2009-2010

Assessing Mercury Accumulation in Wintering Sea Ducks At Parker River National Wildlife Refuge

BioDiversity Research Institute

ASSESSING MERCURY ACCUMULATION IN WINTERING SEA DUCKS AT THE PARKER RIVER NATIONAL WILDLIFE REFUGE
2009-2010

SUBMITTED TO:

Nancy Pau
Parker River National Wildlife Refuge
6 Plum Island Turnpike
Newburyport, MA 01950

SUBMITTED BY:

Dustin Meattey and Lucas Savoy
BioDiversity Research Institute
19 Flaggy Meadow Rd.
Gorham, Maine 04038

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To obtain copies of this report contact:
BioDiversity Research Institute
19 Flaggy Meadow Rd.
Gorham, ME 04038
USA
(207) 839-7600

dustin.meattey@briloon.org
www.briloon.org

FRONT PHOTO CAPTION: Common Eider (*Somateria mollissima*). Photo provided by Lucas Savoy.

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EXECUTIVE SUMMARY

This report summarizes efforts to determine mercury (Hg) exposure levels in sea duck species wintering at Parker River National Wildlife Refuge. Parker River National Wildlife Refuge is comprised of 4,662 acres of quality coastal salt marsh, tidal flat, and beach habitat located in northeastern Massachusetts. Numerous species and large numbers of migratory shorebirds and wintering waterfowl species utilize the diverse habitat of Parker River NWR during the fall and winter months. Previous studies have shown elevated levels of Hg in whole blood samples collected from saltmarsh sharp-tailed sparrows (*Ammodramus caudacutus*) at Parker River NWR (Lane et al. 2008). This study aims to provide an aquatic, marine ecosystem comparison. Common eider (*Somateria mollissima*), white-winged scoter (*Melanitta fusca deglandi*), and American scoter (*Melanitta americana)* (formerly known as black scoter) were captured between the months of December and March. Common eider and scoter species were captured using floating mist-nets. All birds captured were banded and standard morphometric measurements were collected. Capture efforts were conducted during the winters of 2009 and 2010.

A total of 29 birds (26 common eider, 3 white-winged scoter) were captured during the winter of 2009 and early spring of 2010 as part of an HPAI (Highly Pathenogenic Avian Influenza) surveillance effort targeting waterfowl species determined by the Atlantic Flyway Council to be of primary and secondary concern. An additional 19 birds (1 common eider, 5 white-winged scoter, 13 American scoter) were captured in the winter of 2010 as part of The Atlantic and Great Lakes Sea Duck Migration Study through the Sea Duck Joint Venture (SDJV). Blood and feather samples were subsequently taken from each individual for total mercury analysis. Blood mercury concentrations were recorded as micrograms per gram (µg/g) wet weight (ww). Feather mercury concentrations were recorded as micrograms per gram (µg/g) fresh weight (fw).

Also included in this report for comparison purposes are mean blood Hg concentrations (µg/g, ww) for similar waterfowl species live-captured and sampled in various other geographic regions. Very few studies exist that explore mercury residue in whole blood of wintering sea ducks. In addition, various sea duck prey items were collected for Hg analysis.

INTRODUCTION

Atmospheric mercury (Hg) deposition has emerged as an important environmental issue across the globe. Pollutant levels tend to be higher in marine environments due to run-off, point-source pollution, and rivers, along with atmospheric deposition. Similarly, species that forage in aquatic environments are at higher risk of increased levels of contamination because of the potential of rapid movement of contaminants in aquatic food chains and the ability of pollutants in intertidal and shallow marine environments to be stored in bottom sediments (Burger and Gochfeld 2008). Following deposition, inorganic Hg may be converted to its more bioavailable form, methylmercury (MeHg). Towards the top of aquatic food chains, MeHg accumulates to toxic levels through a bioaccumulation factor of about 10 million (Driscoll C.T. et al. 2007). Mercury exposure in waterfowl species is a multi-step process that involves uptake into the intestines through diet, transport in blood and subsequent accumulation in internal tissues such as liver, kidneys, and muscle followed by redistribution to plumage during feather growth and elimination through eggs and excreta (Monteiro and Furness 1995).

Particularly for long-lived bird species feeding at higher trophic levels, biomagnification of Hg presents a greater risk of neurological, behavioral, and reproductive impacts (Burgess and Meyer 2008; Evers et al. 2005; Evers et al. 2008). In North America and Europe, sea duck species have long served as important indicators of ecological health and inshore marine pollution. Serious declines in several of these species have led to increased investigations into the effects of environmental contaminants on their populations and physiology. Trace elements in sea ducks have typically been determined in liver or kidney samples, while non-lethal sampling using feather and blood samples has recently been used with increased frequency (Wayland et al. 2000). With increased sampling efforts and a better understanding of the dynamics of mercury contamination in the aquatic environments, waterfowl species have become increasingly important bioindicators of both freshwater and marine ecosystem health.

Based on Evers et al. (2005), species of waterfowl in the Northeast at highest risk to methylmercury availability include piscivores and molluscivores . Many sea duck species, especially eiders and scoters feed heavily on mollusks. When available, blue mussels represent a large percentage of a common eider's diet (Goudie et al. 2000). For this reason, it is also

important to take into consideration contaminant and heavy metal concentrations in the prey base of these species.

A total of 48 birds, representing three species, were captured and sampled during the winters of 2009 and 2010. Tissues (i.e. blood and/or feathers) were collected from each individual for Hg analysis. Statistical comparisons were made between species, capture periods, and capture locations. Prey items including blue mussels and periwinkles (*Littorina littorea*) were also collected to determine prey base Hg concentrations for the area.

