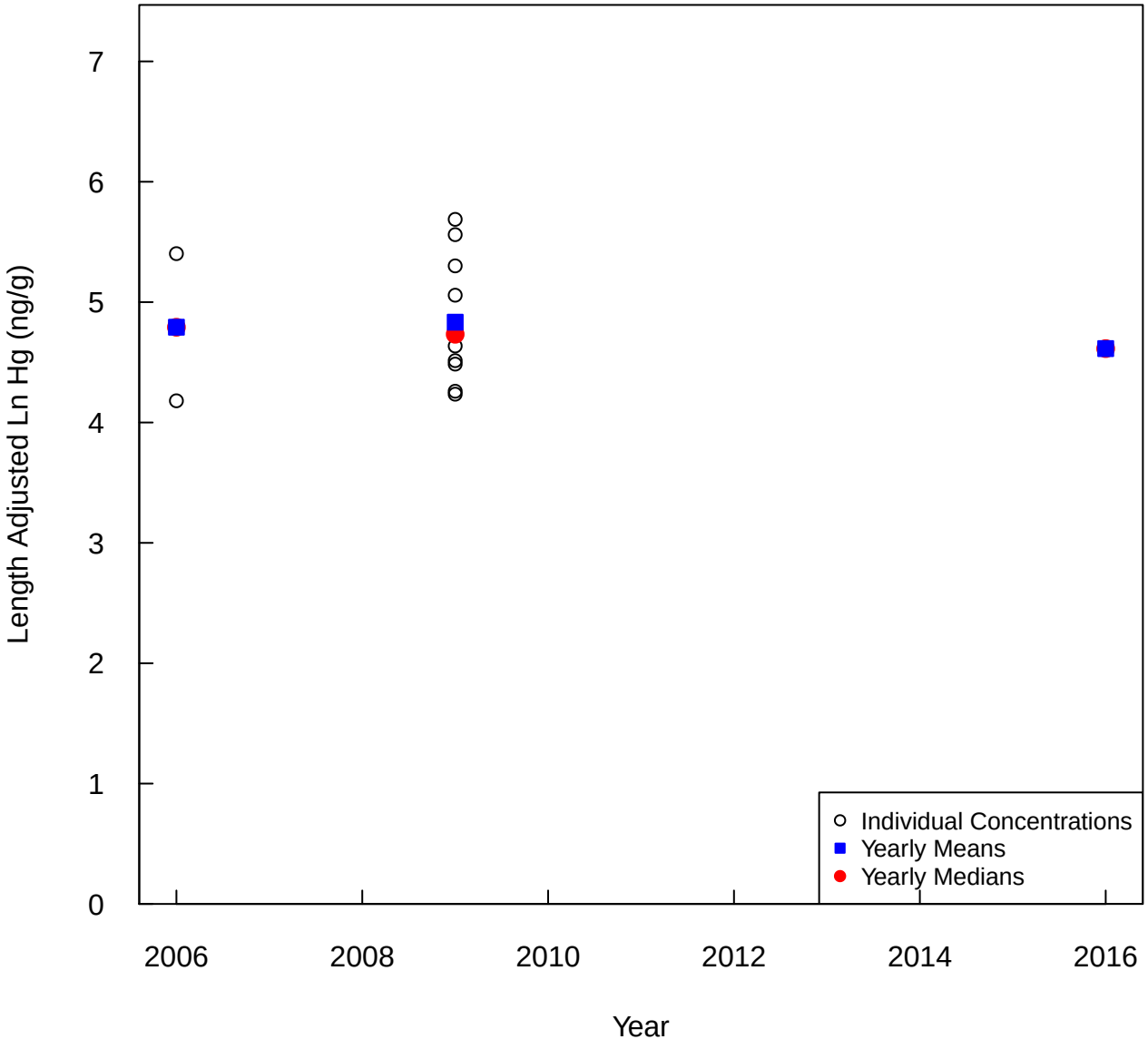


Figure 4–69
Rainbow Smelt – Frenchman Bay (Reference)
Length Adjusted Ln Mercury Concentrations

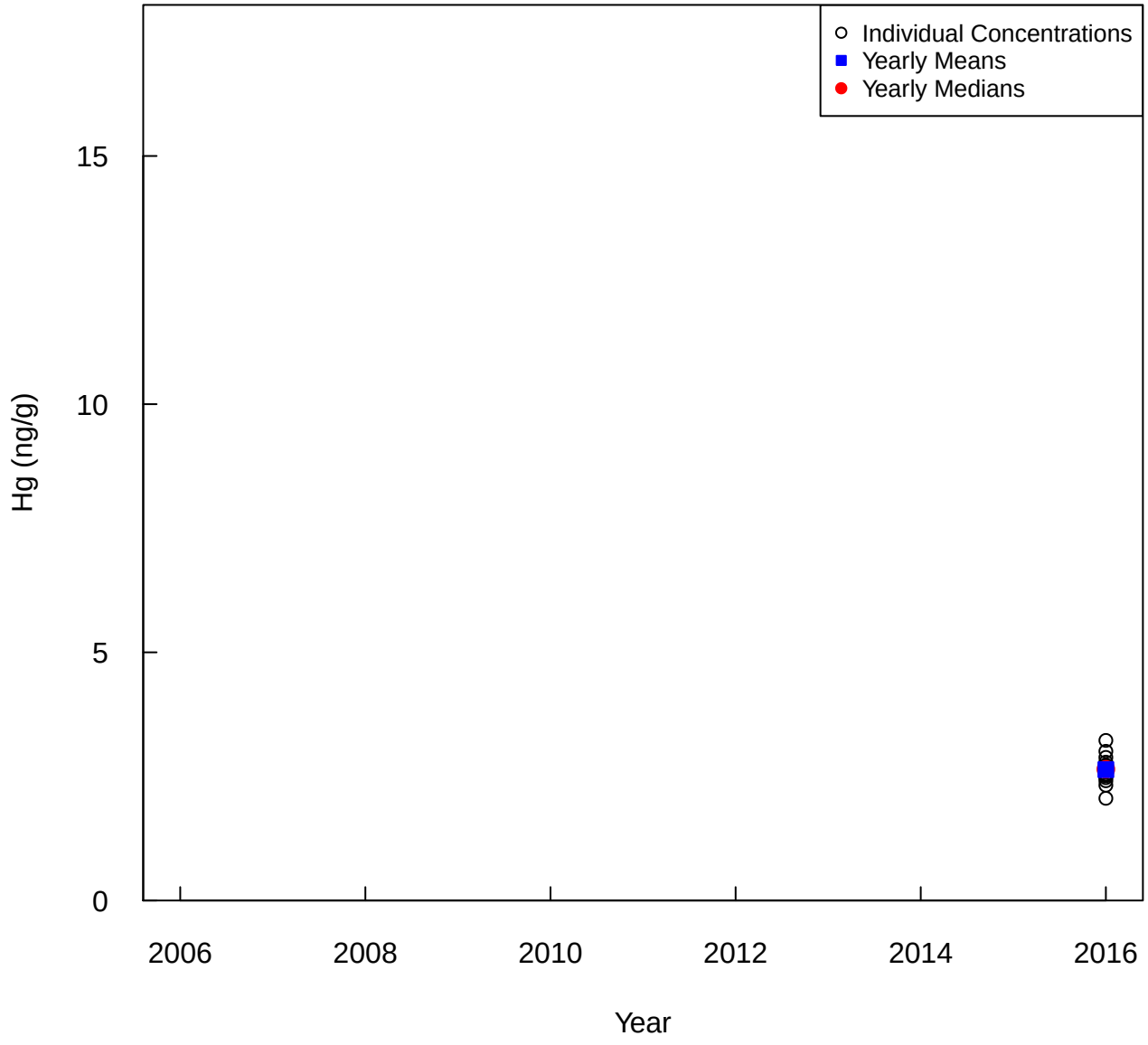
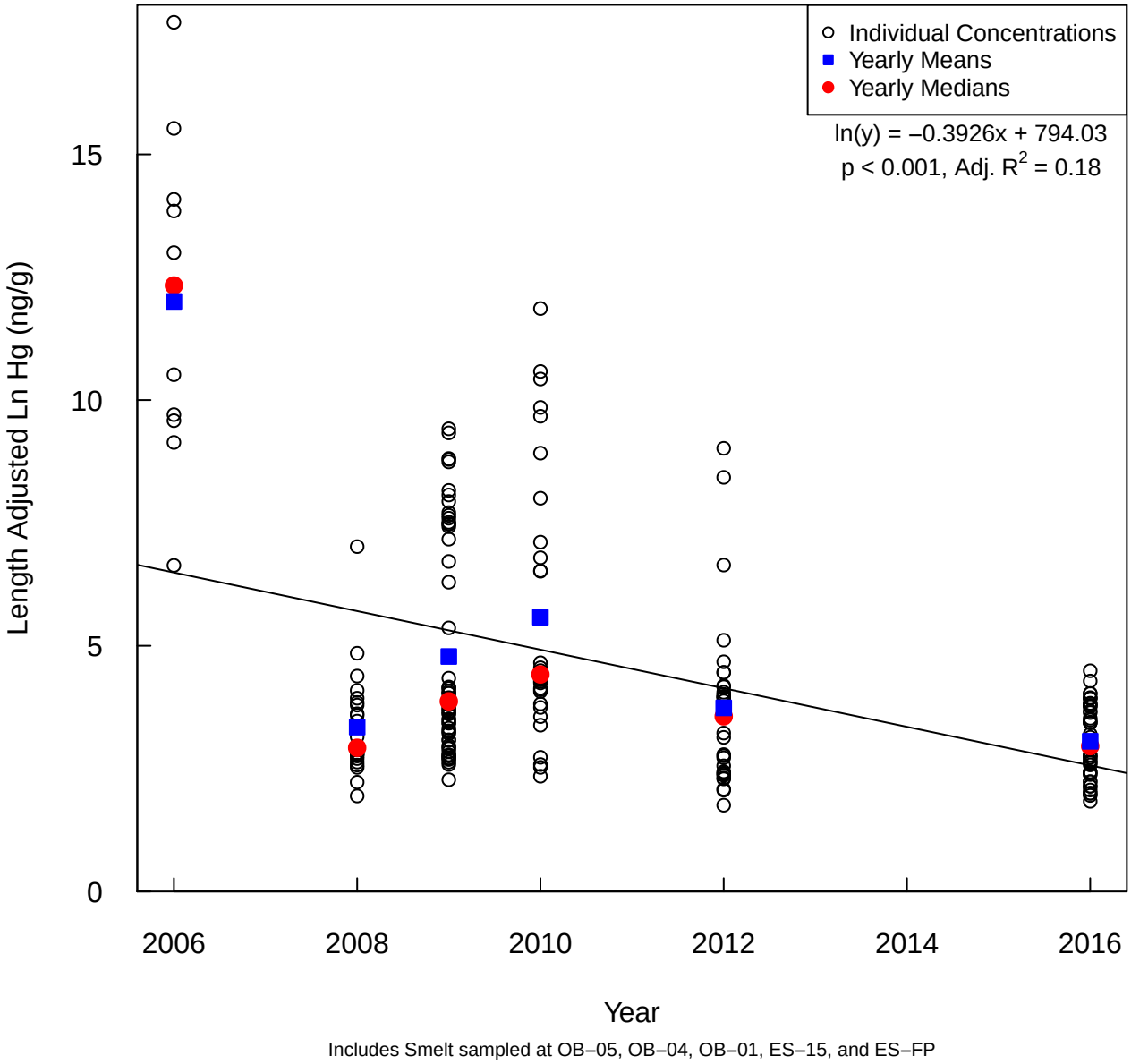


