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Environmental Contaminants in Brook Trout (*Salvelinus fontinalis*) from Cove Brook and Two Tributaries of the Sheepscot River

December 2008

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Executive Summary

The Atlantic salmon (*Salmo salar*) is a federally-listed endangered species with a Distinct Population Segment (DPS) designated in Maine. In July 2006, thirty-six brook trout (*Salvelinus fontinalis*) were collected from tributaries of two Maine rivers within the DPS and used as surrogates for assessing potential contaminant exposure in Atlantic salmon parr. Eighteen trout were collected from two reaches in Cove Brook, a tributary of the Penobscot River, and 18 fish were collected from two tributaries of the Sheepscot River - Finn Brook and Weaver Brook. Brook trout were analyzed as whole-body samples (minus livers and a gill portion) for 22 organochlorine compounds and 19 trace elements. Liver and gill tissues from trout were extracted for a U.S. Geological Survey investigation to measure biochemical response.

Brook trout in the study averaged six inches (161 millimeters) in length and about one ounce (25 to 30 grams) in weight. These average brook trout length and weight are similar to the size of Atlantic salmon parr. There was no significant difference in trout weights or lengths between the two DPS watersheds. Ages of trout in the collections ranged from I+ to III+. These brook trout ages would mimic the residence time of salmon parr in the two DPS watersheds. Lipid content in brook trout averaged 3% with a range of 0.60 to 6.27 %. As with size and age, brook trout lipid content would be similar to Atlantic salmon parr.

Except for low levels of *p,p'*-DDE (a DDT metabolite) detected in two of 36 fish - one from Cove Brook (0.004 parts-per-million, ppm; wet weight) and one from Finn Brook (0.015 ppm) - levels of 21 other organochlorine compounds, including total polychlorinated biphenyls, were below analytical detection limits (< 0.002 ppm to < 0.010 ppm).

Several trace elements were detected in whole-body brook trout samples. Mercury concentrations ranged from non-detect to 0.11 ppm wet weight, well below the suggested tissue threshold-effect level of 0.20 ppm. Similarly, arsenic, selenium, and zinc levels in brook trout were not elevated compared to concentrations reported in other trout studies or in other species used in Maine, regional, and national biomonitoring programs. Copper concentrations in brook trout were higher than levels reported in other species used in other biomonitoring programs. With the exception of copper, trace elements levels in brook trout generally appeared to be lower concentrations than white suckers collected in the same watersheds. Beryllium, molybdenum, and vanadium concentrations were below detection in all trout samples.

Keywords: brook trout, DDE, trace elements, Maine

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List of Acronyms and Abbreviations

BSRFH	Bureau of Sea Run Fisheries and Habitat (DMR)
DDE	dichlorodiphenyldichloroethylene
DPS	Distinct Population Segment
MEDEP	Maine Department of Environmental Protection
MEDMR	Maine Department of Marine Resources
MEFO	Maine Field Office (USFWS)
µg/g	micrograms per gram (parts-per-million)
ng/g	nanograms per gram (parts-per-billion)
PCB	polychlorinated biphenyl
ppm	parts-per-million (µg/g)
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
ww	wet weight

PREFACE

This report provides documentation of environmental contaminants in whole-body brook trout collected from Cove Brook and two tributaries of the Sheepscot River. Analytical work was completed under U.S. Fish and Wildlife Service (USFWS) Analytical Control Facility Catalog 5100020 and Purchase Orders 94420-03-Y289 (Organics) and 94420-03-Y290 (Trace Elements). Funding was provided by the Maine Department of Marine Resources, Bureau of Sea Run Fisheries and Habitat (BSRFH), through an Agreement for Special Services (Maine No. 94V G106105, USFWS Reimbursable Agreement No. 53411-1901-5011) and by the USFWS Division of Environmental Quality.

Questions, comments, and suggestions related to this report are encouraged. Written inquiries should refer to Report Number FY07-MEFO-5-EC and be directed to:

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This report complies with the peer review and certification provisions of the Information Quality Act (Public Law 106-554, Section 515).

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1. Background

The Atlantic salmon (*Salmo salar*) is a federally-listed endangered species in a Distinct Population Segment (DPS) across eastern and Downeast Maine that includes eight rivers – the Sheepscot River, Ducktrap River, Cove Brook, Narraguagus River, Pleasant River, Machias River, East Machias River, and Dennys River. The Atlantic salmon Recovery Plan (NMFS and USFWS 2005), Status Review (Fay *et al*. 2006), nonpoint source pollution management plans (Arter 2003, Arter 2005a), water quality monitoring plans (Arter 2005b, Arter and Snapp 2006, Arter and Snapp 2007), and a watershed management plan (Caron 2003) all highlight the lack of information regarding contaminant exposure in fish within the DPS watersheds.

Potential contaminant sources and threats in the Gulf of Maine DPS rivers include hazardous waste sites, junkyards, agricultural pesticide spray operations, road runoff, fuel spills, silvicultural pesticide applications, municipal wastewater treatment plants, and materials associated with seasonal camps, homes, and small commercial entities. Atmospheric deposition may also introduce contaminants into the DPS rivers.

Elevated body burdens of contaminants in salmon, trout, and other fish have been related to adverse biological effects (Lemly 1996, Wiener and Spry 1996, Monosson 1999/2000). Organic contaminants may present a threat to reproduction and development in salmonids and other fish (Monosson 1999/2000), while exposure to inorganic contaminants affects predator avoidance, behavior and development (Berntssen *et al*. 2003, Webber and Haines 2003). Parr and pre-migrating Atlantic salmon smolts foraging in the DPS rivers accumulate contaminants through the ingestion of prey and through direct absorption of some water-dissolved contaminants across gill membranes. Due to their protected status and low numbers, lethal collections of Atlantic salmon parr for tissue residue analyses are not possible. Other fish species in the DPS waters must be used to determine potential contaminant body burdens.

Contaminant residues in white sucker (*Catostomas commersoni*), a lower trophic level species than salmonids, have been measured in several of the DPS rivers (Mierzykowski 2007). In the sucker study, only low levels of *p,p'*-DDE (max. 8 ng/g; parts-per-billion) were detected in samples from the Sheepscot River, Cove Brook, Pleasant River, and the Narraguagus River. Low detections of Total PCBs (max. 18 ng/g) were detected in two of the eight DPS rivers – Pleasant and East Machias River – and the compound was below detection in five of the other eight rivers. In the Dennys River, below the Eastern Surplus Superfund Site, Total PCB in white suckers ranged from 17 to 62 ng/g. Concentrations of twenty other organochlorine compounds in white suckers from the eight rivers were below analytical detection limits. Metals levels in suckers were generally similar to levels reported in other Maine, regional, and national biomonitoring programs. Mercury was detected in suckers at elevated levels (i.e., above a suggested tissue threshold effect level) in the Machias River and Sheepscot River. White suckers are not an ideal indicator species for demonstrating contaminant uptake and biomagnification in salmonids, but do provide information on the environmental condition of the aquatic habitat. This brook trout study was conducted to determine tissue residue levels in a species at a higher trophic level than white suckers.

2. Objectives

Determine organic and inorganic contaminant residue burdens in brook trout from Cove Brook and two Sheepscot River tributaries.

Compare concentrations in the present study: a) between collection locations, b) against suggested threshold-effect levels for trout or other species, c) to other Maine brook trout studies, d) to state, regional, and national tissue residue monitoring programs; and, to a lesser extent, d) to the white sucker study results.

3. Study Areas

Brook trout were collected from Cove Brook and two tributaries of the Sheepscot River - Finn Brook and Weaver Brook (Figure 1). Collection locations were selected by personnel from the Bureau of Sea Run Fisheries and Habitat based on the availability of brook trout habitat and previous capture experience. Two tributaries of the Sheepscot River were fished rather than the mainstem or West Branch because brook trout tend to be more abundant in small streams than warmer, more turbid reaches of large rivers (Bonney 2006).

3.1 Cove Brook. Cove Brook is a tributary of the Penobscot River (river mile 16.05) in the towns of Hampden and Winterport. The 4.5-mile brook is located across Waldo and Penobscot Counties and drains an area of approximately 11 square miles (Caron 2003). Potential contaminant sources include a former landfill, gravel pits, an abandoned aviation fuel pipeline, railroad right-of-way, road runoff, and non-point sources associated with commercial and residential developments. Two locations were sampled for brook trout in Cove Brook. Sampling locations were west of State Route 1A (Cove 1) and east of the Coles Corner Road (Cove 2) (Figure 2).

3.2. Sheepscot River. The 34-mile Sheepscot River is located in Lincoln and Kennebec Counties and drains an area of 228 square miles (Meister 1982). Potential contaminant sources to the Sheepscot River include discharges from a fish hatchery and nonpoint sources associated with agricultural, commercial, and residential developments (Arter 2005b). Brook trout were collected from two Sheepscot River tributaries - Finn Brook and Weaver Brook.

3.2.1 Finn Brook – Finn Brook is located in the town of Whitefield and the village of North Whitefield, Lincoln County, at river mile 16.54 on the Sheepscot. The 3.7-mile brook is west of the bridge that crosses State Route 126 (Figure 3). Atlantic salmon rearing and spawning habitat exists at the confluence of the brook and the Sheepscot River, but a habitat survey has not been conducted of Finn Brook (Abbott 2006).

3.2.2 Weaver Brook – The Weaver Brook sampling reach was between State Route 218 and the Sheepscot River. The 2.1-mile brook is also located in the town of Whitefield approximately 1.5 miles south of the town center (Figure 4) at river mile 9.22 on the mainstem of the Sheepscot. Atlantic salmon rearing and spawning habitat exists in the mainstem of the Sheepscot River north of the Weaver Brook confluence, and rearing habitat exists in the

mainstem of the river south of the Weaver Brook confluence (Abbot 2006).

4. Methods

4.1 Fish Collections. Prior to sampling, a scientific collection permit was obtained from the Maine Department of Inland Fisheries and Wildlife. An Intra-Service Section 7 Biological Evaluation was also prepared. The evaluation was reviewed, and approved by two USFWS Endangered Species Specialists not associated with the study. The Section 7 Biological Evaluation was also provided to the National Marine Fisheries Service in the National Oceanic and Atmospheric Administration. Personnel from the Maine Department of Marine Resources, Bureau of Sea Run Fisheries and Habitat (BSRFH) and USFWS used electrofishing backpack units to collect brook trout from the Sheepscot River tributaries and Cove Brook. Fish were held in aerated buckets containing water from the collection sites until processed. Fish were processed within two hours of capture; most were processed within one hour.