Common eider mean blood Hg concentrations in 2009 and 2010 (0.97 and 0.71 µg/g, respectively) continue to exceed any other values yet to be published for that species. White-winged and American scoter mean blood Hg concentrations (0.28 and 0.22 µg/g, respectively) are within the averages reported in other similar studies. Blue mussels and periwinkles sampled at Parker River NWR contain significantly higher Hg concentrations than those collected at a comparison site in Maine. These findings outline the need for more extensive sampling of wintering sea duck species and their prey base in the Parker River NWR area.

STUDY AREA

Parker River National Wildlife Refuge is comprised of 4,662 acres of quality coastal salt marsh, tidal flat, and beach habitat located in northeastern Massachusetts (Figure 1). Numerous species and large numbers of migratory shorebirds and wintering waterfowl species utilize the diverse habitat of Parker River NWR during the fall and winter months.

Sampling sites were generally located within Plum Island Sound and the Merrimack River outlet (Figure 1). Actual capture sites were chosen based on availability of target species and marine conditions (i.e. tide, wind, etc.).

Figure 1. Map of bird sampling locations within Plum Island Sound and Merrimack River outlet.

METHODS

Bird sampling efforts occurred during the winter and early spring months of 2009 and 2010.

Sample Collection and Handling

Non-lethal capture methods were used for the sampling of all birds. Blood and feather samples were collected using published BRI protocols (Evers 2008). Blood was drawn using a small gauge needle to puncture either the cutaneous ulner vein in the wing or the tarsal vein on the leg. Heparinized capillary tubes collected blood, and no more than 1% of the bird's body weight in blood was collected. The tubes were sealed on both ends with Critocaps® and placed in a labeled 10 cc plastic vacutainer. Additional blood samples were stored in heparinized and/or no-additive microtainers and placed on ice in a cooler and frozen within six hours of collection. The second secondary flight feather from each wing and two tail feathers were

clipped from each bird. Collected feathers were then placed in a clean, labeled, envelope and stored in a refrigerator. All samples were labeled with the date of collection, age and sex of the bird, USFWS band number, and capture location. Blue mussels and periwinkles were collected from rocks in shallow areas and near feeding areas and the capture locations. A subset of similarly sized samples were collected and analyzed for comparison.

Sample Analysis

Samples collected in 2009 were shipped to the Utah Veterinary Diagnostic Laboratory, Logan, Utah for analysis. All subsequent samples from this and other cited BRI studies were analyzed at the Wildlife Research Mercury Lab at BRI Headquarters in Gorham, ME. All tissue samples were analyzed for total mercury using thermal decomposition technique with a direct Hg analyzer (DMA 80, Milestone Incorporated) using the US EPA Method 7473 (US EPA 2007). Blood and feather samples were analyzed for total mercury. Blood results are reported in micrograms per gram (µg/g) and on a wet weight (ww) basis. Feather results are reported in micrograms per gram on a fresh weight (fw) basis.

Capture Techniques

Bird sampling efforts occurred opportunistically between the months of December and April during both sampling years. Common eiders and scoter species were captured using a floating mist net apparatus (Figure 2). This set-up consists of 3-5 floating metal platforms anchored to shore and extending perpendicular to the shoreline. Between these platforms, appropriately sized mist nets are strung. Depending on target species, appropriate decoys are laid out in a formation surrounding the mist nets to attract birds in flight (Brodeur et al. 2008).

Figure 2. Floating mist nets set up amidst common eider decoys in Plum Island Sound, 2009.

RESULTS and DISCUSSION

A total of 48 birds, representing three species, were captured and sampled during the winters of 2009 and 2010. Tissues (i.e. blood and/or feathers) were collected from each individual for Hg analysis. Statistical comparisons were made between species, capture periods, and capture locations.

Blood Hg by Year

Common eiders were the only species to be captured in the same location for two consecutive years. These individuals were captured in the vicinity of Ipswich Bluffs in Plum Island Sound. In 2009, common eider blood Hg ranged from 0.14 to 1.76 µg/g, ww and contained a mean value of 0.97 µg/g, ww. In 2010, values ranged from 0.22 to 1.54 µg/g, ww

and contained a mean value of 0.71 µg/g, ww. While the mean Hg values were slightly higher in 2009 (Figure 3), there was no statistically significant difference between the two capture years (p = 0.1519).

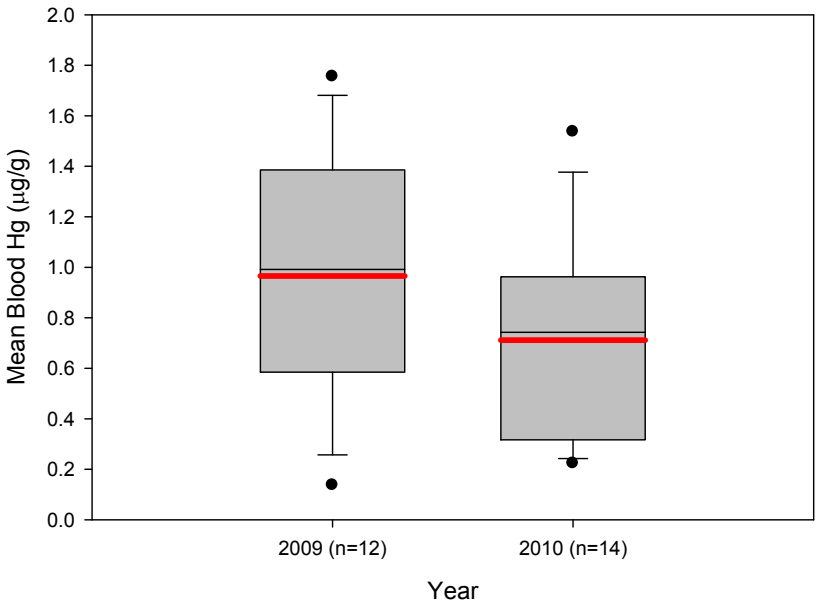

Figure 3. Mean blood Hg concentrations in common eiders captured in 2009 and 2010.