Figure 4–70
Rainbow Smelt – Whole River
Length Adjusted Loglinear Regression



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

Figure 4–71
Rainbow Smelt – OB–05
Length Adjusted Loglinear Regression

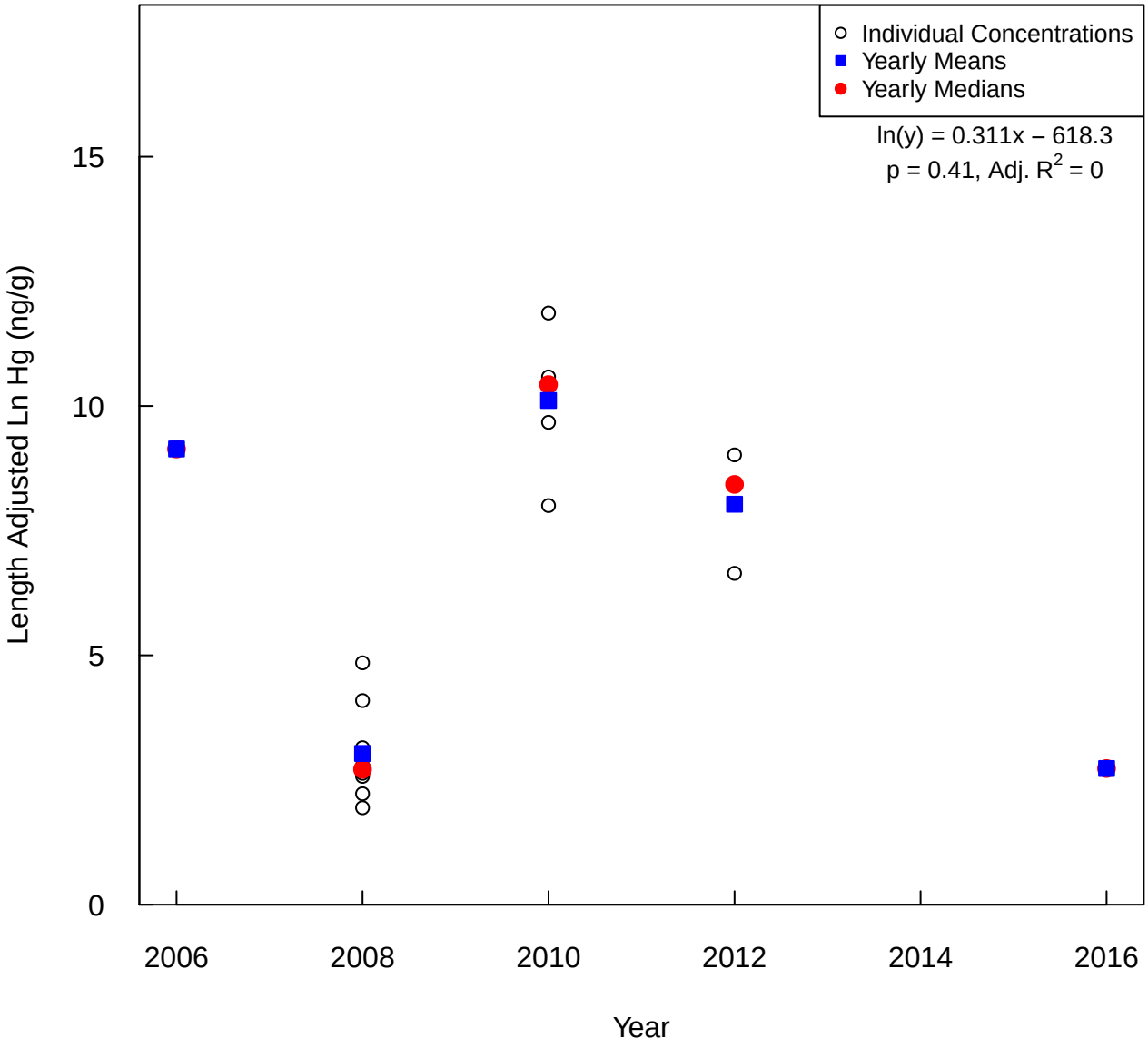


Figure 4–72
Rainbow Smelt – OB–04