4.2 Fish Processing. Fish were euthanized with a strike to the head. Total weight in grams and total length in millimeters were measured for each fish. Scales were collected from above the lateral line and placed in labeled envelopes. Fish scales were aged by fisheries biologists with the Maine Department of Inland Fisheries and Wildlife.

One gill arch and the livers from each fish were extracted by personnel from the U.S. Geological Survey for cytochrome P450 analyses (Elskus 2008). The mass of liver tissue and gill arch removed from each fish was approximately one gram. The remainders of the whole-body brook trout carcasses were then individually wrapped in aluminum foil, packaged in labeled zip-loc bags, and frozen. Frozen carcass samples were shipped to analytical laboratories under contract with the USFWS.

4.3 Contaminant Analyses. Thirty-six tissue samples were sent for analytical quantification of 22 organochlorine compounds, 19 trace elements, percent moisture, and percent lipids.

Organochlorine analyses were conducted at the Mississippi State Chemical Laboratory in Mississippi State, Mississippi. Quantification of residues was determined by megabore column electron gas chromatography. The compounds in the organochlorine scan included polychlorinated biphenyl (Total), hexachlorobenzene, hexachlorocyclohexanes (*alpha* BHC, *beta* BHC, *gamma* BHC, *delta* BHC), chlordane compounds (*alpha* chlordane, *gamma* chlordane, oxychlordane, heptachlor epoxide, *cis*-nonachlor, *trans*-nonachlor), DDT metabolites (*o,p*'-DDD, *o,p*'-DDD, *o,p*'-DDT, *p,p*'-DDD, *p,p*'-DDE, *p,p*'-DDT), dieldrin, endrin, mirex, and toxaphene. Wet weight detection limit for organochlorine compounds was 0.002 µg/g, except for PCB-Total (0.01 µg/g), and toxaphene (0.050 µg/g).

Trace element analyses were conducted by Laboratory and Environmental Testing, Inc. of Columbia, Missouri. Inductively coupled plasma atomic emission spectrometry was used to determine concentrations of aluminum, boron, barium, beryllium, cadmium, chromium, copper, iron, magnesium, manganese, molybdenum, nickel, lead, strontium, vanadium, and zinc. Mercury concentrations were determined by cold vapor atomic absorption, and graphite furnace

atomic absorption was used to measure arsenic and selenium. Wet weight detection limits were 0.50 – 0.60 µg/g for aluminum, boron, iron, magnesium, and molybdenum; 0.10 µg/g for chromium, manganese, nickel, vanadium and zinc; 0.07 – 0.08 µg/g for copper; 0.05 – 0.06 µg/g for arsenic, barium, lead, selenium, and strontium; and 0.02 – 0.03 µg/g for beryllium, cadmium, and mercury.

4.4 Quality Assurance/Quality Control. Standard procedures of the USFWS Analytical Control Facility were used for quality assurance and quality control including duplicates, procedural blanks, spikes, and certified reference material. The QA/QC results were deemed acceptable by the USFWS Analytical Control Facility.

4.5 Data presentations and statistical analyses. All contaminant concentrations are expressed in µg/g (parts-per-million) on a wet weight basis. The arithmetic mean, standard deviation, and range are presented in the Results section and tables of this report. Data from Sheepscot tributaries (n = 9 fish per tributary; total of 18) were combined for statistical comparisons with the collection sites within Cove Brook (n = 9 per site; total of 18). A t-test was used to determine differences in biological metrics or contaminant concentrations (Systat 2008). The acceptable level of significance was $p < 0.05$. In instances when a sample was below the detection limit, a value one-half the detection limit was used in the computation of means or in statistical analyses. If one-half or more of the samples at a site were below detection, a mean was not calculated.

5. Results

5.1 Length and weight, age, and percent lipids. Fish metric and lipid data are listed in Table 1 (Cove Brook) and Table 2 (Sheepscot River tributaries).

5.1.1 Length and weight - The mean length and weight of all trout samples was 161 ± 27.3 millimeters (range: 115 – 222 mm) and 47 ± 26.3 grams (range: 16 – 122 g), respectively. There was no significant difference in trout length ($p = 0.962$) or weight ($p = 0.493$) between Cove Brook and the two Sheepscot tributaries. Similarly, there was no significant difference in fish length and weight between locations in Cove Brook (length $p = 0.494$, weight $p = 0.584$) and between the two Sheepscot tributaries (length $p = 0.082$, weight $p = 0.174$). The length-weight relationships for trout samples from the collection areas are depicted in Figure 5.

5.1.2 Age – Among the 36 samples, trout ages ranged from I+ to III+ (Figure 6). In Cove Brook, the age distribution was 11 % at I+, 67 % at II+ and 22 % at III+. No III+ fish were caught in the Sheepscot tributaries and the age distribution was 56 % at I+ and 44 % at II+.

5.1.3 Percent lipids – Lipid content in 36 brook trout samples ranged from 0.60 % to 6.27 % with a mean of 3.35 %. Trout from the Sheepscot tributaries had a significantly higher lipid content than fish from Cove Brook ($p = 0.007$). There was no significant difference in trout lipid content between the two Cove Brook sampling locations ($p = 0.975$). In the Sheepscot tributaries, however, lipid content was significant higher in trout from Weaver Brook than trout from Finn Brook ($p < 0.001$).

5.2 Organochlorine compounds. Among the 22 organochlorine compounds in the analytical scan, only one compound, *p,p'*-DDE, was found above detection limits in two of the 36 samples. (Table 3 - Cove Brook and Table 4 - Sheepscot River tributaries). DDE was detected in one brook trout sample from Cove Brook at 0.004 µg/g and in one sample from Finn Brook at 0.015 µg/g.

5.3 Trace elements. Trace element results are listed in Table 5 (Cove Brook) and Table 6 (Sheepscot River tributaries).

5.3.1 Aluminum (Al) – Aluminum was detected in all trout samples except one from Cove Brook. The mean aluminum levels at Cove Brook and the Sheepscot tributaries were 9.5 ± 11.25 µg/g (range: below detection – 26.0 µg/g) and 7.4 ± 5.84 µg/g (range: 1.0 – 24.0 µg/g), respectively. There was no significant difference in aluminum concentrations between Cove Brook and the Sheepscot tributaries ($p = 0.507$). Aluminum was significantly higher at the downstream Cove Brook site than the upstream site ($p = 0.036$). There was no significant difference in aluminum concentrations between the two Sheepscot tributaries ($p = 0.057$).

5.3.2 Arsenic (As) - Arsenic was detected in all Cove Brook samples except one. The mean arsenic level at Cove Brook was 0.09 ± 0.038 µg/g (range: below detection – 0.20 µg/g). There was no significant difference in arsenic concentrations between the upstream and downstream Cove Brook collection sites ($p = 0.332$). In the Sheepscot tributaries, arsenic concentrations were higher in Finn Brook than Weaver Brook at the level of statistical significance ($p = 0.049$). There was no significant difference in arsenic concentrations between Cove Brook fish and trout from the Sheepscot tributaries ($p = 0.580$).

5.3.3 Boron (B) – Except for one fish from Finn Brook (0.60 µg/g) with a concentration at the detection limit, boron was not detected in brook trout.

5.3.4 Barium (Ba) – Barium was detected in all whole-body brook trout samples. Significantly higher barium levels were detected in fish from the Sheepscot tributaries than Cove Brook ($p < 0.001$). There was no significant difference in barium levels between the two Cove Brook collection locations ($p = 0.053$). At the downstream Cove Brook location the barium mean was 0.12 ± 0.046 µg/g, while at the upstream location, the mean concentration was 0.08 ± 0.017 µg/g. In the Sheepscot tributaries, barium was significantly higher ($p = 0.002$) in trout from Weaver Brook (mean 0.82 ± 0.380 µg/g) than Finn Brook (mean 0.33 ± 0.097 µg/g).

5.3.5 Beryllium (Be) – Except for one fish from the downstream Cove Brook location (0.02 µg/g) with a concentration at the detection limit, beryllium was not detected in brook trout.

5.3.6 Cadmium (Cd) – Cadmium was below detection limits (0.02 – 0.03 µg/g) in all Cove Brook samples. Two of nine samples from Finn Brook had detectable levels of cadmium (0.03 and 0.05 µg/g). Five of nine samples from Weaver Brook had cadmium levels at or slightly above the detection limit (0.03 µg/g).

5.3.7 Chromium (Cr) – Chromium was sporadically detected at all locations. Two samples in each of the Cove Brook reaches had detectable levels of chromium. In the downstream Cove Brook reach two samples had chromium levels of 1.10 µg/g and 0.20 µg/g. In the upstream reach in Cove Brook, one sample had 0.85 µg/g and another had 1.10 µg/g of chromium. Two samples in Finn Brook had chromium concentrations of 0.74 µg/g and 1.10 µg/g. In Weaver Brook, three brook trout samples had chromium levels of 0.62 µg/g, 0.30 µg/g, and 1.50 µg/g.

5.3.8 Copper (Cu) – Copper was detected in all trout samples. Copper levels were significantly higher ($p = 0.028$) in trout from the downstream Cove Brook location (3.34 ± 2.35 µg/g) than the upstream location (1.33 ± 0.815 µg/g). Copper concentrations in the two Sheepscot River tributaries were similar ($p = 0.911$; Finn Brook 1.86 ± 1.156 µg/g, Weaver Brook 1.91 ± 0.562 µg/g). There was no significant differences in copper concentrations between Cove Brook and the Sheepscot River tributaries ($p = 0.393$).

5.3.9 Iron (Fe) – All brook trout samples contained iron. In the two Sheepscot River tributaries, iron levels were significantly higher in trout from Finn Brook (17 ± 5.3 µg/g) than Weaver Brook (12 ± 3.0 µg/g; $p = 0.014$). In Cove Brook, trout from the downstream collection location (33 ± 28.6 µg/g) appeared to have higher iron concentrations than fish from the upstream location (15 ± 3.4 µg/g), but the difference was not significant ($p = 0.077$). There was no significant difference in iron concentrations between Cove Brook and the Sheepscot River tributaries ($p = 0.082$).