Blood Hg by State

Total blood Hg concentrations in common eiders captured at Parker River NWR in 2010 were compared to Hg concentrations in birds caught in Maine and Rhode Island during the same year. Mean blood concentrations in common eiders from Parker River NWR in 2010 ranged from 0.22 to 1.54 µg/g, ww and contained a mean value of 0.71 µg/g, ww. In comparison, mean blood Hg levels in common eiders sampled in Maine ranged from 0.08 to 0.59 µg/g, ww and contained a mean Hg level of 0.22 µg/g, ww. Common eiders captured and sampled in Rhode Island in 2010 contained total blood Hg concentrations ranging from 0.12 to 0.22 µg/g, ww and contained a mean value of 0.14 µg/g, ww.

The results showed that eiders captured at Parker River had significantly higher levels of blood Hg than those captured in either of the other states (Figure 4) (MA/ME $p < 0.0001$, MA/RI $p = 0.0035$).

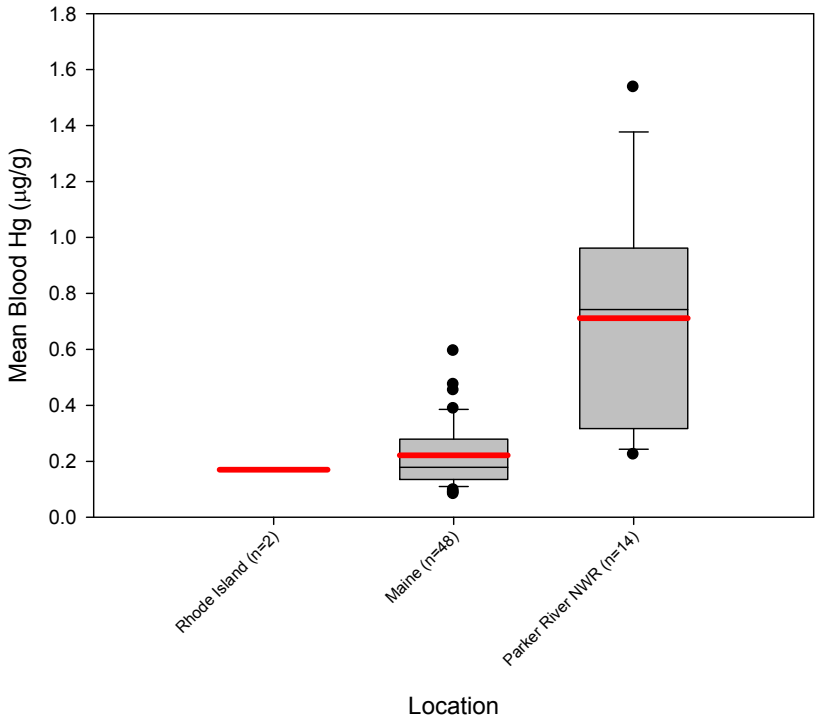

Figure 4. Mean blood Hg concentrations in common eiders captured in three different states in 2010.

White-winged scoters captured at Parker River showed higher average levels of Hg than those captured in other locations, but these differences were not statistically significant (Figure 5) (MA/ME p = 0.7466, MA/RI p = 0.1407).

White-winged scoters captured at Parker River NWR in 2010 contained total blood Hg values ranging from 0.24 to 0.33 µg/g, ww and contained a mean value of 0.28 µg/g, ww. In comparison, white-winged scoters captured in Maine in 2010 ranged from 0.21 to 0.33 µg/g, ww and contained a mean value of 0.26 µg/g, ww. In Rhode Island, birds in 2010 contained blood Hg values ranging from 0.11 to 0.28 µg/g, ww and contained a mean value of 0.22 µg/g, ww.

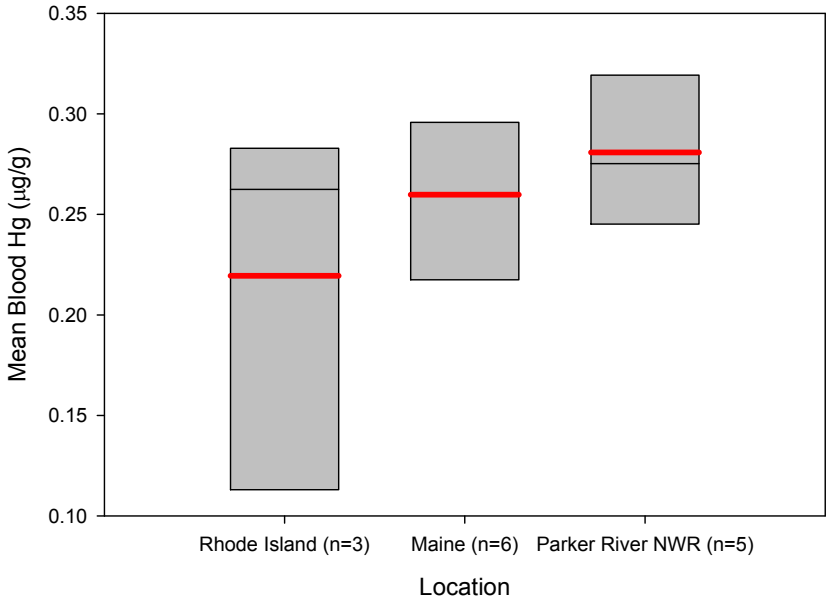

Figure 5. Mean blood Hg concentrations in white-winged scoters captured in three different states in 2010.