Length Adjusted Loglinear Regression

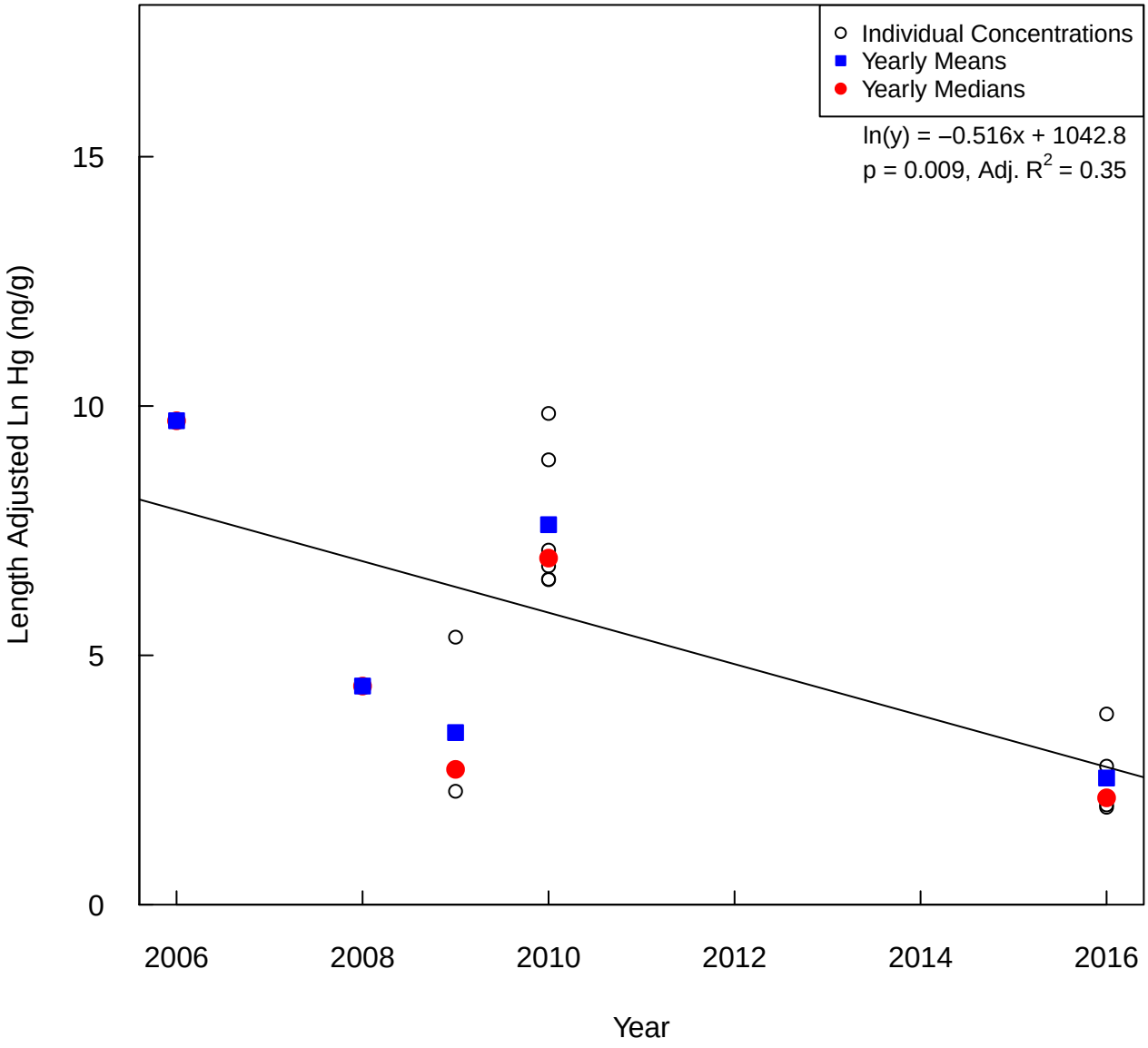


Figure 4–73
Rainbow Smelt – OB–01
Length Adjusted Loglinear Regression

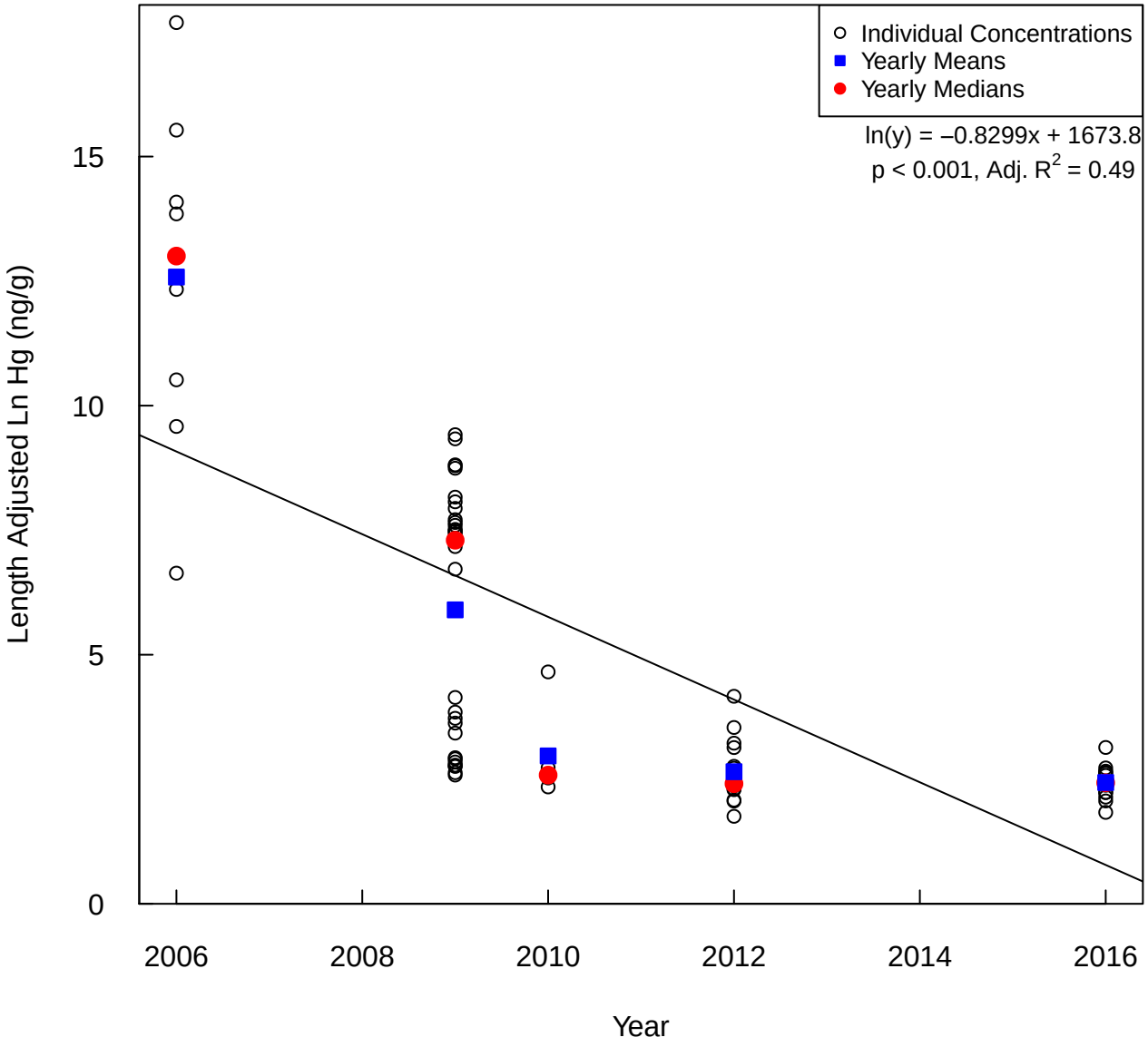


Figure 4–74
Rainbow Smelt – ES–15
Length Adjusted Loglinear Regression

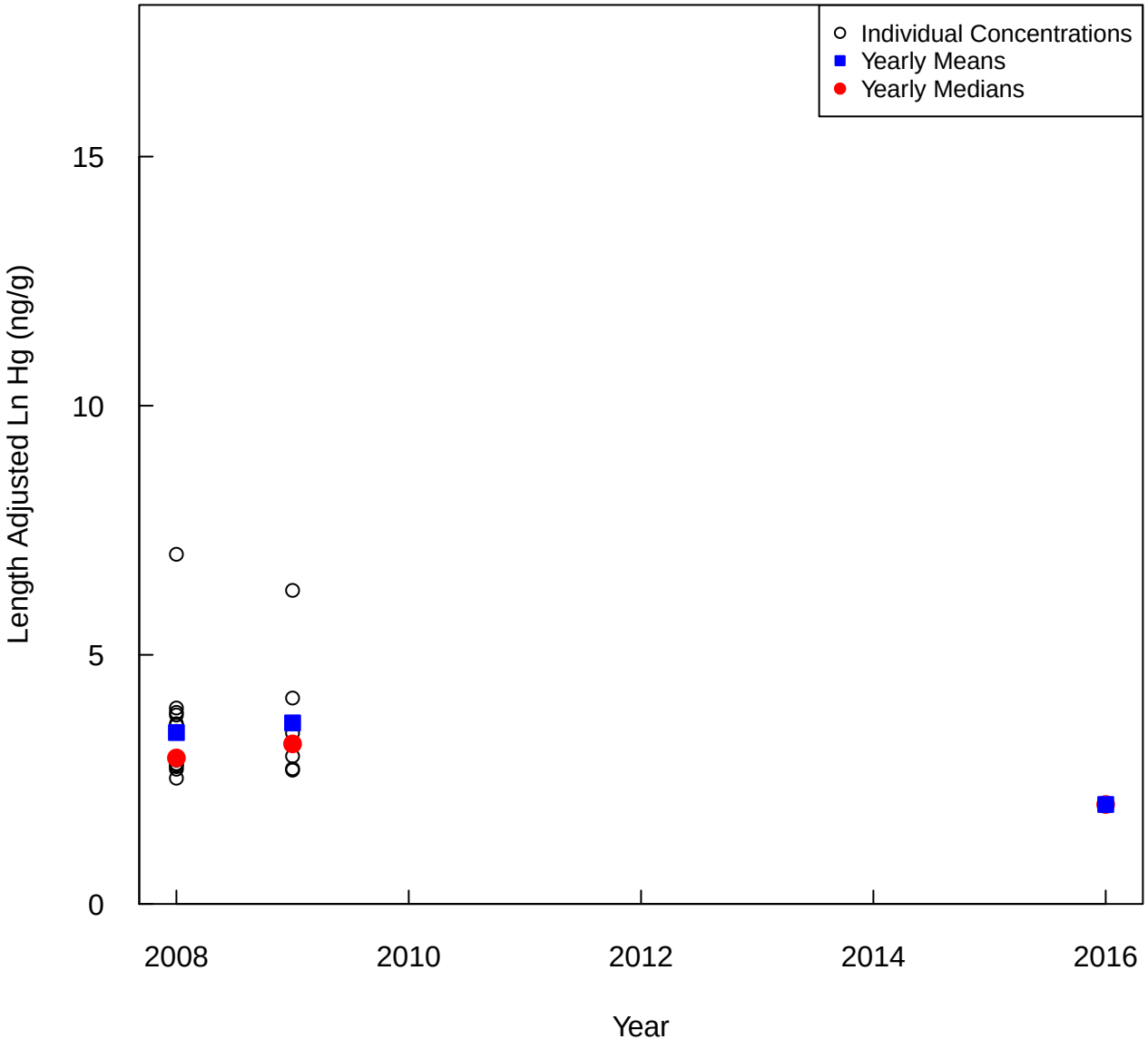