5.3.10 Mercury (Hg) – Mercury was detected in all trout from Cove Brook (0.08 ± 0.023 µg/g) and Finn Brook (0.06 ± 0.015 µg/g). Only three of nine samples from Weaver Brook had detectable concentrations of mercury (range: 0.03 – 0.04 µg/g). There was no significant difference in mercury levels between the upstream and downstream Cove Brook locations ($p = 0.385$). Substituting one-half the detection limit for non-detects in Weaver Brook, there was a significant difference in mercury levels between Finn Brook and Weaver Brook ($p < 0.001$). Applying the same non-detect convention in the comparison between Cove Brook and the Sheepscot tributaries resulted in a significant difference ($p < 0.001$) with higher levels in Cove Brook fish.

5.3.11 Magnesium (Mg) – Magnesium was detected in all trout samples. In Cove Brook the mean magnesium concentration was 355 ± 17.1 µg/g (range: 329 – 383 µg/g), while in the two Sheepscot River tributaries the mean was 314 ± 19.6 µg/g (range: 283 – 357 µg/g). Magnesium levels were significantly higher in brook trout from Cove Brook than the Sheepscot River tributaries ($p < 0.001$). There was no significant difference in magnesium concentrations in trout between the Cove Brook sampling locations ($p = 0.813$) or between Finn Brook and Weaver Brook ($p = 0.069$).

5.3.12 Manganese (Mn) – Manganese was detected in all samples. Mean manganese concentrations in brook trout were 7.7 ± 3.6 µg/g (range: 3.4 – 12.8 µg/g) in Cove Brook and 6.6 ± 2.7 µg/g (range: 2.8 – 12.2 µg/g) in the Sheepscot River tributaries. Manganese was significantly higher in trout from Weaver Brook than Finn Brook ($p = 0.007$), but there was no

significant difference in manganese tissue concentrations between Cove Brook and the Sheepscot River tributaries ($p = 0.307$) or between the Cove Brook sampling locations ($p = 0.157$).

5.3.13 Molybdenum (Mo) – Molybdenum was below detection limits (0.05 – 0.06 µg/g) in all samples.

5.3.14 Nickel (Ni) – Except for seven fish, three from Cove Brook and four from the Sheepscot tributaries, nickel was not found above the 0.10 µg/g detection limit. The highest nickel concentration in Cove Brook was 0.59 µg/g and the highest in the Sheepscot tributaries was 0.66 µg/g from Weaver Brook.

5.3.15 Lead (Pb) – Lead followed the same pattern as nickel with scattered detections at the collection locations. In Cove Brook, lead was detected in two of 18 samples and both detections were slightly above the detection limit (0.06 µg/g). In Finn Brook, one sample contained lead at 0.10 µg/g. Three of nine samples in Weaver Brook had detectable lead residues. Two fish had lead concentrations at the detection limit of 0.06 µg/g and one fish had a level of 0.09 µg/g.

5.3.16 Selenium (Se) – The mean selenium level in 38 brook trout samples was approximately 0.4 µg/g with a range between 0.23 and 0.68 µg/g. There was no significant difference in selenium concentrations between fish collected from Cove Brook and the Sheepscot River tributaries ($p = 0.130$). Similarly, there was no significant difference in selenium tissue levels between collection locations in Cove Brook. Brook trout from Finn Brook, however, had significantly higher selenium levels than fish from Weaver Brook ($p < 0.001$).

5.3.17 Strontium (Sr) – Strontium was detected in all brook trout samples with the highest concentration being recorded in Weaver Brook (27.40 µg/g). Mean strontium concentrations in brook trout were 9.50 ± 1.78 µg/g in Cove Brook and 10.03 ± 6.29 µg/g in the Sheepscot River tributaries. Strontium levels in brook trout were not significantly different between Cove Brook and the Sheepscot River tributaries ($p = 0.733$), and between the Cove Brook collection locations ($p = 0.795$). However, significantly higher strontium levels were detected in trout from Weaver Brook than in Finn Brook ($p = 0.002$).

5.3.18 Vanadium (V) – Vanadium was below the detection limit (0.10 µg/g) in all samples.

5.3.19 Zinc (Zn) – Mean zinc concentrations were 26.9 ± 2.94 µg/g (range: 22.2 – 32.0 µg/g) in Cove Brook and 24.1 ± 3.32 µg/g (range: 17.3 – 29.2 µg/g) in the Sheepscot River tributaries. Cove Brook trout had significantly higher zinc concentrations than brook trout from the Sheepscot River tributaries. Zinc tissue levels in brook trout were not significantly different between the lower Cove Brook sampling reach and the upper reach ($p = 0.343$), or between the Finn Brook and Weaver Brook sampling locations ($p = 0.232$).

6. Discussion

Tissue residue results were quantitatively compared between river locations and between rivers. Our results were qualitatively compared to contaminant data reported for other trout studies in Maine (Warner and Fenderson 1962, Akielaszek and Haines 1981, Mierzykowski *et al*. 1997, Stafford and Haines 1997, Bonney 2006, EPA 2008a, EPA 2008b). Tissue concentrations in brook trout were also qualitatively compared to regional (Yeardley *et al*. 1998, Kamman *et al*. 2005), and national (Hinck *et al*. 2008) biomonitoring programs. These biomonitoring programs provide mean and/or median organic or trace element contaminant information for several freshwater species from large rivers or lakes. Mean contaminant levels in these regional and national programs are for <u>all species combined</u> and should be viewed with caution when used in comparison to a single species such as the brook trout. Fish tissue residues were also evaluated against suggested effect thresholds reported in the scientific literature and to web-based search tools (USACOE/USEPA 2005, RAIS 2008).

Since livers and a gill arch were removed from each brook trout for biochemical analyses (Elskus 2008), whole-body concentrations listed in this report are not true whole-body concentrations. The liver is a detoxifying organ that can accumulate higher levels of some contaminants than other organs or muscle tissue. Consequently, slightly higher concentrations for some contaminants would have been likely had the livers been included in the tissue residue analyses. This limitation was recognized during the study design. Our options were to have matched biochemical analyses and tissue residue analyses for individual fish, or to collect separate sets of fish for biochemical analyses and tissue residue analyses. To avoid over-collecting in these small brooks, we chose to use the same fish for both analyses.

6.1 <u>Organochlorine compounds</u>. Twenty-one organochlorine compounds were below detection limits in all samples (Tables 3 and 4). Only the DDT metabolite, *p,p*'-DDE, was detected in two samples. DDT was used in northern Maine in the 1950s and 1960s for the control of spruce budworm (*Choristoneura fumiferana*). The insecticide was last used in Maine in 1967 (Dimond and Owen 1996), but the compound decays slowly due to low soil temperatures, high organic matter, and low microbial population (Owen *et al*. 1977). During the years of DDT spraying in the state, elevated concentrations of the compound were detected in fish tissue. In an early 1960s study in Maine, Warner and Fenderson (1962) reported DDT concentrations in whole-body brook trout ranging from 0.3 to 25.9 µg/g (assumed wet weight). The levels of DDE currently detected in the brook trout sample from Cove Brook (0.004 µg/g) and the sample from Finn Brook (0.015 µg/g) illustrate the persistence of this insecticide after its last use in Maine 40 years ago.

The *p,p'*-DDE level in the brook trout sample collected from Cove Brook (0.004 µg/g) in 2006 was identical to the mean of three composite white suckers samples collected from the same reaches in 2004 (Mierzykowski 2007). In 2005, none of the white sucker composite samples from the Sheepscot River had detectable levels of *p,p'*-DDE. The *p,p'*-DDE level in the brook trout sample from Finn Brook (0.015 µg/g) was lower than the mean level reported in the EPA

Regional Environmental Monitoring and Assessment program for 28 brook trout samples collected from Maine lakes in the early 1990s (0.023 µg/g; EPA 2008b) and less than the mean reported in the BEST program (0.045 µg/g; Hinck *et al*. 2008).

DDE Assessment: Although DDE, a breakdown metabolite of DDT was detected in single fish from Cove Brook and Finn Brook, the levels were not elevated compared to suggested threshold effect levels. For DDT, the parent compound of DDE, a protective whole-body concentration of 0.60 µg/g in juvenile and adult fish, and 0.70 µg/g for early life-stage fish has been suggested (Beckvar *et al*. 2005). DDE levels in the two brook trout samples were orders of magnitude below this suggested sub-lethal effect threshold.

6.2 Trace elements. Trace elements are naturally occurring and regularly found in soil, sediment, water, and biota. Some trace elements are essential nutrients for biota, but may be hazardous at highly elevated levels. Although concentrations were measured in 19 trace elements, only five are discussed below – arsenic, copper, mercury, selenium, and zinc. Aluminum and chromium are not discussed since trout samples were wrapped in aluminum foil. Boron, beryllium, cadmium, molybdenum, lead, and vanadium concentrations were at or below their respective detection limits. Iron, magnesium, and manganese are essential elements and practically non-toxic (Merian 1991). Ecological effect data related to barium or strontium levels in fish tissue could not be located (USACOE/USEPA 2005, RAIS 2008).

6.2.1 Arsenic - Arsenic is a metalloid used in the production of pesticides and wood preservatives. Coal-fired power utilities and metal smelters annually release tons of arsenic into the atmosphere (Environment Canada 1993). Pressure-treated lumber has been used extensively for construction, and wood remnants with earlier pressure-treated formulations containing chromated copper arsenate may exist within riparian areas of some of the brook trout collection locations for this study. The bioavailability of arsenic from this wood debris is not known. Arsenic is a teratogen and carcinogen, which bioconcentrates in organisms, but does not biomagnify in food chains (Eisler 1994).

In brook trout, the mean arsenic level (0.09 µg/g) was similar to values reported in the BEST (0.11 µg/g) and EMAP-NE (0.08 µg/g) biomonitoring programs (Table 7), and slightly higher than mean levels reported in two brook trout studies of Mere Brook in southern Maine (0.05 µg/g, Mierzykowski *et al*. 1997; 0.03 µg/g, EPA 2008a; Table 8). The highest detection (0.39 µg/g) in the present study was detected in a sample from Finn Brook. Arsenic levels in brook trout from Cove Brook and the two Sheepscot River tributaries were lower than levels found in a earlier study of white suckers from the two drainages (Tables 9 and 10).

Arsenic Assessment: When detected, arsenic levels in brook trout from Cove Brook and the two Sheepscot River tributaries were considerably lower than the arsenic concentration range (5.4 - 11.6 µg/g) that may affect survival in some fish species (Jarvinen and Ankley 1999).