Total blood Hg levels in American scoters captured at Parker River fell within a similar range with those captured in other sampling locations (Figure 6).

American scoters captured in the vicinity of Parker River NWR in 2010 contained total blood Hg values ranging from 0.08 to 0.32 µg/g, ww and contained a mean value of 0.22 µg/g, ww. In comparison, American scoters captured in Maine ranged from 0.18 to 0.26 µg/g, ww and contained a mean value of 0.22 µg/g, ww. Birds captured in Rhode Island ranged from 0.10 to 0.40 µg/g, ww and contained a mean value of 0.22 µg/g, ww. Birds captured in New Brunswick ranged from 0.05 to 0.33 µg/g, ww and contained a mean value of 0.18 µg/g, ww.

While Hg concentrations in American scoters at Parker River NWR are slightly elevated, there was no significant difference in Hg levels among any of these locations (MA/ME $p = 1.0$, MA/RI $p = 0.9987$, MA/NB $p = 0.1769$).

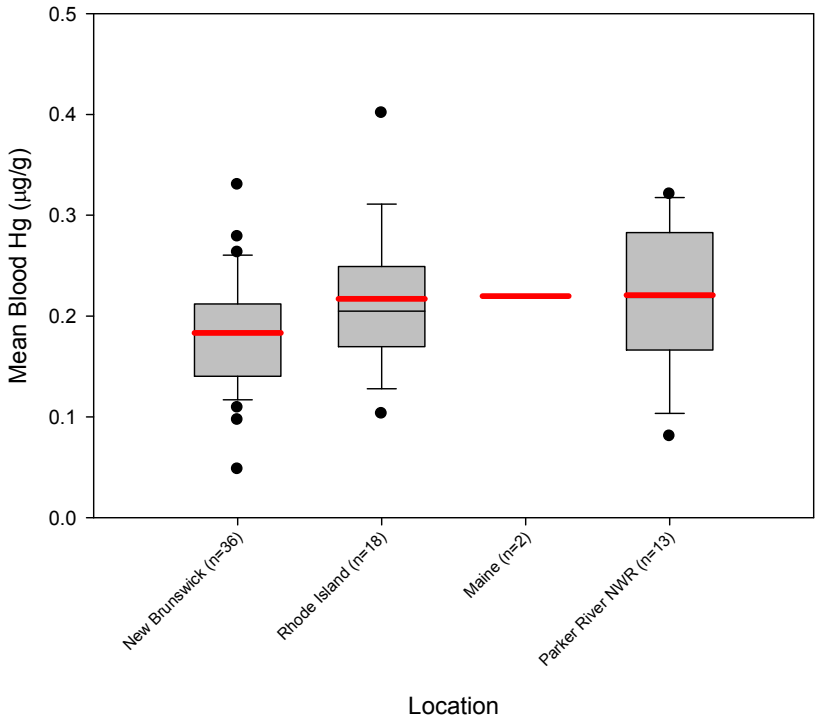

Figure 6. Mean blood Hg concentrations in American scoters captured in four different states/provinces in 2010.

Blood Hg by Location

During the winter of 2010, common eiders were captured in two separate locations around Plum Island. Fourteen individuals were captured at Ipswich Bluffs in Plum Island Sound. One individual was caught at the North end of Plum Island at the mouth of the Merrimack River near Salisbury, NH. While the small sample size at the Salisbury location does not allow for valid statistical analysis, a visual investigation using the Salisbury Hg level coupled with the comparison site in Maine, indicate birds captured at Ipswich Bluffs likely have much higher blood Hg concentrations (Figure 7). The Hg value of the bird captured at the Salisbury location was equal to the minimum Hg value recorded at Ipswich Bluffs. Eiders captured at Ipswich Bluffs contained total blood Hg levels ranging from 0.22 to 1.54 µg/g, ww and contained a mean value of 0.71 µg/g, ww. In comparison, the one individual captured at the outlet of the Merrimack River contained a blood Hg concentration of 0.14 µg/g, ww.