Figure 4–75
Rainbow Smelt – ES–FP
Length Adjusted Loglinear Regression

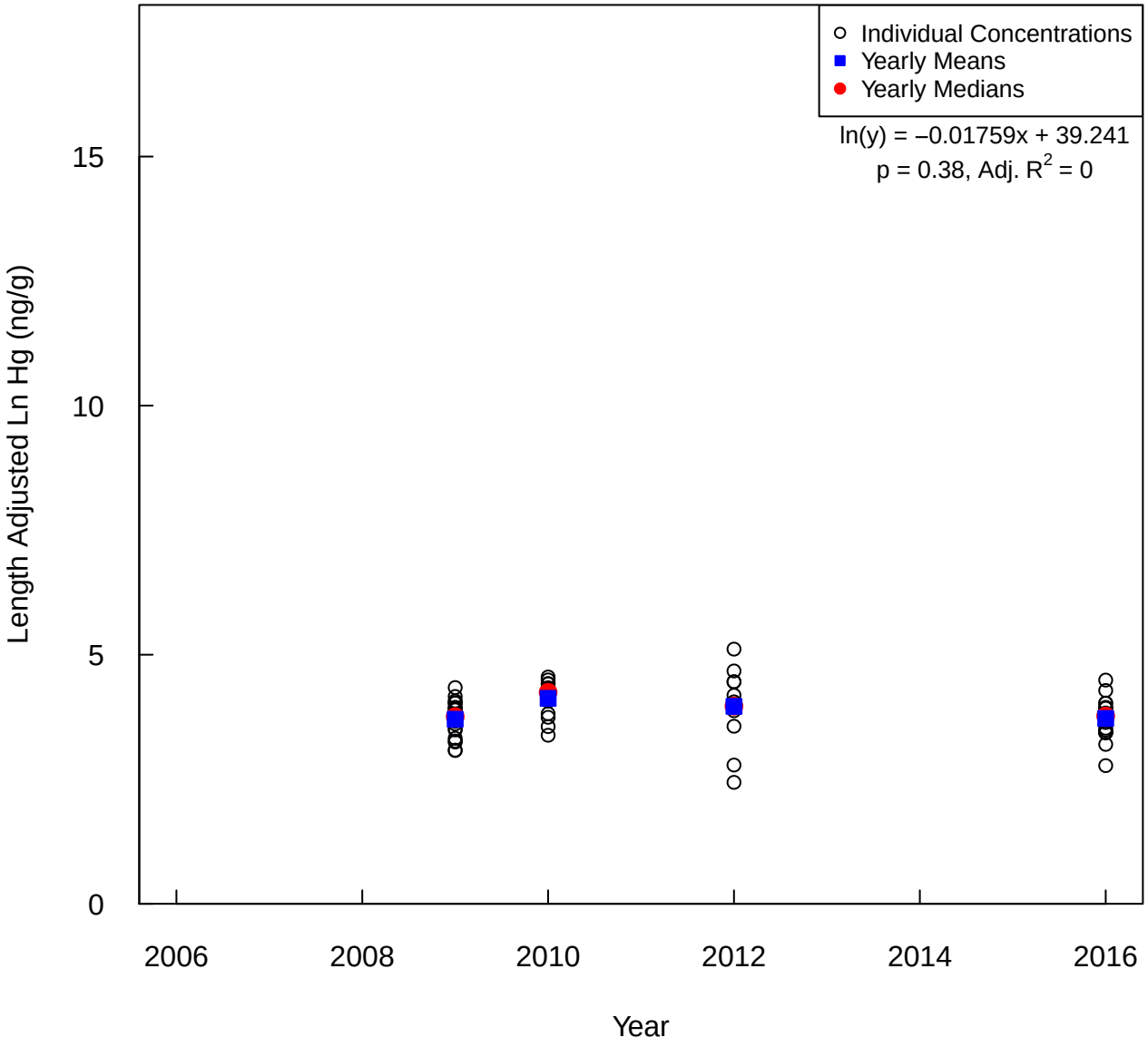


Figure 4–76
American Eel – OV–04 (Reference)
Length Adjusted Loglinear Regression

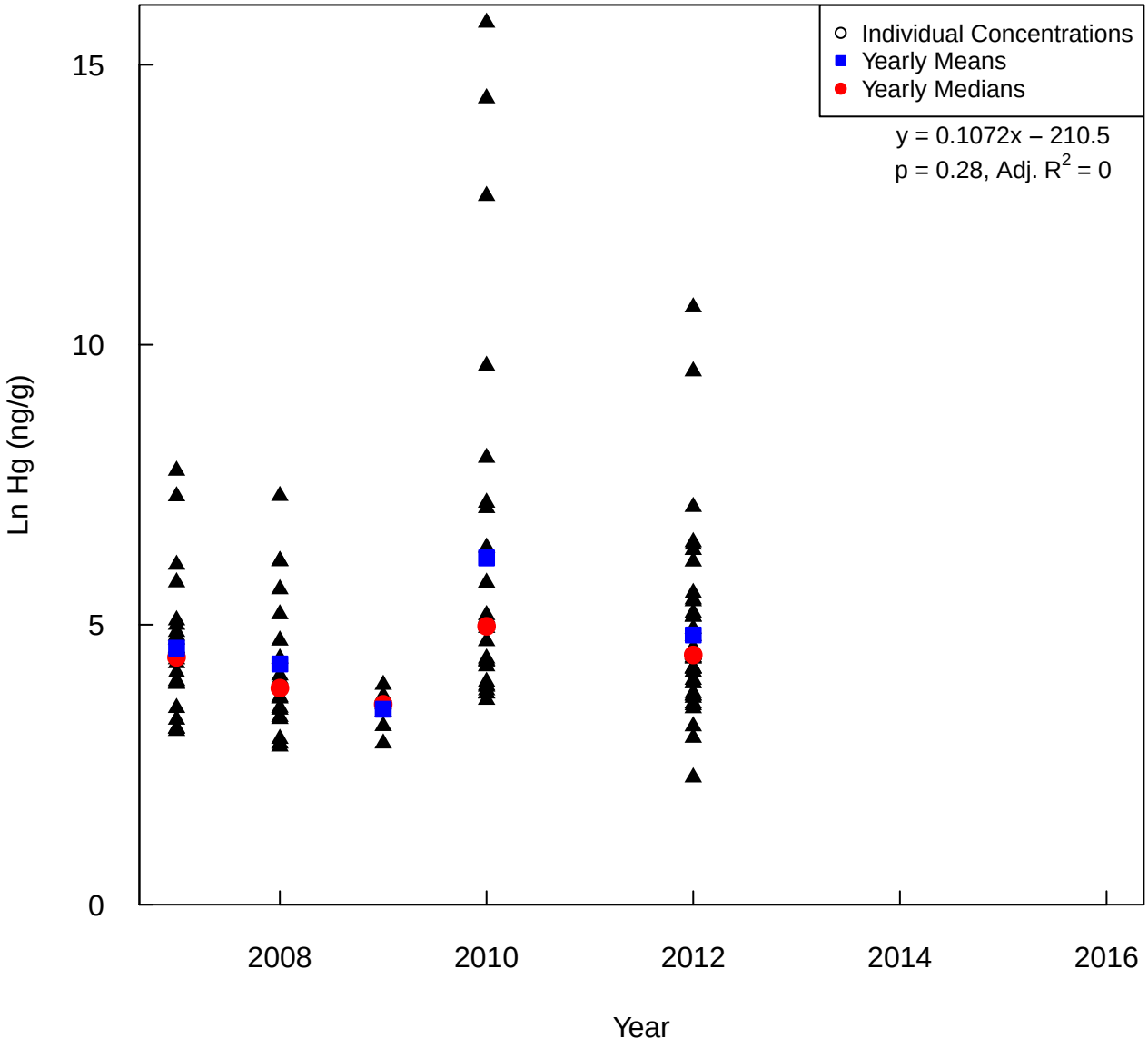
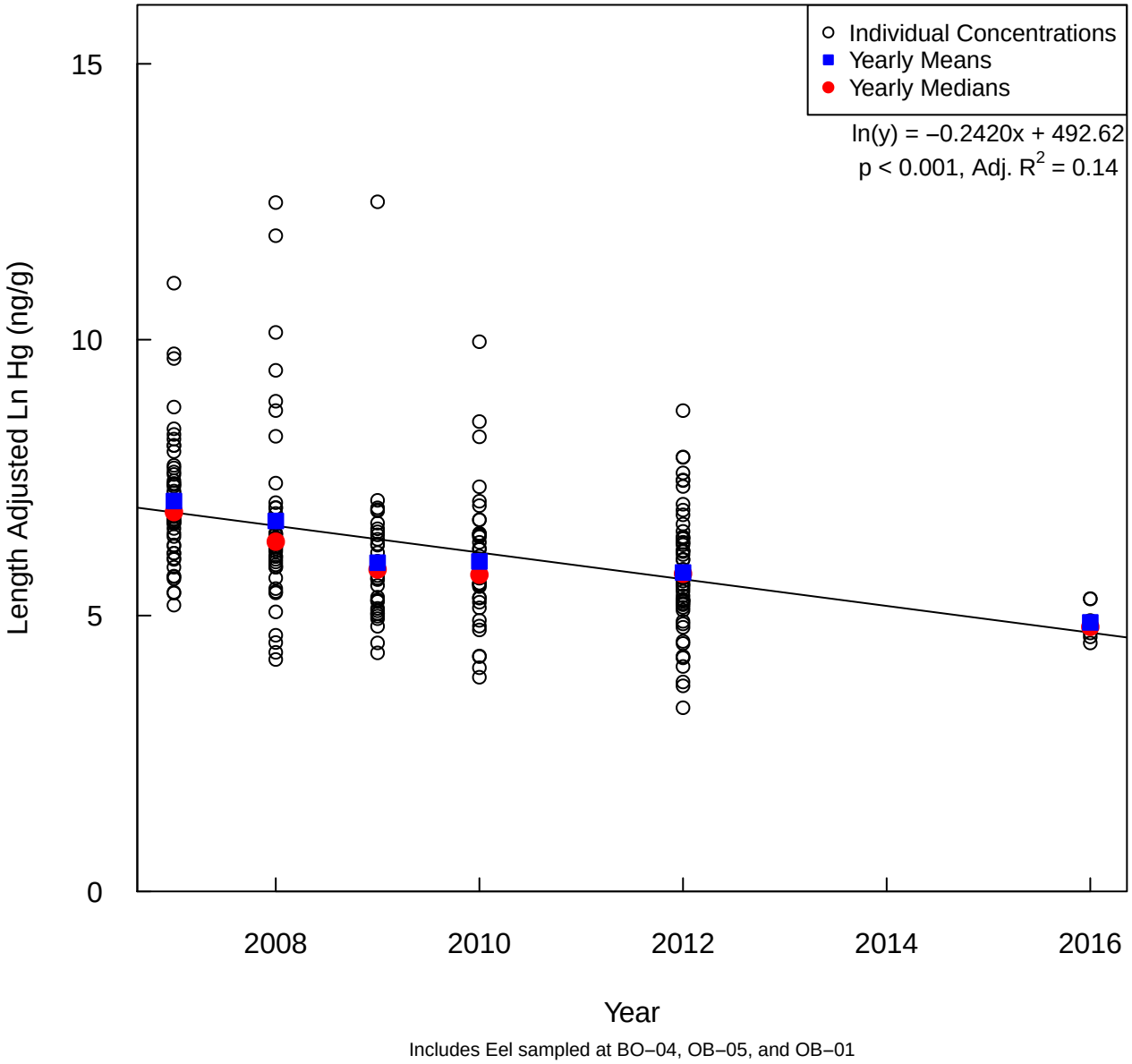