6.2.2 Copper - Copper is used in the preservation and coloring of foods, and in brass and copper water pipes and domestic utensils (Gross *et al*. 2003). Copper is also a fish neurotoxin

that is found in fungicides, algaecides, vehicle exhaust and brake pad wear (Sandahl *et al*. 2004). Exposure to waterborne or dissolved copper impairs juvenile salmon sensory physiology and predator avoidance (Hecht *et al*. 2007, Sandahl *et al*. 2007). Copper is not carcinogenic, mutagenic, or teratogenic at environmentally realistic concentration (Eisler 1997).

Copper was detected in all brook trout samples from Cove Brook and the Sheepscot River tributaries. The median copper concentration in brook trout (1.75 µg/g, Table 8) was higher than the medians reported in the BEST (0.86 µg/g) and EMAP-NE (0.44 µg/g) biomonitoring programs. Similar copper concentrations were reported in studies of brook trout in Mere Brook at the U.S. Naval Air Station in Brunswick (1.46 µg/g, Mierzykowski *et al*. 1997; 1.77 µg/g EPA 2008a; Table 7). Copper concentrations in brook trout were also consistently higher than levels found during the white sucker study of the two drainages (Tables 9 and 10).

Copper Assessment: Brook trout exposed to copper sulfate at 9.4 µg/L for 720 days had a muscle concentration of 3.4 µg/g with no effect on survival, growth, or reproduction (McKim and Benoit 1974, cited in Jarvinen and Ankley 1999). A suggested copper toxicity threshold range is 11.1 to 42.0 µg/g (Stouthart *et al*. 1996, cited by Hinck *et al*. 2008). All brook trout samples from Cove Brook and the two Sheepscot River tributaries had copper concentrations below the suggested effect threshold range. The highest copper concentration in our study was a fish from Cove Brook with 7.90 µg/g.

6.2.3 Mercury - Mercury is a global pollutant with biological mercury hotspots existing in the northeastern United States (Evers *et al*. 2007). Sources of mercury contamination include emissions from coal-fired energy facilities, incinerators, mining activities, operation of chloralkali plants, and disposal of mercury-contaminated products such as batteries and fluorescent lamps (Eisler 1987). Mercury is a mutagen, teratogen, and carcinogen which bioconcentrates in organisms and biomagnifies through food chains (Eisler 1987). The most toxic form or mercury is the organic form, methylmercury. Methylmercury may account for nearly all of the total mercury in fish tissue (Grieb *et al*. 1990) and preferentially accumulates in axial muscle tissue. Chronic exposure to elevated dietary mercury (> 10 µg/g) caused oxidative stress, brain lesions, and altered behavior in Atlantic salmon parr (Berntssen *et al*. 2003).

Mercury was detected in all but one trout sample from Cove Brook, in all nine trout samples from Finn Brook, and in three of nine samples from Weaver Brook (Tables 5 and 6). The highest mercury concentration was detected in a sample from Cove Brook (0.11 µg/g). The mean mercury level for all 36 samples was 0.06 µg/g. This wild fish mercury concentration was about twice as high as the concentration found in hatchery-reared yearling brook trout in Maine (Bonney 2006). The whole-body mercury concentrations in Cove, Finn and Weaver Brooks were similar to levels found in similar size trout from Mere Brook in 1995 and 2007 (Table 7).

Mercury increases with fish size and age (Wiener *et al*. 2003). In fish collected in 1978 and 1979 from three northern Maine lakes, brook trout (skinless, boneless muscle samples) ranging in size from 240 to 430 mm had mercury concentrations ranging from 0.08 to 0.58 µg/g (Akielaszek and Haines 1981). Similarly, 31 samples of large brook trout (mean length 266 mm) from several Maine lakes, also skinless and boneless muscle samples, had a mean mercury

content of 0.31 µg/g (Stafford and Haines 1997). In a synthesis of 24 studies conducted in northeast North America, Kammen *et al*. (2005) found a mean mercury level of 0.29 µg/g in 319 whole-body brook trout (standard length 245 mm).

The median mercury concentration in whole-body brook trout in the present study (0.06 µg/g) was lower than the median mercury values reported in the BEST (0.13 µg/g), and EMAP-NE (0.11 µg/g) biomonitoring programs (Table 8). Compared to the earlier sucker study (Mierzykowski 2007), mercury levels in brook trout were nearly one-half the concentrations found in white suckers (Tables 9 and 10).

Mercury Assessment: Beckvar *et al*. (2005) suggested that a mercury whole-body tissue threshold-effect level (t-TEL) of 0.20 µg/g would be protective of juvenile and adult fish. None of the trout samples in this study approached the suggested mercury t-TEL.

6.2.4 Selenium - Selenium is a beneficial or essential element for some biota at trace amounts to parts-per-billion concentrations, but toxic at elevated concentrations (Eisler 1985). Selenium is present in rocks and soils. However, coal and oil combustion, nonferrous metal production, iron manufacturing, municipal and sewage refuse incineration, and production of phosphate fertilizers introduce greater amounts of selenium into the environment than natural sources (Ohlendorf 2003).

Selenium was detected in all brook trout samples (n = 36, Tables 5 and 6). Mean selenium was highest in Finn Brook (0.48 µg/g), followed by Cove Brook (0.44 µg/g) and lowest in Weaver Brook (0.28 µg/g). These selenium means appear lower than levels reported in similar-size brook trout from Mere Brook in southern Maine (0.53 µg/g, 0.67 µg/g; Table 7). The mean selenium level in brook trout in the present study (0.41 µg/g) was between the means reported in national (0.59 µg/g) and regional (0.37 µg/g) biomonitoring programs (Table 8).

Selenium Assessment: A proposed selenium fish toxicity threshold is 1 µg/g (Lemly 1996; converted from 4 µg/g dry weight based on 75% moisture). A higher selenium toxicity threshold level for whole-body fish has also been proposed (2.25 µg/g; DeForest *et al*. 1999, converted from 9 µg/g dry weight based on 75% moisture). Brook trout from Cove Brook and the two Sheepscot River tributaries were substantially lower than the suggested selenium threshold levels of Lemly (1996) and DeForest *et al*. (1999).

6.2.5 Zinc - Zinc is used in galvanized metal alloys, paints, wood preservatives, fertilizers, and rodenticides (Opresko 1992, Eisler 1993). Zinc is an essential trace nutrient that is required in relatively high concentrations and is a cofactor of enzymes regulating metabolic processes (Leland and Kuwabara 1985). Citing several sources, Murphy *et al*. (1978) reported average zinc whole fish concentrations from uncontaminated areas ranging from 12 to 43 µg/g.

Zinc was detected in all brook trout samples (mean 25.5 µg/g). Compared to other Maine brook trout studies (23.3 µg/g, Mierzykowski *et al*. 1997; 19.3 µg/g, EPA 2008a), and to averages in

regional (21.1 µg/g, Yeardley *et al*. 1998) and national (35.2 µg/g; Hinck *et al*. 2008) biomonitoring programs, zinc levels were not elevated.

Zinc Assessment: A suggested zinc toxicity threshold range is 40 to 64 µg/g (Spehar 1976, cited by Hinck *et al*. 2008). None of the 36 brook trout samples in this study were within the suggested toxicity threshold range.

7. Summary and Management Recommendation

In July 2006, thirty-six brook trout were collected from tributaries of two Maine rivers within the DPS and used as surrogates for assessing potential contaminant exposure in Atlantic salmon parr. Eighteen trout were collected from two reaches in Cove Brook, a tributary of the Penobscot River, and 18 fish were collected from two tributaries of the Sheepscot River - Finn Brook and Weaver Brook. Brook trout were analyzed as whole-body samples (minus livers and a gill portion) for 22 organochlorine compounds and 19 trace elements. Liver and gill tissues from trout were extracted for a U.S. Geological Survey investigation to measure biochemical response.

Brook trout in the study averaged 161 millimeters (~ 6 inches) in length and from 25 to 30 grams (~ one ounce) in weight. These average brook trout length and weight are similar to the size of Atlantic salmon parr. There was no significant difference in trout weights or lengths between the two DPS watersheds. Ages of trout in the collections ranged from I+ to III+. These brook trout ages would mimic the residence time of salmon parr in the two DPS watersheds. Lipid content in brook trout averaged 3% with a range of 0.60 to 6.27 %. As with size and age, brook trout lipid content would be similar to Atlantic salmon parr.

Except for low levels of *p,p'*-DDE (a DDT metabolite) detected in two of 36 fish - one from Cove Brook (0.004 µg/g) and one from Finn Brook (0.015 µg/g) - levels of 21 other organochlorine compounds, including total polychlorinated biphenyls, were below analytical detection limits (< 0.002 µg/g to < 0.010 µg/g).

It should be noted that the removal of the liver and one gill arch from brook trout samples for the biochemical response portion of this study (Elskus 2008) may have slightly affected contaminant concentrations, particularly the organochlorine compounds. The liver is a detoxifying organ and a portion of the contaminant burden in fish may be sequestered in liver tissue. Liver weights of brook trout in this study were generally less than one gram constituting less than four percent of the total body weight in an individual fish. Since nearly all organochlorine concentrations in trout were at or below detection limits, dramatically higher concentrations (i.e., approaching threshold levels) would not be expected even if the livers were not extracted.

Several trace elements were detected in whole-body brook trout samples. Mercury concentrations ranged from non-detect to 0.11 µg/g, well below the suggested tissue threshold-effect level of 0.20 µg/g (Beckvar *et al*. 2005). Similarly, arsenic, selenium, and zinc levels in brook trout were not elevated compared to concentrations reported in other trout studies (Mierzykowski *et al*. 1997, EPA 2008a) or in other species used in Maine (Mierzykowski 2007, EPA 2008b), regional (Yeardley *et al*. 1998), and national (Hinck *et al*. 2008) biomonitoring programs. Copper concentrations in brook trout were higher than levels reported in other species used in other biomonitoring programs. With the exception of copper, trace elements levels in brook trout generally appeared to be lower concentrations than white suckers collected in the same watersheds. Beryllium, molybdenum, and vanadium concentrations were below detection in all brook trout samples.

In Cove Brook and the two Sheepscot River tributaries, elevated levels of contaminants were not detected in brook trout of similar size and age as Atlantic salmon parr. Tissue residue screenings of brook trout from these waters do not suggest pronounced contamination, at least of Total PCBs, organochlorine pesticides, and most trace elements. Our results should not be construed to represent potential levels of contamination in fish residing in the mainstems of the Sheepscot or Penobscot rivers. The mainstems of the Sheepscot and Penobscot have a number of point sources (e.g., industrial and municipal discharges) and non-point sources (e.g., highway and agricultural runoff) along their banks that may contribute to contamination in fish. Finally, other contaminants than the compounds and elements that we measured may be having an impact on brook trout or salmon in these and other DPS river watersheds. Tissue residue studies are not suitable for contaminants that do not bioaccumulate or biomagnify in fish tissue (e.g., polycyclic aromatic hydrocarbons, organophosphate pesticides).