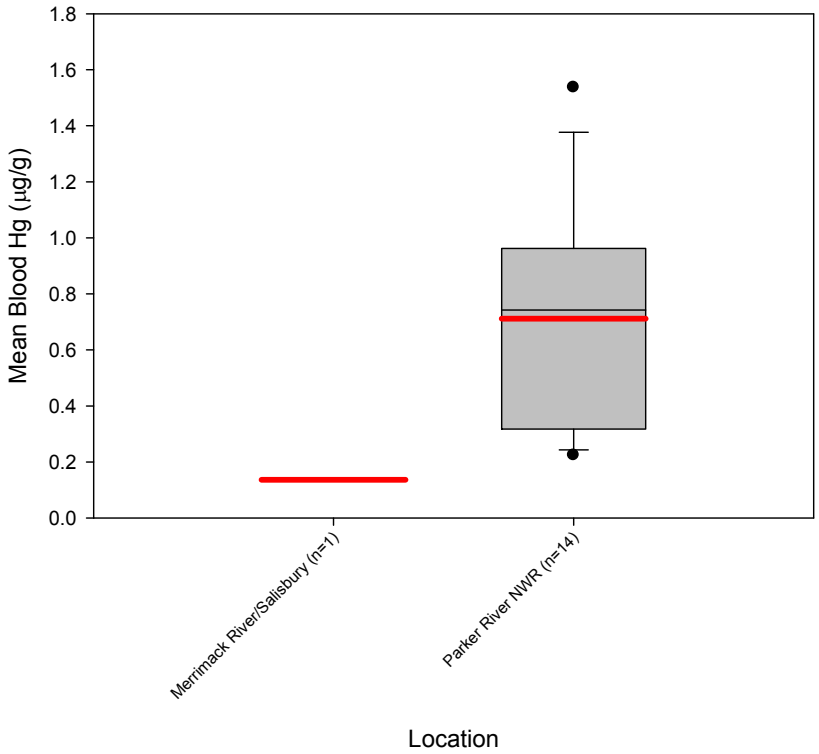

Figure 7. Mean blood Hg concentrations in common eiders captured in two separate locations in 2010.

Mercury in Prey Items

Blue mussels and periwinkles were collected from a location near Ipswich Bluffs in the winter of 2010. These samples were analyzed for total Hg. Common eiders and scoter species are molluscivores, and eiders in particular feed heavily on blue mussels, measuring Hg levels in prey items should correlate with Hg levels found in the blood of species that feed upon them. Blue mussels and periwinkles collected at Parker River NWR both contained significantly greater concentrations of Hg than those same species collected at the comparison location in Maine (Figures 8 & 9) (mussels $p < 0.0001$, periwinkles $p = 0.0007$). Mussels collected at both locations averaged 38.0 mm in length at Parker River and 30.4 mm in Maine.

Gulfwatch, a long-term marine contaminants monitoring program, focused within the Gulf of Maine, uses the blue mussel as its bio-indicator species. Mercury concentrations in blue mussels at various long-term monitoring stations in the Gulf of Maine provides comparison data for mussels collected in this study. When compared to the most recent Gulfwatch data

(LeBlanc et al. 2009), Hg concentrations in blue mussels collected in this study do not appear higher than most of their monitoring sites. Mussels collected in this sea duck study, however, were smaller in size than those collected by Gulfwatch, and therefore may contain lower concentrations of Hg, so direct comparison might not be valid. A simple comparison between Parker River NWR and Maine sights, however, suggests that not only waterfowl species, but their prey items as well, are accumulating elevated levels of Hg from somewhere in the Parker River NWR environment.

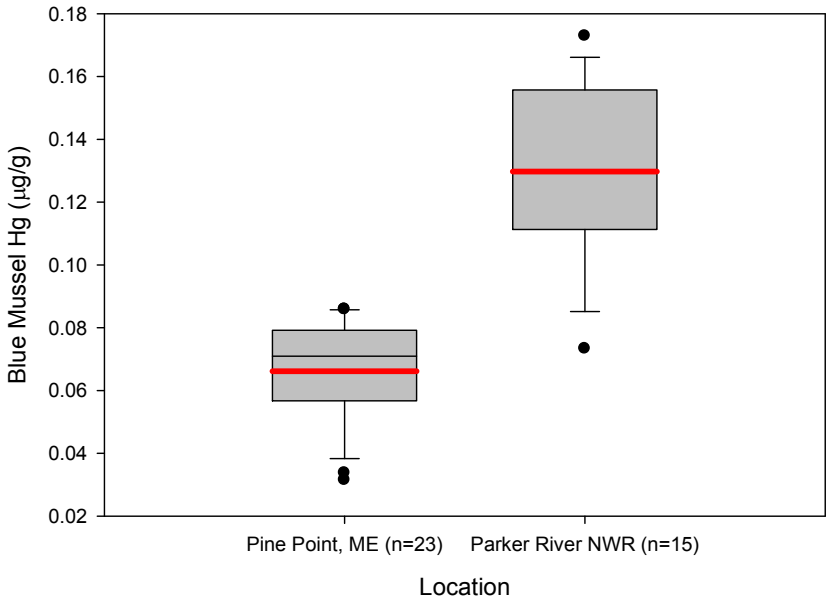

Figure 8. Hg concentrations in blue mussels collected at Parker River NWR and Pine Point, ME

Mean Hg concentrations in blue mussels from Parker River NWR in 2010 ranged from 0.07 to 0.17 µg/g, ww and contained a mean value of 0.13 µg/g, ww. In comparison, mean Hg levels in blue mussels sampled in Maine ranged from 0.03 to 0.09 µg/g, ww and contained a mean Hg level of 0.07 µg/g, ww.