Figure 4–77
American Eel – Whole River
Length Adjusted Loglinear Regression



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

Figure 4–78
American Eel – BO–04
Length Adjusted Loglinear Regression

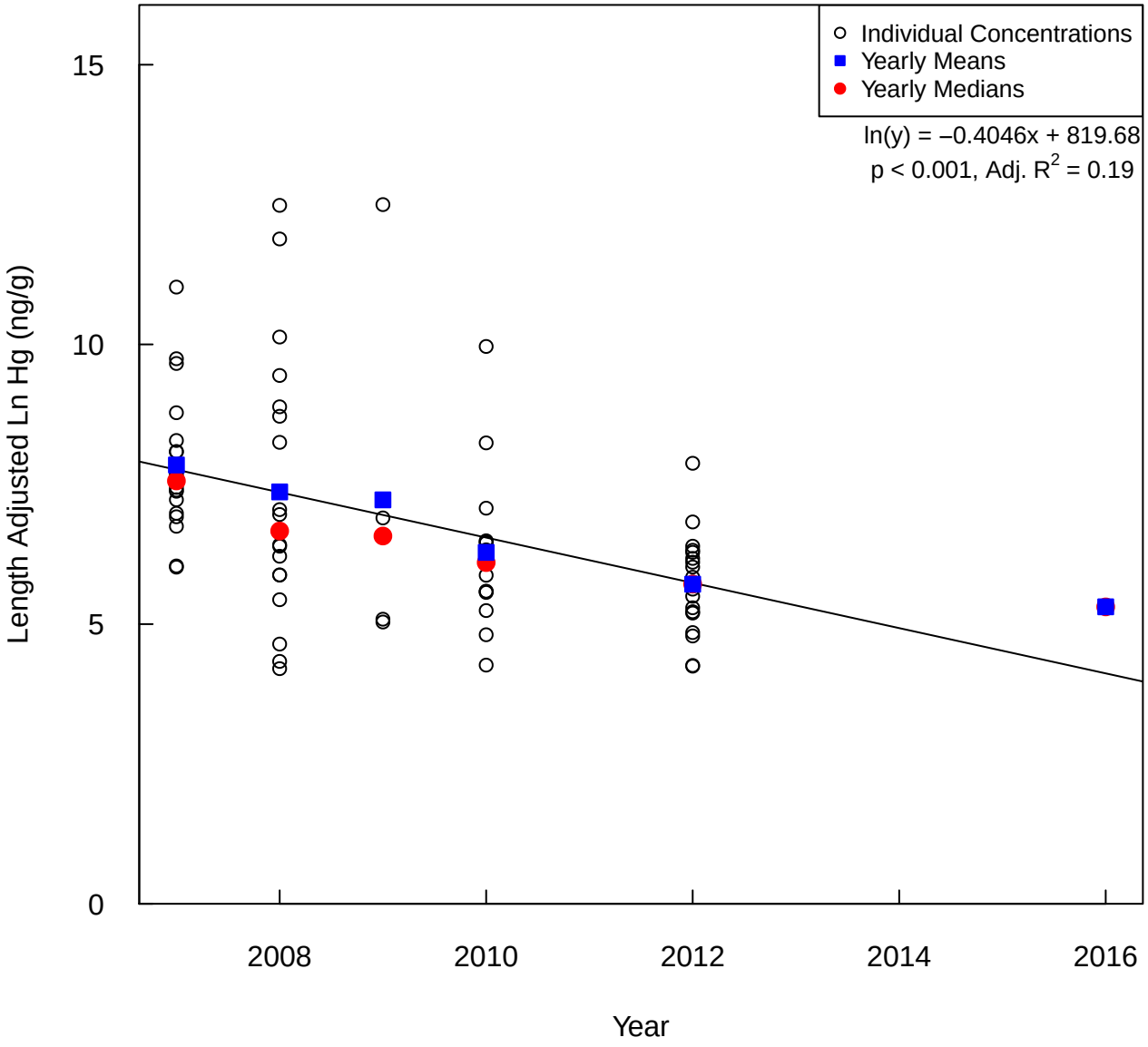


Figure 4–79