A study of hatchery-reared and wild broodstock salmon in northeast USFWS National Fish Hatcheries (Millard *et al*. 2004) found the highest concentrations of Total PCB, dioxin toxic equivalents (TCDD-TEQ), and mercury in a returning sea-run salmon in the Merrimack River. It would be useful to examine any dead adult Atlantic salmon recovered from fish traps and weirs in the Maine DPS to determine if fish returning from the sea have contaminant burdens that may be sufficient to affect reproductive status. In 2008, fillets from two adult sea-run Atlantic salmon that died in fish traps on the Dennys River and Narraguagus River were submitted for comprehensive residue analyses – polychlorinated dibenzo-p-dioxins, polychlorinated dibenzofurans, PCB congeners, polybrominated diphenyl ethers, organochlorine pesticides, and trace elements. We recommend that residue analyses of Atlantic salmon killed in trap or weirs in the Maine DPS continue.

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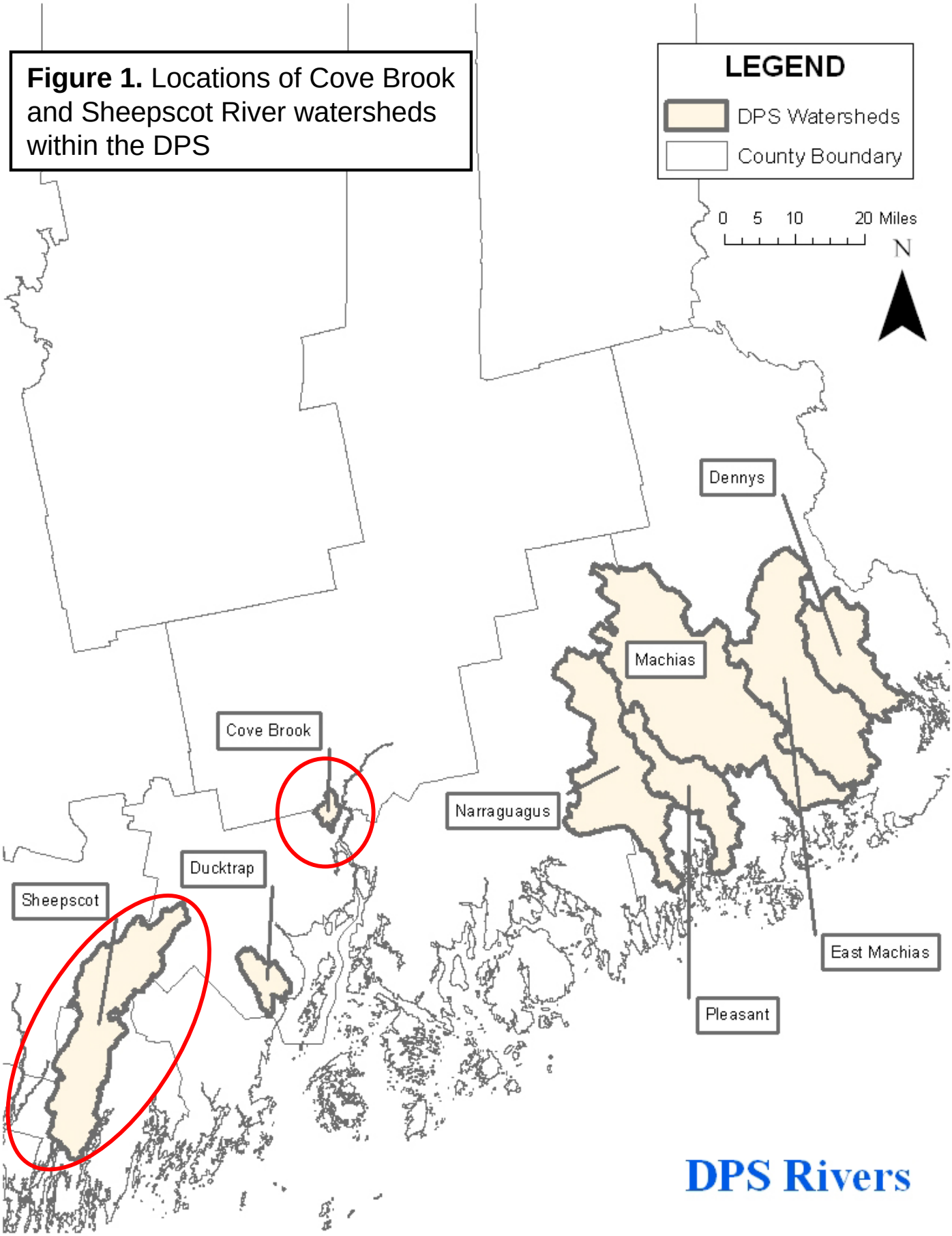


Figure 1. Locations of Cove Brook and Sheepscot River watersheds within the DPS

Figure 2. Brook trout collection locations – Cove Brook 1 and 2

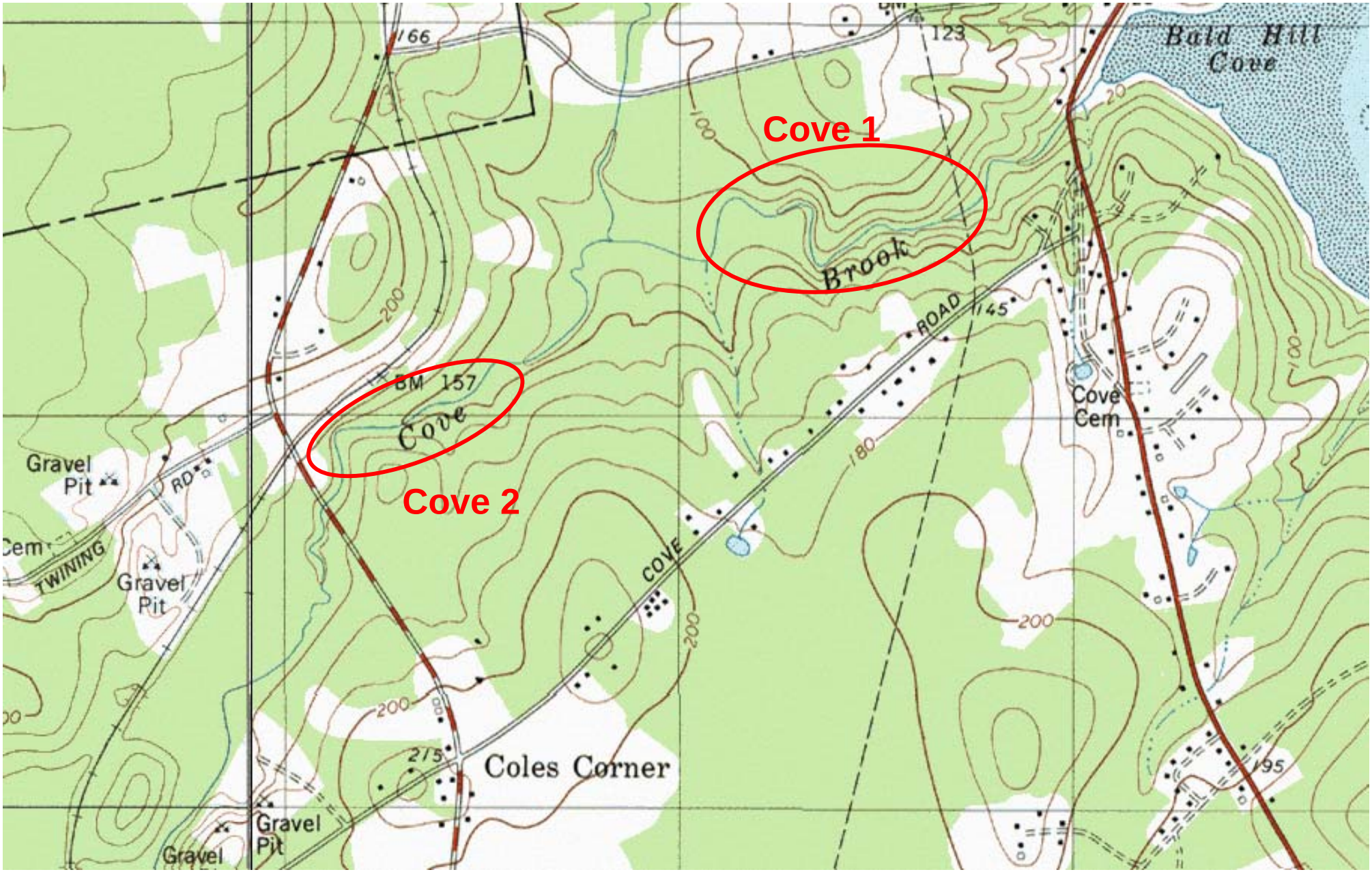


Figure 3. Brook trout collection location – Sheepscot River 1 (Finn Brook)