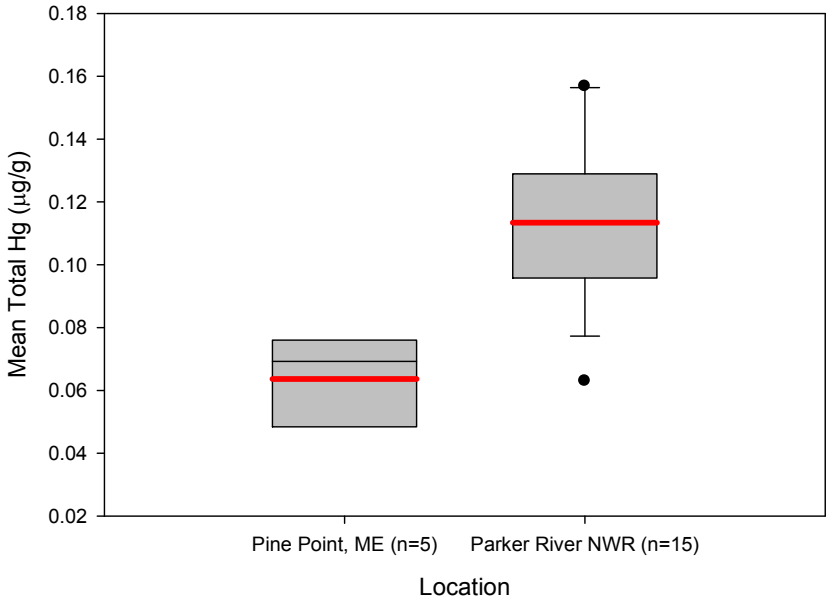

Figure 9. Hg concentrations in periwinkles collected at Parker River NWR and Pine Point, ME

Mean Hg concentrations in periwinkles from Parker River NWR in 2010 ranged from 0.06 to 0.16 µg/g, ww and contained a mean value of 0.11 µg/g, ww. In comparison, mean Hg levels in periwinkles sampled in Maine ranged from 0.05 to 0.08 µg/g, ww and contained a mean Hg level of 0.06 µg/g, ww.

DISCUSSION

Common Eider

Mercury thresholds in eider and other sea duck species' blood and feather tissues, associated with adverse affects, have not been identified. Several field studies across North America have investigated the presence of Hg in blood and feather tissue of multiple species of eiders on their breeding grounds, but much fewer have been conducted on over-wintering birds. Mercury values from common eiders captured and sampled in other areas during similar time periods are used as a means of comparison to those found in this study.

Common eiders captured at Parker River NWR and the surrounding area continue to demonstrate Hg levels much higher than any that have yet been found in published literature (Table 1).

Table 1. Mean blood Hg concentrations in common eiders from this study compared with those found in other studies.

Species	Location	Period	Tissue	n	Hg	SD	Min	Max	Study
COEI	Parker River NWR (2009)	Wintering	Blood	12	0.97	0.47	0.14	1.76	This Study
COEI	Parker River NWR (2010)	Wintering	Blood	14	0.71	0.40	0.22	1.54	This Study
COEI	Salisbury Beach, NH (2010)	Wintering	Blood	1	0.14	-	-	-	This Study
COEI	Pine Point, ME	Wintering	Blood	43	0.22	0.12	0.08	0.59	BRI Unpublished Data
COEI	Casco Bay, ME	Wintering	Blood	5	0.22	0.1	0.12	0.37	BRI Unpublished Data
COEI	Rhode Island	Wintering	Blood	2	0.14	0.07	0.12	0.22	BRI Unpublished Data

White-Winged Scoter

Mercury concentrations identified in white-winged scoters wintering at the vicinity of Parker River National Wildlife Refuge fall within the general range of values reported in other published and unpublished literature (Table 2). Mercury levels reported in this study appear slightly elevated in comparison to those determined in white-winged scoters in some Canadian sites. These birds, however, were sampled during the nesting and molting periods. While temporal variance in Hg concentrations has been explored in other species (mostly dabbling ducks), little is still known about how sea ducks are affected by similar changes in time and behavior. Similar to common eiders, to our knowledge there is no known existing data that explores adverse effect thresholds in scoter species. Without this information, it is difficult to assess potential injury to these species in a particular environment. When compared to data from existing studies, white-winged scoters in our study area do not appear to be accumulating Hg concentrations to levels exceeding those found elsewhere.

Table 2. Mean blood Hg concentrations in white-winged scoters from this study compared with those found in other studies.

Species	Location	Period	Tissue	n	Hg	SD	Min	Max	Study
WWSC	Parker River NWR (2009)	Wintering	Blood	3	0.28	0.12	0.16	0.38	This Study
WWSC	Salisbury Beach, NH (2010)	Wintering	Blood	5	0.28	0.04	0.24	0.33	This Study
WWSC	Redberry Lake, SK	Nesting	Blood	141	0.19	0.06	-	-	Wayland et al. 2007
WWSC	Admiralty Island, AK	Molting	Blood	15	0.12	0.03	0.06	0.21	BRI Unpublished Data
WWSC	Rhode Island	Wintering	Blood	3	0.22	0.09	0.11	0.28	BRI Unpublished Data
WWSC	Pine Point, ME	Wintering	Blood	6	0.26	0.04	0.21	0.33	BRI Unpublished Data
WWSC	Penobscot Bay, ME	Wintering	Blood	1	0.14	-	-	-	BRI Unpublished Data

American Scoter

Mercury concentrations identified in American scoters wintering at the vicinity of Parker River National Wildlife Refuge fall within the general range of values reported in other published and unpublished literature (Table 3). When compared to data from existing studies, American scoters in our study area do not appear to be accumulating Hg concentrations to levels exceeding those found elsewhere.

Table 2. Mean blood Hg concentrations in American scoters from this study compared with those found in other studies.