American Eel – OB–05
Length Adjusted Loglinear Regression

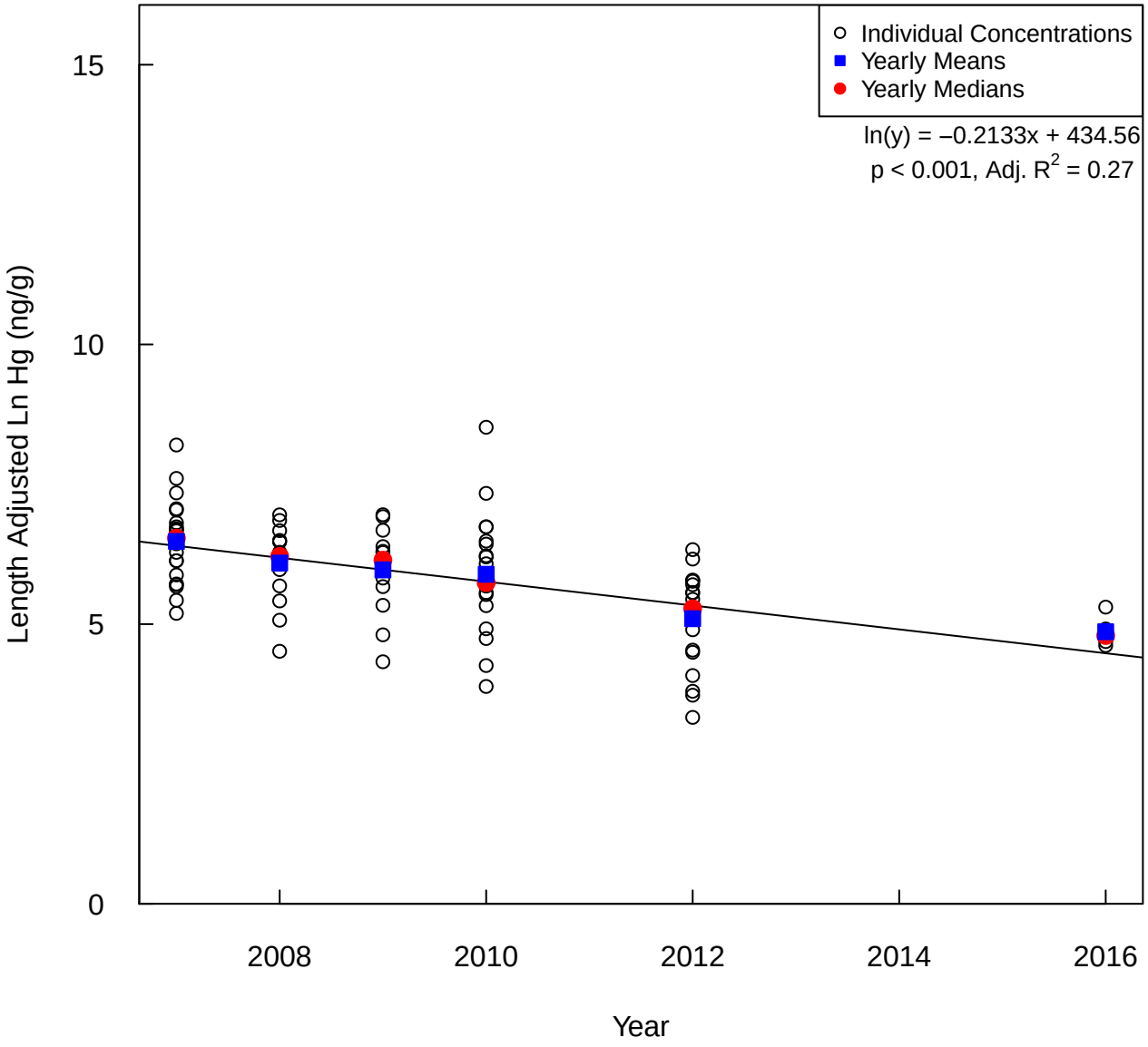


Figure 4–80
American Eel – OB–01
Length Adjusted Loglinear Regression

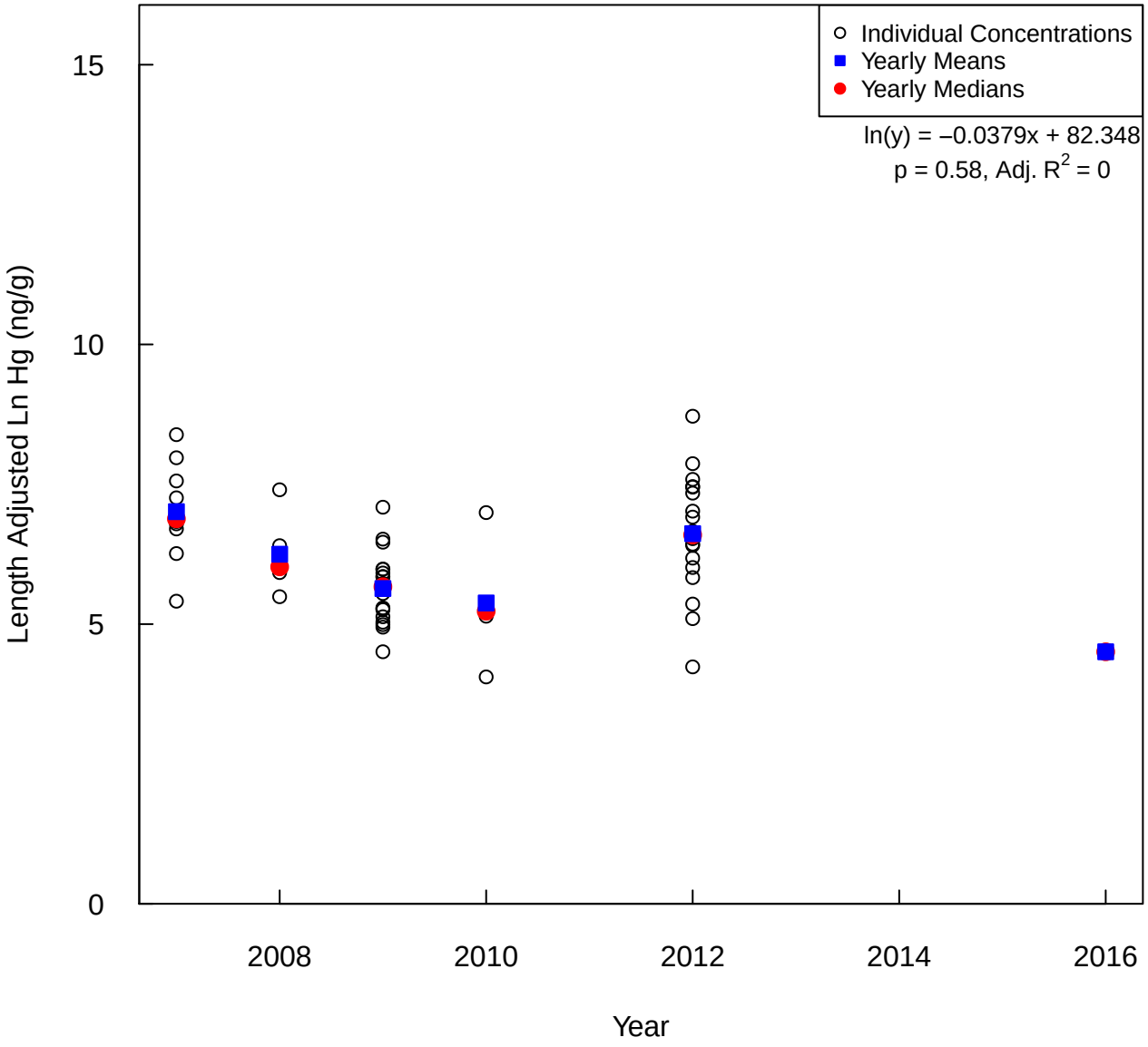
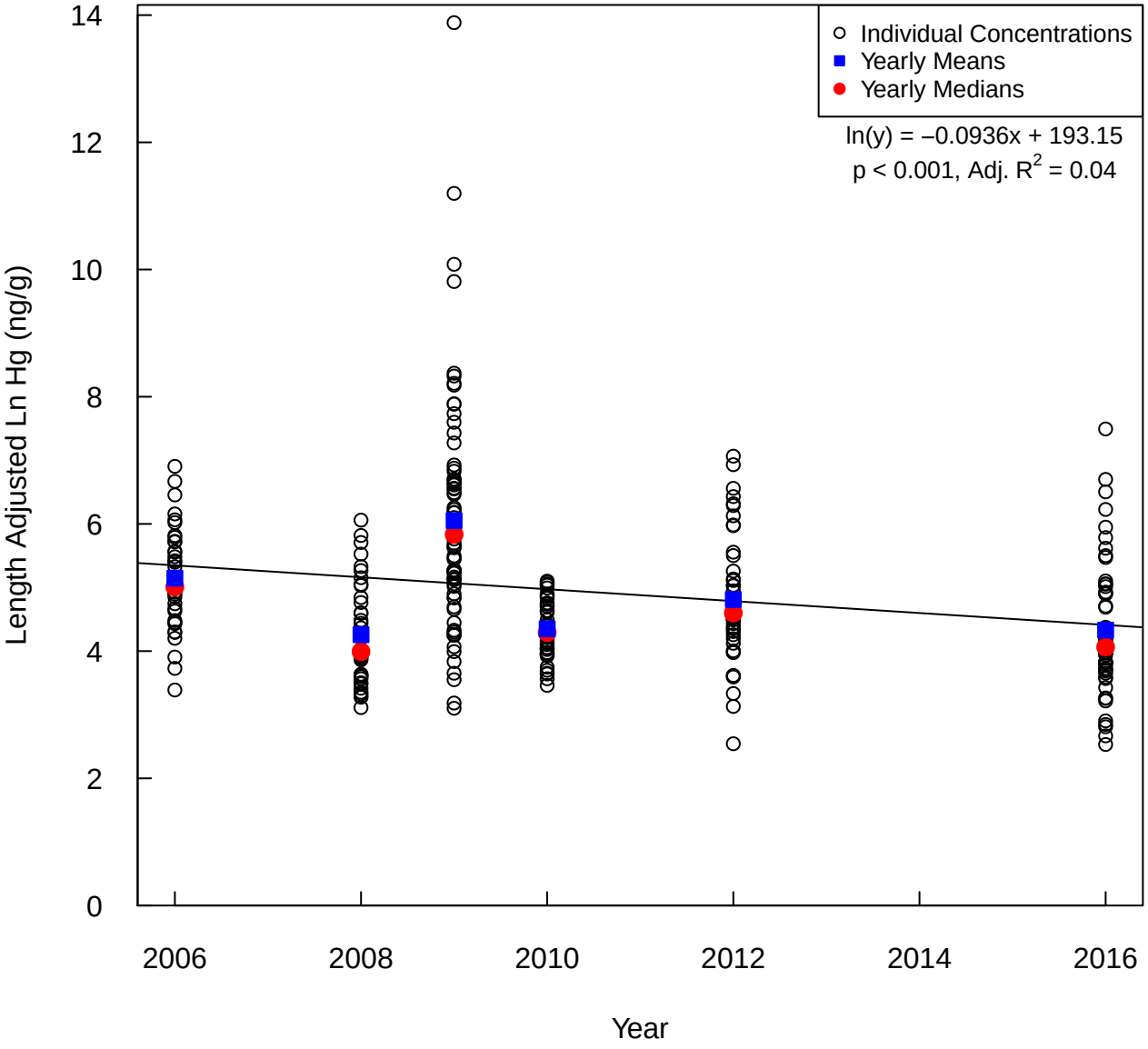