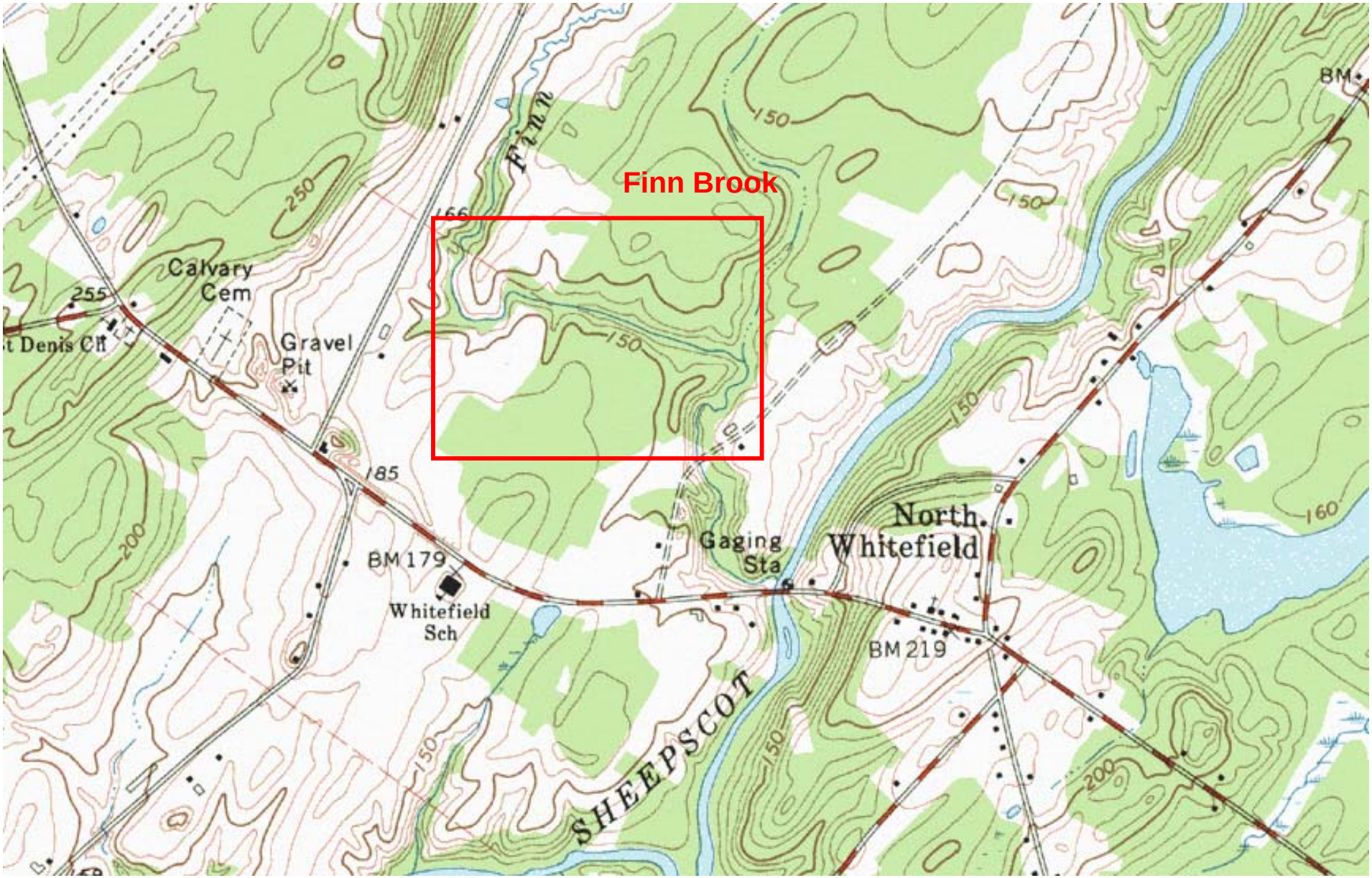


Figure 4. Brook trout collection location – Sheepscot River 2 (Weaver Brook)

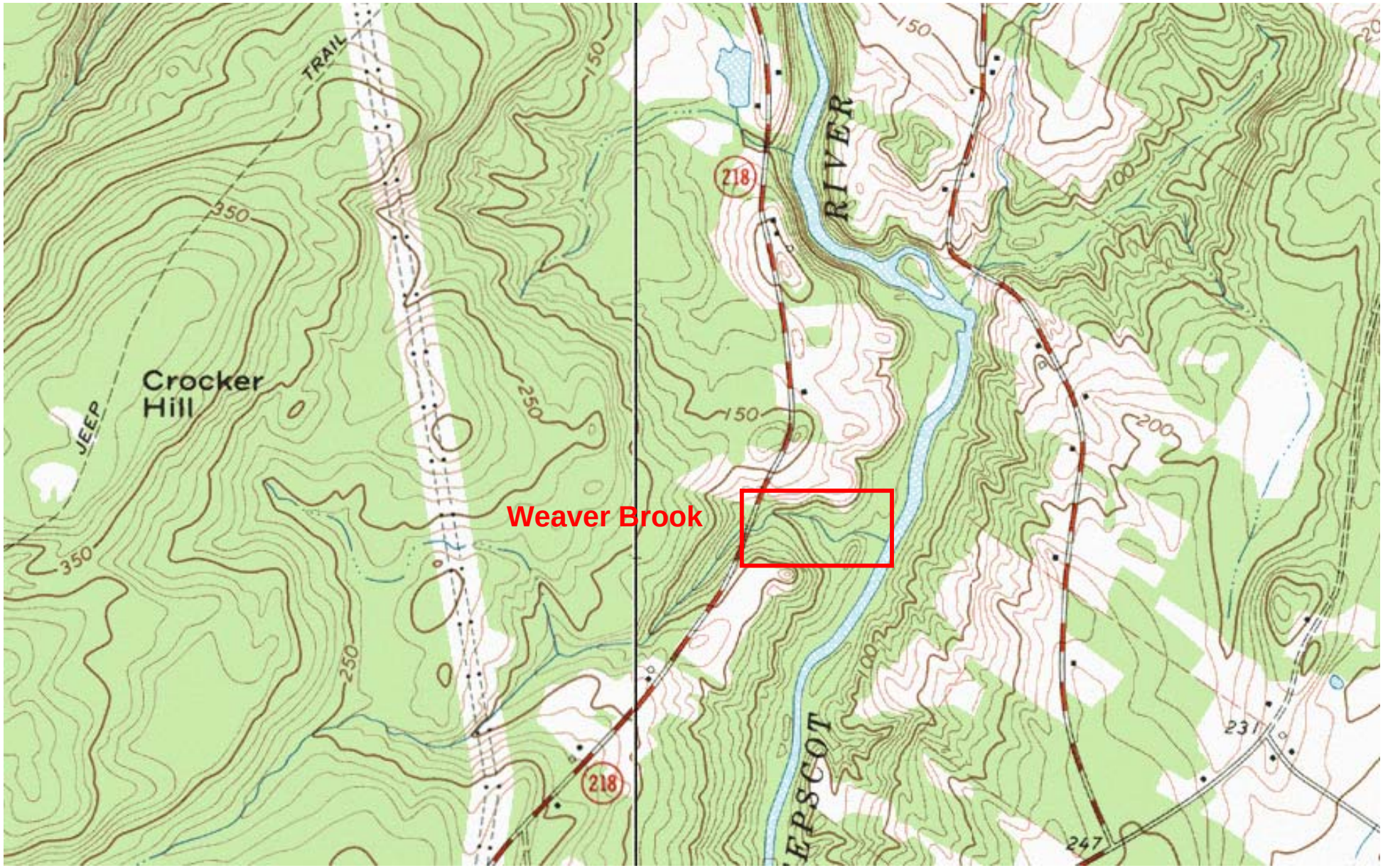
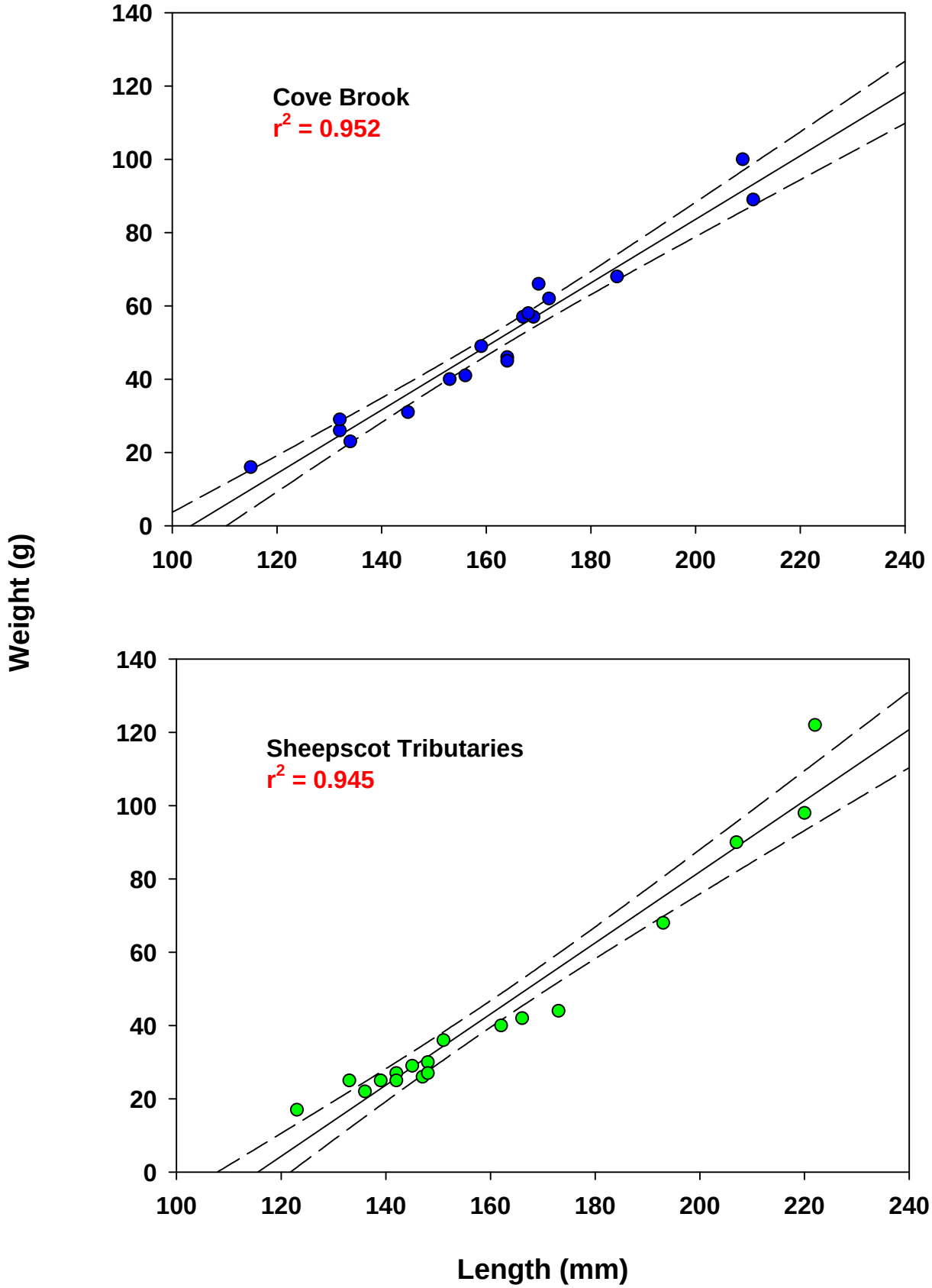