Species	Location	Period	Tissue	n	Hg	SD	Min	Max	Study
BLSC	Salisbury Beach, NH (2010)	Wintering	Blood	13	0.22	0.07	0.08	0.32	This Study
BLSC	Unalaska Island, AK	Wintering	Blood	3	0.29	0.13	0.15	0.42	BRI Unpublished Data
BLSC	Pine Point, ME	Wintering	Blood	2	0.22	0.06	0.18	0.26	BRI Unpublished Data
BLSC	Rhode Island	Wintering	Blood	18	0.22	0.07	0.10	0.40	BRI Unpublished Data
BLSC	Restigouche River, NB	Spring Migration	Blood	39	0.18	0.06	0.05	0.33	BRI Unpublished Data

Mercury in Prey Items

Our analysis of prey items at Parker River NWR and those in an alternate site in the Gulf of Maine suggest that blue mussels and other mollusks may be accumulating higher concentrations of Hg in the Parker River ecosystem. Common eiders, which feed primarily on blue mussels, have higher Hg concentrations in blood tissue than have been reported in any other known literature for that species. The contaminant level relationship between eiders and prey items in aquatic ecosystems suggests that high eider Hg concentrations may be a direct link to bioaccumulation from their prey base. A more extensive sampling effort of blue mussels and similar prey items, coupled with increased waterfowl capture and sampling in the Parker River NWR, could provide a more detailed correlation between these two variables.

CONCLUSIONS and RECOMMENDATIONS

This study confirms that waterfowl species wintering in the Parker River and Plum Island Sound areas are accumulating Hg in their blood and feather tissues. While white-winged scoter and American scoter blood Hg levels were comparable to those of similar species captured in other locations, Hg levels in common eider captured in Plum Island Sound contained significantly higher concentrations than any other individuals of the same or similar species captured in other locations cited in this report. Identifying potential effect thresholds through

tissue analyses, such as blood profiles, would be a valuable next step. Compare results from Plum Island Sound eiders to eiders from lower Hg sites.

It was also shown that blue mussels collected in Plum Island Sound were significantly higher in Hg than those collected at different sites in Maine. Future efforts to conduct more extensive sampling of the prey base in the area could determine how Hg levels in eiders are correlated with Hg levels in their prey.

Stable isotope and Hg analysis of sea duck blood and prey items could provide a better understanding of the relationship between Hg in sea ducks and their prey base.

Additionally, future projects utilizing the growing field of satellite telemetry could be important in understanding the seasonal movements and habitat utilization of sea ducks wintering in the Plum Island area, as well as identifying the breeding grounds used by wintering eiders at Parker River NWR. This would not only help determine winter site fidelity among these individuals, but could also be used to identify any effects that high Hg levels are having on the reproductive success of eiders that use Parker River NWR as an important staging and wintering ground.

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Appendix I

2009 Captures

Band #	Date	Species	Age	Sex	Site	Tissue	Total Hg (µg/g)
1827-07107	1/6/2009	WWSC	AHY	Female	Parker River Sound	Blood	**0.378**
1827-07108	1/6/2009	WWSC	AHY	Female	Parker River Sound	Blood	**0.160**
1827-07109	1/6/2009	WWSC	SY	Female	Parker River Sound	Blood	**0.292**
1827-07110	2/25/2009	COEI	AHY	Male	Parker River Sound	Blood	**0.666**
1827-07111	3/10/2009	COEI	AHY	Male	Parker River Sound	Blood	**1.150**
1827-07112	3/10/2009	COEI	AHY	Female	Parker River Sound	Blood	**0.537**
1827-07113	3/13/2009	COEI	AHY	Male	Parker River Sound	Blood	**1.206**
1827-07114	3/13/2009	COEI	AHY	Female	Parker River Sound	Blood	**0.627**
1827-07115	3/13/2009	COEI	AHY	Female	Parker River Sound	Blood	**0.974**
1827-07116	3/13/2009	COEI	AHY	Male	Parker River Sound	Blood	**1.445**
1827-07117	3/13/2009	COEI	AHY	Male	Parker River Sound	Blood	**1.755**
1827-07118	3/13/2009	COEI	AHY	Female	Parker River Sound	Blood	**1.008**
1827-07119	3/27/2009	COEI	AHY	Male	Parker River Sound	Blood	**0.137**
1827-07120	3/27/2009	COEI	AHY	Female	Parker River Sound	Blood	**0.570**
1827-07121	3/27/2009	COEI	AHY	Male	Parker River Sound	Blood	**1.508**
1827-07107	1/6/2009	WWSC	AHY	Female	Parker River Sound	Feather	**3.048**
1827-07108	1/6/2009	WWSC	AHY	Female	Parker River Sound	Feather	**0.931**
1827-07109	1/6/2009	WWSC	SY	Female	Parker River Sound	Feather	**3.800**
1827-07110	2/25/2009	COEI	AHY	Male	Parker River Sound	Feather	**1.629**
1827-07111	3/10/2009	COEI	AHY	Male	Parker River Sound	Feather	**4.859**
1827-07112	3/10/2009	COEI	AHY	Female	Parker River Sound	Feather	**1.227**
1827-07113	3/13/2009	COEI	AHY	Male	Parker River Sound	Feather	**1.786**
1827-07114	3/13/2009	COEI	AHY	Female	Parker River Sound	Feather	**2.288**
1827-07115	3/13/2009	COEI	AHY	Female	Parker River Sound	Feather	**0.403**
1827-07116	3/13/2009	COEI	AHY	Male	Parker River Sound	Feather	**2.147**
1827-07117	3/13/2009	COEI	AHY	Male	Parker River Sound	Feather	**1.201**
1827-07118	3/13/2009	COEI	AHY	Female	Parker River Sound	Feather	**1.392**
1827-07119	3/27/2009	COEI	AHY	Male	Parker River Sound	Feather	**1.229**
1827-07120	3/27/2009	COEI	AHY	Female	Parker River Sound	Feather	**1.537**
1827-07121	3/27/2009	COEI	AHY	Male	Parker River Sound	Feather	**1.310**