Figure 4–81
Atlantic Tomcod – Whole River
Length Adjusted Loglinear Regression



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

Figure 4–82
Atlantic Tomcod – BO–04
Length Adjusted Loglinear Regression

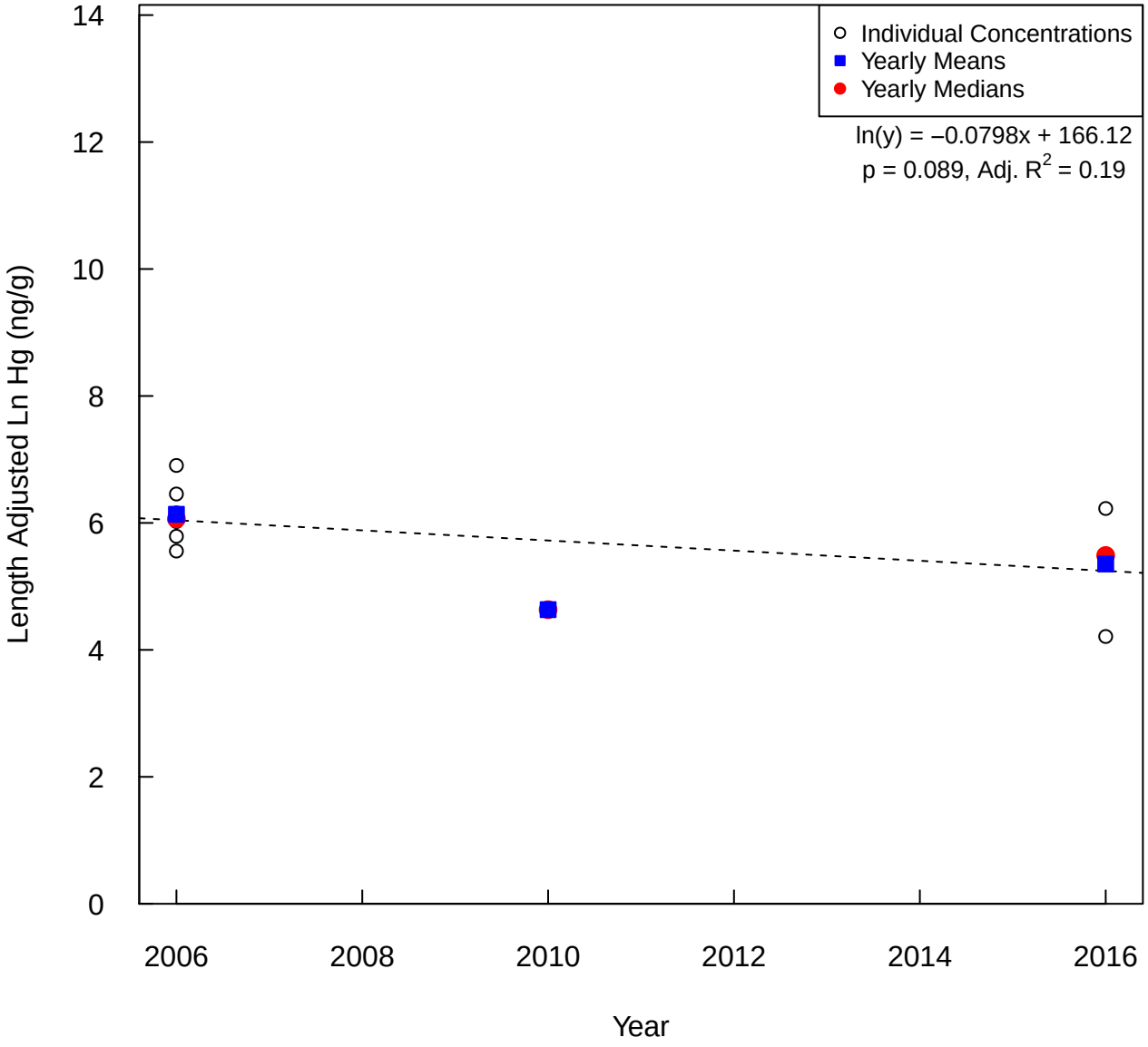


Figure 4–83
Atlantic Tomcod – OB–05
Length Adjusted Loglinear Regression