Figure 5. Length-weight relationship of brook trout samples



Dash Lines = 95% Confidence Interval

Figure 6. Number of brook trout by age and location

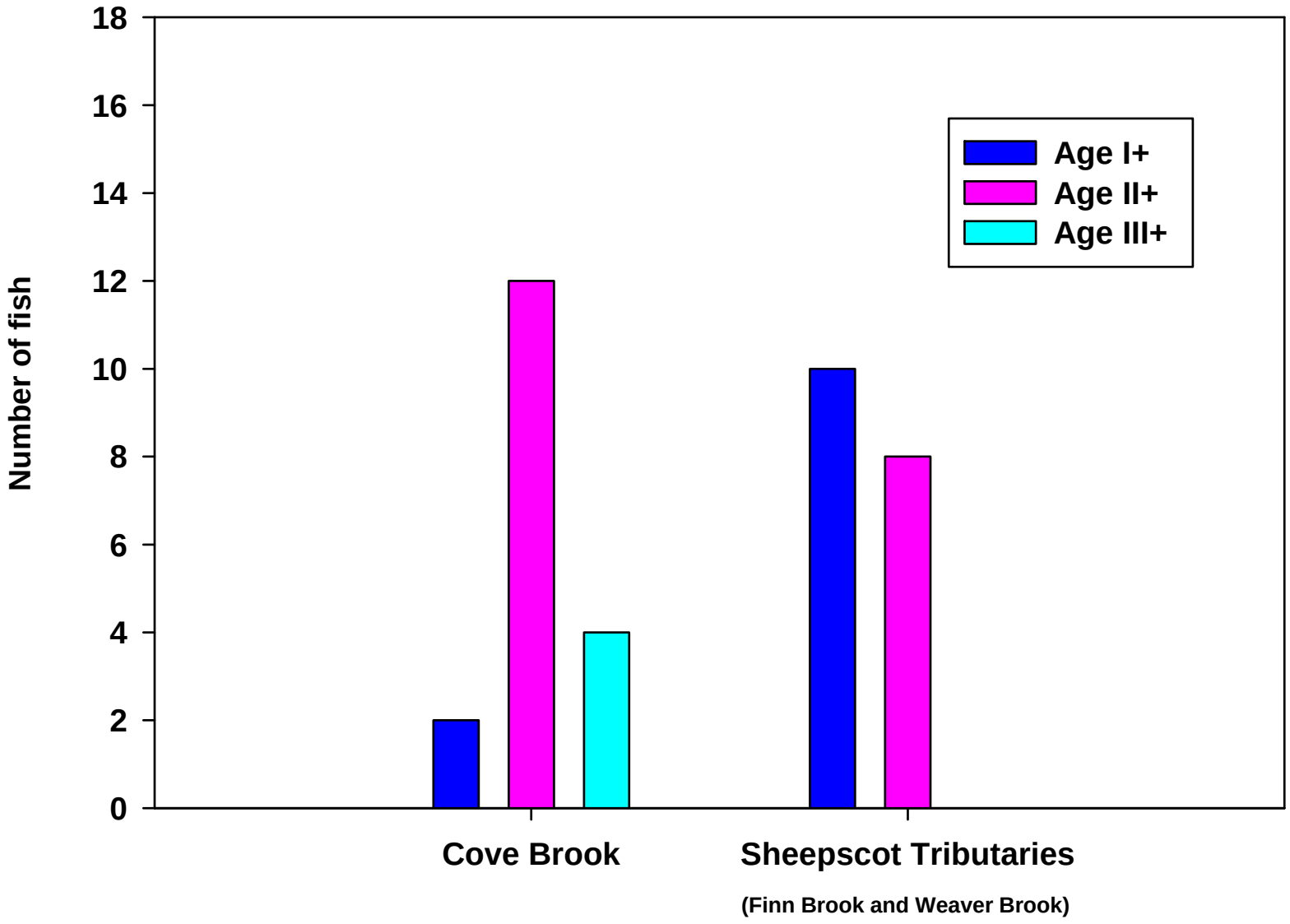


Table 1. Length, weight, age, and lipid content of brook trout from Cove Brook

Sample No.	Length (mm)	Weight (g)	Age	Lipid (%)
Cove Brook 1 - Below gravel pit	**N 44° 40' 52" / W 068° 52' 28"**			
Cove 1-1	151	36	II+	3.74
Cove 1-2	139	25	II+	2.06
Cove 1-3	123	17	I+	1.38
Cove 1-4	133	25	II+	2.42
Cove 1-5	220	98	III+	3.86
Cove 1-6	136	22	I+	4.91
Cove 1-7	193	68	III+	2.45
Cove 1-8	166	42	II+	1.97
Cove 1-9	142	27	II+	1.68
Cove 1 Mean	155.9	40.0		2.72
Standard Deviation	31.81	26.55		
Cove Brook 2 - Below Coles Corner Road	**N 44° 41' 09" / W 068° 52' 16"**			
Cove 2-1	222	122	III+	5.23
Cove 2-2	207	90	II+	2.90
Cove 2-3	173	44	III+	1.02
Cove 2-4	162	40	II+	4.22
Cove 2-5	145	29	II+	3.15
Cove 2-6	147	26	II+	0.60
Cove 2-7	142	25	II+	3.04
Cove 2-8	148	30	II+	1.97
Cove 2-9	148	27	II+	2.16
Cove 2 Mean	166.0	48.1		2.70
Standard Deviation	29.39	34.39		
Grand Mean (1 & 2)	160.9	44.1		2.71
Standard Deviation	30.16	30.09		

Table 2. Length, weight, age, and lipid content of brook trout from the Sheepscot River tributaries

Sample No.	Length (mm)	Weight (g)	Age	Lipid (%)
Sheepscot River tributary 1 - Finn Brook	**N 44° 13' 33" / W 069° 35' 47"**			
Shee 1-1	185	68	II+	4.13
Shee 1-2	209	100	II+	3.05
Shee 1-3	134	23	I+	2.18
Shee 1-4	156	41	I+	1.89
Shee 1-5	169	57	I+	3.30
Shee 1-6	164	46	I+	1.45
Shee 1-7	145	31	I+	3.15
Shee 1-8	172	62	II+	4.16
Shee 1-9	211	89	II+	2.95
Shee 1 Mean	171.7	57.4		2.92
Standard Deviation	26.36	25.56		
Sheepscot River tributary 2 - Weaver Brook	**N 44° 08' 58" / W 069° 37' 15"**			
Shee 2-1	170	66	II+	4.86
Shee 2-2	115	16	I+	3.92
Shee 2-3	159	49	II+	4.96
Shee 2-4	167	57	I+	6.18
Shee 2-5	168	58	II+	6.27
Shee 2-6	164	45	I+	4.95
Shee 2-7	132	26	I+	5.52
Shee 2-8	132	29	I+	4.04
Shee 2-9	153	40	II+	4.94
Shee 2 Mean	151.1	42.9		5.07
Standard Deviation	19.88	16.63		
Grand Mean (1 & 2)	161.4	50.2		3.99
Standard Deviation	25.00	22.22		

Table 3. Organochlorine compounds in brook trout from Cove Brook, µg/g wet weight.

Sample No.	PCB-Total	alpha BHC	beta BHC	gamma BHC	delta BHC	alpha chlordane	gamma chlordane	oxy-chlordane	heptachlor epoxide	cis-nonachlor	trans-nonachlor	o,p'-DDD	o,p'-DDE	o,p'-DDT	p,p'-DDD	p,p'-DDE	p,p'-DDT	dieldrin	endrin	HCB	mirex	toxa-phene
Below gravel pit																						
Cove 1-1	< 0.01	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	**0.004**	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.05
Cove 1-2	< 0.01	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.05
Cove 1-3	< 0.01	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.05
Cove 1-4	< 0.01	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.05
Cove 1-5	< 0.01	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.05
Cove 1-6	< 0.01	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.05
Cove 1-7	< 0.01	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.05
Cove 1-8	< 0.01	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.05
Cove 1-9	< 0.01	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.05
Below Coles Corner Road																						
Cove 2-1	< 0.01	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.05
Cove 2-2	< 0.01	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.05
Cove 2-3	< 0.01	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.05
Cove 2-4	< 0.01	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.05
Cove 2-5	< 0.01	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.05
Cove 2-6	< 0.01	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.05
Cove 2-7	< 0.01	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.05
Cove 2-8	< 0.01	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.05
Cove 2-9	< 0.01	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.05

Single p,p'-DDE detection highlighted and bolded.
Values in red indicate detection limit.
Trout analyzed whole-body minus liver and one gill arch

Table 4. Organochlorine compounds in brook trout from two Sheepscot River tributaries, µg/g wet weight.

Sample No.	PCB-Total	alpha BHC	beta BHC	gamma BHC	delta BHC	alpha chlordane	gamma chlordane	oxy-chlordane	heptachlor epoxide	cis-nonachlor	trans-nonachlor	o,p'-DDD	o,p'-DDE	o,p'-DDT	p,p'-DDD	p,p'-DDE	p,p'-DDT	dieldrin	endrin	HCB	mirex	toxa-phene
Finn Brook																						
Shee 1-1	< 0.01	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.05
Shee 1-2	< 0.01	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.05
Shee 1-3	< 0.01	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.05
Shee 1-4	< 0.01	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.05
Shee 1-5	< 0.01	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.05
Shee 1-6	< 0.01	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.05
Shee 1-7	< 0.01	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.05
Shee 1-8	< 0.01	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	**0.015**	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.05
Shee 1-9	< 0.01	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.05
Weaver Brook																						
Shee 2-1	< 0.01	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.05
Shee 2-2	< 0.01	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.05
Shee 2-3	< 0.01	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.05
Shee 2-4	< 0.01	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.05
Shee 2-5	< 0.01	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.05
Shee 2-6	< 0.01	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.05
Shee 2-7	< 0.01	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.05
Shee 2-8	< 0.01	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.05
Shee 2-9	< 0.01	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.05

Single p,p'-DDE detection highlighted and bolded.
Values in red indicate detection limit.
Trout analyzed whole-body minus liver and one gill arch

Table 5. Trace elements in brook trout from Cove Brook, µg/g wet weight.