Appendix II

2010 Captures

Band #	Date	Species	Age	Sex	Site	Tissue	Total Hg (µg/g), ww
1917-62506	12/3/2010	BLSC	HY	Female	Merrimack River/Salisbury	Blood	**0.250**
1917-62507	12/3/2010	BLSC	HY	Female	Merrimack River/Salisbury	Blood	**0.176**
1917-62511	12/3/2010	BLSC	HY	Female	Merrimack River/Salisbury	Blood	**0.274**
1917-62501	12/2/2010	BLSC	HY	Male	Merrimack River/Salisbury	Blood	**0.156**
1917-62502	12/3/2010	BLSC	HY	Male	Merrimack River/Salisbury	Blood	**0.218**
1917-62503	12/3/2010	BLSC	HY	Male	Merrimack River/Salisbury	Blood	**0.137**
1917-62504	12/3/2010	BLSC	HY	Male	Merrimack River/Salisbury	Blood	**0.321**
1917-62505	12/3/2010	BLSC	HY	Male	Merrimack River/Salisbury	Blood	**0.219**
1917-62508	12/3/2010	BLSC	HY	Male	Merrimack River/Salisbury	Blood	**0.291**
1917-62509	12/3/2010	BLSC	HY	Male	Merrimack River/Salisbury	Blood	**0.224**
1917-62510	12/3/2010	BLSC	HY	Male	Merrimack River/Salisbury	Blood	**0.081**
1917-62512	12/3/2010	BLSC	HY	Male	Merrimack River/Salisbury	Blood	**0.313**
1917-62515	12/5/2010	BLSC	ATY	Male	Merrimack River/Salisbury	Blood	**0.209**
1827-07141	3/10/10	COEI	AHY	Female	Ipswich Bluff	Blood	**0.808**
1827-07143	3/11/10	COEI	AHY	Female	Ipswich Bluff	Blood	**0.791**
1827-07144	3/11/10	COEI	SY	Female	Ipswich Bluff	Blood	**1.536**
1827-07145	3/11/10	COEI	AHY	Female	Ipswich Bluff	Blood	**0.884**
1827-07146	3/11/10	COEI	AHY	Female	Ipswich Bluff	Blood	**0.379**
1827-07159	3/17/10	COEI	SY	Female	Ipswich Bluff	Blood	**1.110**
1827-07160	3/18/10	COEI	AHY	Female	Ipswich Bluff	Blood	**0.530**
1827-07164	3/22/10	COEI	AHY	Female	Ipswich Bluff	Blood	**0.282**
1937-73501	12/2/2010	COEI	HY	Female	Merrimack River/Salisbury	Blood	**0.136**
1827-07139	3/10/10	COEI	AHY	Male	Ipswich Bluff	Blood	**0.329**
1827-07140	3/10/10	COEI	AHY	Male	Ipswich Bluff	Blood	**0.913**
1827-07142	3/10/10	COEI	SY	Male	Ipswich Bluff	Blood	**1.217**
1827-07161	3/22/10	COEI	AHY	Male	Ipswich Bluff	Blood	**0.262**
1827-07162	3/22/10	COEI	AHY	Male	Ipswich Bluff	Blood	**0.694**
1827-07163	3/22/10	COEI	AHY	Male	Ipswich Bluff	Blood	**0.223**
1917-62513	12/3/2010	SUSC	HY	Male	Merrimack River/Salisbury	Blood	**0.159**
1937-73502	12/3/2010	WWSC	HY	Female	Merrimack River/Salisbury	Blood	**0.254**
1937-73503	12/3/2010	WWSC	HY	Female	Merrimack River/Salisbury	Blood	**0.275**
1937-73505	12/3/2010	WWSC	HY	Female	Merrimack River/Salisbury	Blood	**0.331**
1937-73506	12/3/2010	WWSC	HY	Female	Merrimack River/Salisbury	Blood	**0.308**
1937-73504	12/3/2010	WWSC	HY	Male	Merrimack River/Salisbury	Blood	**0.237**

Appendix III

Blue Mussel and Periwinkle Collection

Sample	Location	Total Hg (µg/g), ww
Blue Mussel	Parker River	**0.130**
Blue Mussel	Parker River	**0.128**
Blue Mussel	Parker River	**0.093**
Blue Mussel	Parker River	**0.173**
Blue Mussel	Parker River	**0.162**
Blue Mussel	Parker River	**0.157**
Blue Mussel	Parker River	**0.118**
Blue Mussel	Parker River	**0.123**
Blue Mussel	Parker River	**0.073**
Blue Mussel	Parker River	**0.141**
Blue Mussel	Parker River	**0.111**
Blue Mussel	Parker River	**0.156**
Blue Mussel	Parker River	**0.107**
Blue Mussel	Parker River	**0.139**
Blue Mussel	Parker River	**0.134**
Perwinkle	Parker River	**0.112**
Perwinkle	Parker River	**0.156**
Perwinkle	Parker River	**0.133**
Perwinkle	Parker River	**0.157**
Perwinkle	Parker River	**0.114**
Perwinkle	Parker River	**0.123**
Perwinkle	Parker River	**0.122**
Perwinkle	Parker River	**0.088**
Perwinkle	Parker River	**0.119**
Perwinkle	Parker River	**0.129**
Perwinkle	Parker River	**0.087**
Perwinkle	Parker River	**0.097**
Perwinkle	Parker River	**0.096**
Perwinkle	Parker River	**0.063**
Perwinkle	Parker River	**0.105**