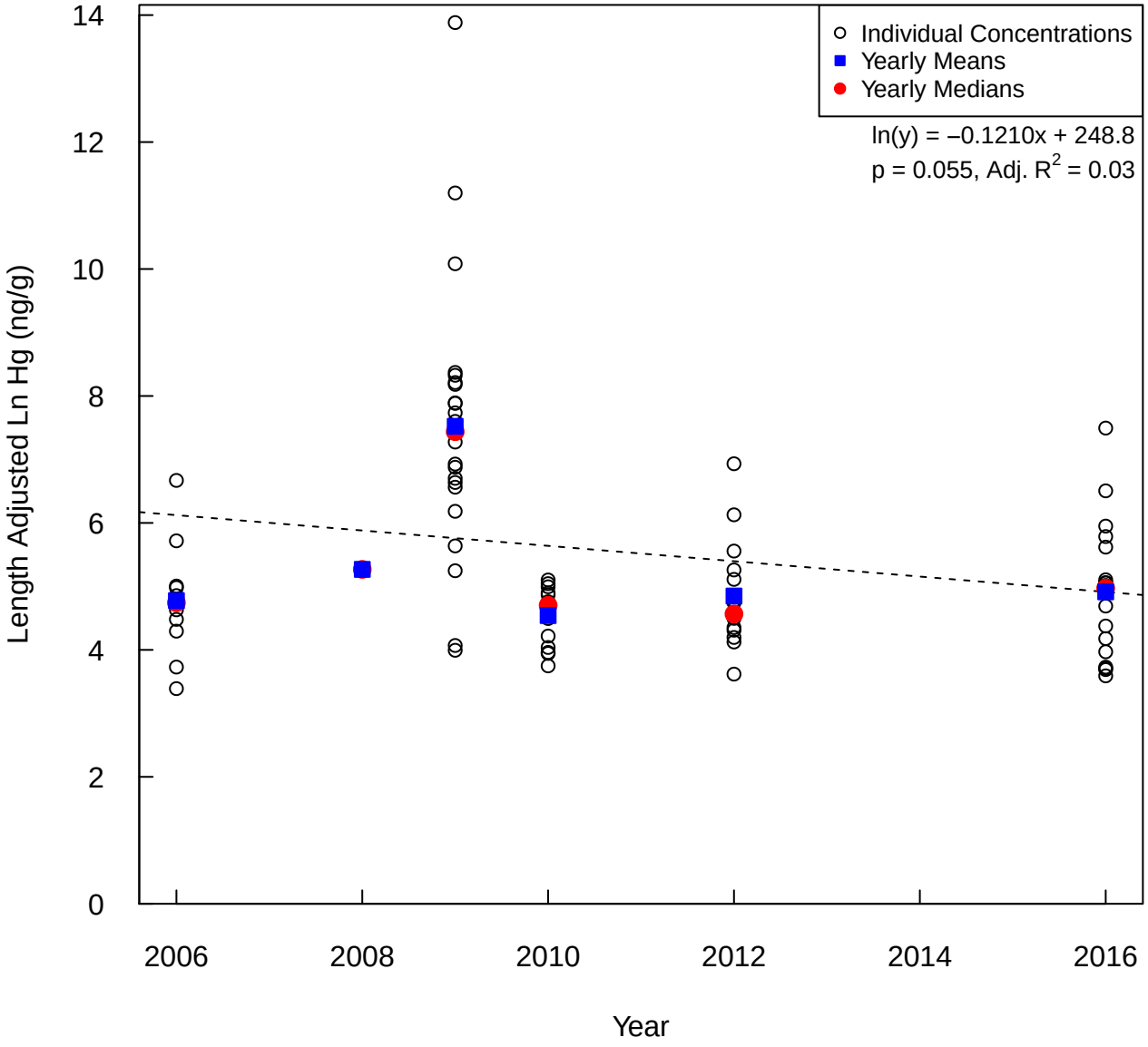


Figure 4–84
Atlantic Tomcod – OB–01
Length Adjusted Loglinear Regression

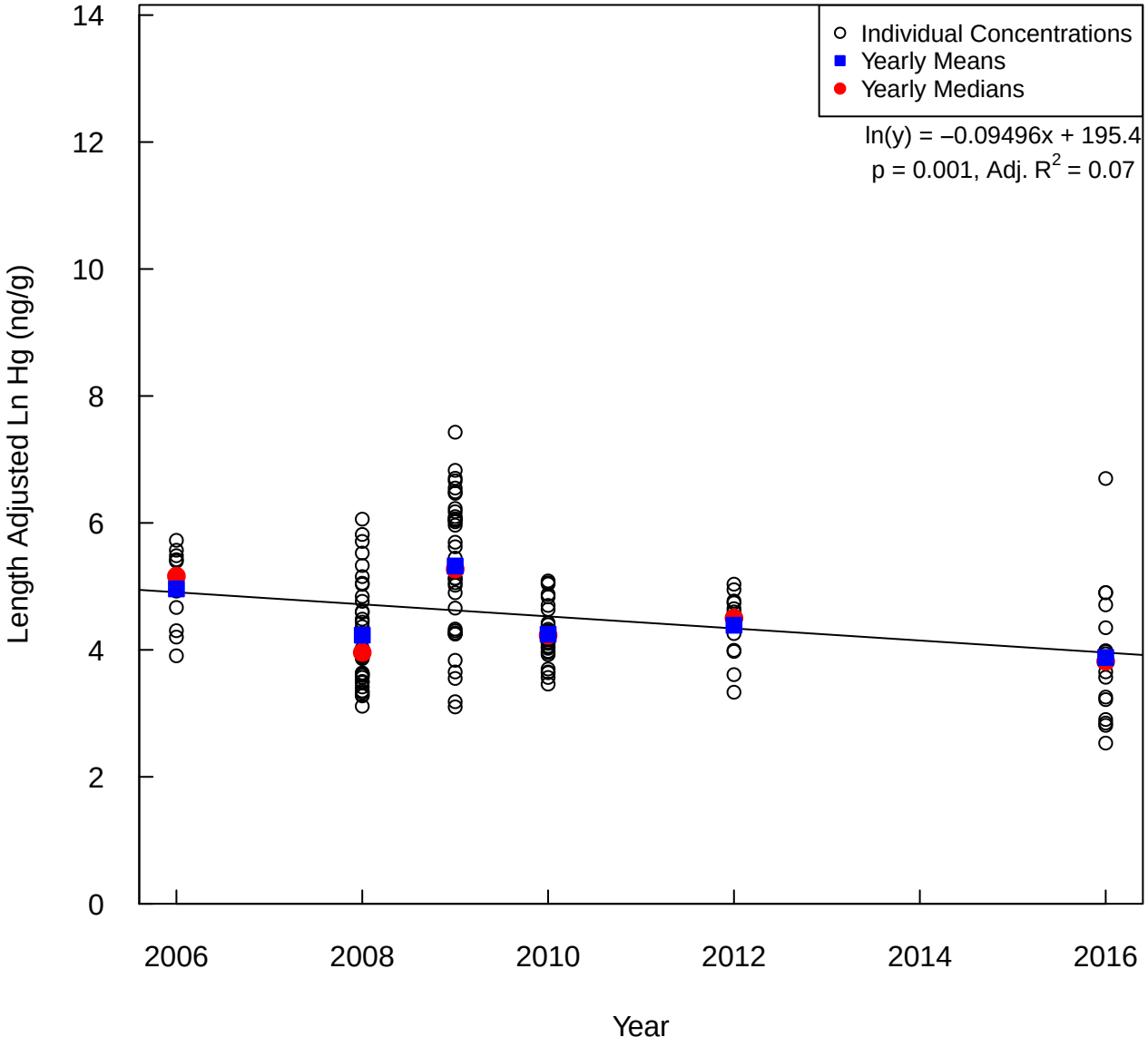


Figure 4–85
Atlantic Tomcod – ES–13
Length Adjusted Loglinear Regression

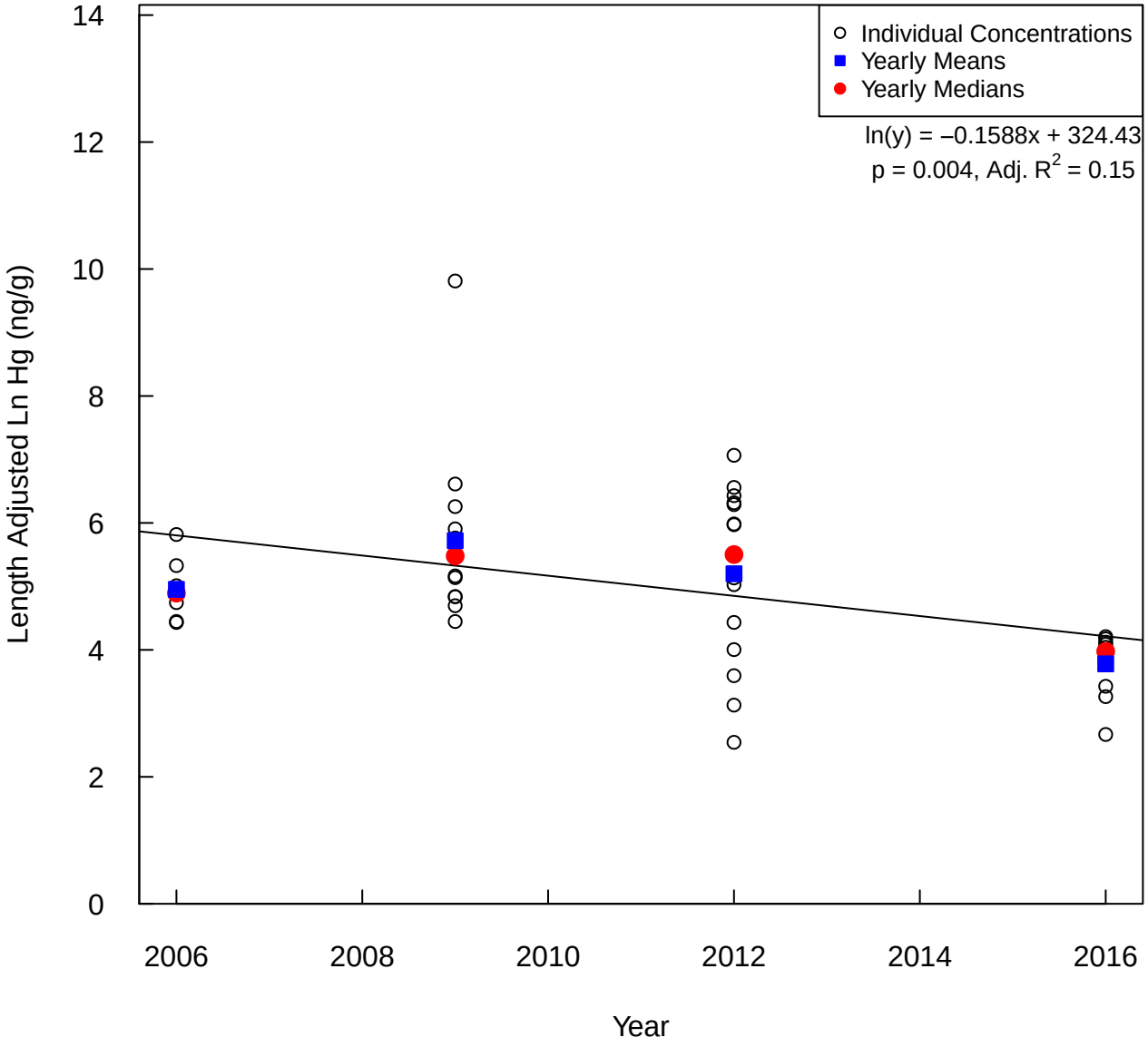


Figure 4–86
Atlantic Tomcod – ES–FP
Length Adjusted Kruskal Wallis Test