Sample No.	Al	As	B	Ba	Be	Cd	Cr	Cu	Fe	Hg	Mg	Mn	Mo	Ni	Pb	Se	Sr	V	Zn
Below gravel pit																			
Cove 1-1	26.0	0.10	<0.5	0.16	<0.03	<0.03	1.10	7.90	35	0.09	333	12.8	<0.5	0.59	<0.05	0.45	6.36	<0.1	30.9
Cove 1-2	7.5	0.10	<0.5	0.06	<0.02	<0.02	<0.1	0.82	14	0.09	332	4.1	<0.5	<0.1	<0.05	0.42	7.18	<0.1	23.6
Cove 1-3	6.8	0.10	<0.5	0.10	<0.02	<0.02	<0.1	3.70	11	0.08	366	9.0	<0.5	<0.1	<0.05	0.38	9.98	<0.1	25.4
Cove 1-4	45.0	0.10	<0.5	0.20	<0.03	<0.03	0.20	6.00	103	0.06	376	8.3	<0.5	<0.1	0.07	0.55	9.90	<0.1	26.8
Cove 1-5	13.0	0.06	<0.5	0.07	<0.03	<0.03	<0.1	2.60	41	0.11	383	5.9	<0.6	<0.1	<0.06	0.39	11.40	<0.1	26.8
Cove 1-6	14.0	0.10	<0.5	0.16	<0.03	<0.03	<0.1	3.20	22	0.07	375	18.8	<0.5	<0.1	<0.05	0.34	12.20	<0.1	30.4
Cove 1-7	1.0	0.07	<0.5	0.10	<0.03	<0.03	<0.1	1.30	16	0.10	350	6.4	<0.5	<0.1	<0.05	0.53	7.57	<0.1	29.8
Cove 1-8	3.8	0.09	<0.5	0.10	<0.03	<0.03	<0.1	1.10	16	0.10	354	8.7	<0.5	<0.1	<0.05	0.39	10.60	<0.1	30.5
Cove 1-9	17.0	0.20	<0.5	0.10	0.02	<0.02	<0.1	3.40	39	0.06	336	6.5	<0.5	<0.1	<0.05	0.37	9.25	<0.1	24.1
C1Mean	14.9	0.10	nd	0.12	nd	nd	nc	3.34	33	0.08	356	8.9	nd	nc	nc	0.42	9.38	nd	27.6
Std Dev	13.6	0.04		0.05				2.35	29	0.02	20	4.4				0.07	1.98		2.9
Below Coles Corner Road																			
Cove 2-1	0.7	0.03	<0.6	0.06	<0.03	<0.03	<0.1	0.88	13	0.10	363	3.4	<0.6	<0.1	<0.06	0.35	9.66	<0.1	24.3
Cove 2-2	2.9	0.10	<0.5	0.10	<0.03	<0.03	0.85	1.70	20	0.08	351	7.8	<0.5	0.44	<0.05	0.66	8.82	<0.1	23.7
Cove 2-3	4.6	0.08	<0.5	0.10	<0.02	<0.02	<0.1	1.00	18	0.09	338	7.9	<0.5	<0.1	<0.05	0.44	8.26	<0.1	26.4
Cove 2-4	8.7	0.07	<0.6	0.09	<0.03	<0.03	<0.1	0.86	13	0.08	352	8.1	<0.6	<0.1	0.06	0.44	9.44	<0.1	27.4
Cove 2-5	0.3	0.06	<0.5	0.09	<0.03	<0.03	<0.1	3.40	11	0.08	362	4.5	<0.5	<0.1	<0.05	0.36	9.24	<0.1	22.2
Cove 2-6	0.6	0.09	<0.5	0.06	<0.02	<0.02	<0.1	1.10	9.8	0.06	381	9.8	<0.5	<0.1	<0.05	0.37	13.90	<0.1	28.3
Cove 2-7	2.1	0.07	<0.5	0.07	<0.03	<0.03	<0.1	1.00	16	0.07	329	5.4	<0.5	<0.1	<0.05	0.51	8.75	<0.1	24.1
Cove 2-8	3.4	0.10	<0.5	0.07	<0.03	<0.03	1.10	1.10	15	0.09	360	4.7	<0.5	0.53	<0.05	0.43	8.71	<0.1	27.7
Cove 2-9	13.0	0.16	<0.5	0.10	<0.02	<0.02	<0.1	0.95	18	0.01	351	6.6	<0.5	<0.1	<0.05	0.55	9.72	<0.1	32.0
C2Mean	4.0	0.08	nd	0.08	nd	nd	nc	1.33	15	0.07	354	6.5	nd	nc	nd	0.46	9.61	nd	26.2
Std Dev	4.26	0.036		0.017				0.815	3.4	0.027	15.1	2.10				0.101	1.680		3.00
Grand Mean	9.5	0.09		0.10				2.33	24	0.08	355	7.7				0.44	9.50		26.9
Std Dev	11.3	0.04		0.04				1.99	22	0.02	17	3.6				0.09	1.79		2.9

µg/g = parts-per-million, nd = non-detect, nc = not calculated, values in red preceded by < symbol indicate non-detects

Shaded values indicate one-half the detection limit. If one-half or more of the samples were non-detect, a mean was not calculated.

Trout analyzed whole-body minus liver and one gill arch

Table 6. Trace elements in brook trout from two Sheepscot River tributaries, µg/g wet weight.

Sample No.	Al	As	B	Ba	Be	Cd	Cr	Cu	Fe	Hg	Mg	Mn	Mo	Ni	Pb	Se	Sr	V	Zn
Finn Brook																			
Shee 1-1	1.9	0.39	0.6	0.18	<0.03	<0.03	<0.1	0.69	12	0.07	309	2.8	<0.5	<0.1	<0.05	0.68	3.10	<0.1	23.4
Shee 1-2	6.8	0.07	<0.5	0.26	<0.03	<0.03	0.74	0.47	16	0.07	324	3.8	<0.5	0.38	<0.05	0.46	6.45	<0.1	23.4
Shee 1-3	6.8	0.07	<0.5	0.37	<0.03	<0.03	<0.1	2.20	13	0.08	343	6.1	<0.5	<0.1	<0.05	0.47	5.47	<0.1	21.7
Shee 1-4	9.7	0.025	<0.5	0.29	<0.02	<0.02	<0.1	1.20	20	0.05	304	5.4	<0.5	<0.1	<0.05	0.43	4.20	<0.1	23.9
Shee 1-5	11.0	0.26	<0.5	0.45	<0.03	0.03	<0.1	1.90	23	0.04	333	5.3	<0.5	<0.1	<0.05	0.65	5.27	<0.1	26.7
Shee 1-6	11.0	0.10	<0.5	0.28	<0.02	<0.02	1.10	1.10	24	0.06	318	6.1	<0.5	0.47	<0.05	0.39	6.41	<0.1	21.8
Shee 1-7	24.0	0.07	<0.5	0.44	<0.03	<0.03	<0.1	3.90	12	0.04	357	5.2	<0.5	<0.1	<0.05	0.46	9.51	<0.1	27.4
Shee 1-8	17.0	0.10	<0.5	0.42	<0.03	0.05	<0.1	3.30	23	0.04	301	3.8	<0.5	<0.1	<0.05	0.45	4.50	<0.1	28.6
Shee 1-9	2.1	0.025	<0.5	0.24	<0.03	<0.03	<0.1	2.00	12	0.06	314	6.0	<0.5	<0.1	0.1	0.37	4.90	<0.1	28.6
S1Mean	10.0	0.12	nc	0.33	nd	nc	nc	1.86	17	0.06	323	4.9	nd	nc	nd	0.48	5.53	nd	25.1
Std Dev	7.0	0.12		0.10				1.16	5	0.02	19	1.2				0.11	1.83		2.8
Weaver Brook																			
Shee 2-1	1.0	0.07	<0.5	0.36	<0.03	0.015	<0.1	2.50	9	0.015	308	3.0	<0.5	<0.1	<0.05	0.23	8.11	<0.1	17.3
Shee 2-2	7.0	0.06	<0.5	1.50	<0.03	0.04	<0.1	3.00	14	0.03	332	12.0	<0.5	<0.1	<0.05	0.33	27.40	<0.1	29.2
Shee 2-3	8.5	<0.05	<0.5	0.90	<0.03	0.015	0.62	1.80	11	0.015	296	9.5	<0.5	0.37	<0.05	0.23	12.70	<0.1	23.1
Shee 2-4	5.9	<0.06	<0.6	0.43	<0.03	0.03	<0.1	1.50	14	0.015	283	7.2	<0.6	<0.1	<0.06	0.27	8.97	<0.1	25.0
Shee 2-5	2.2	<0.06	<0.6	0.56	<0.03	0.015	0.30	1.20	11	0.04	302	7.2	<0.6	<0.1	0.09	0.27	11.10	<0.1	19.4
Shee 2-6	8.2	<0.06	<0.6	1.30	<0.03	0.03	1.50	1.90	16	0.03	334	11.5	<0.6	0.66	0.06	0.39	19.30	<0.1	23.6
Shee 2-7	2.8	<0.06	<0.6	0.87	<0.03	0.015	<0.1	2.10	8	0.015	311	7.6	<0.6	<0.1	0.06	0.28	16.60	<0.1	25.7
Shee 2-8	5.9	<0.05	<0.5	0.81	<0.03	0.04	<0.1	1.40	14	0.015	291	9.8	<0.5	<0.1	<0.05	0.28	13.00	<0.1	25.0
Shee 2-9	2.2	<0.05	<0.5	0.68	<0.03	0.04	<0.1	1.80	8	0.015	296	6.6	<0.5	<0.1	<0.05	0.24	13.50	<0.1	19.9
S2Mean	4.9	nc	nd	0.82	nd	0.03	nc	1.91	12	nc	306	8.3	nd	nc	nc	0.28	14.52	nd	23.1
Std Dev	2.8			0.38		0.01		0.56	3		18	2.8				0.05	5.95		3.7
Grand Mean	7.4	nc	nc	0.57	nd	nc	nc	1.89	14	0.04	314	6.6	nd	nc	nc	0.38	10.03	nd	24.1
Std Dev	5.8			0.37				0.88	5	0.02	20	2.7				0.13	6.29		3.3

µg/g = parts-per-million, nd = non-detect, nc = not calculated, values in red preceded by < symbol indicate non-detects
Shaded values indicate one-half the detection limit. If one-half or more of the samples were non-detect, a mean was not calculated.
Trout analyzed whole-body minus liver and one gill arch

Table 7. Mean trace element concentrations in brook trout from this study compared to collections in Mere Brook, µg/g wet weight.

Element	Cove Brook 2006 18 Individual Fish	Finn Brook 2006 9 Individual Fish	Weaver Brook 2006 9 Individual Fish	Mere Brook 1995[a] 5 Composite Samples (16 fish) and 2 Individual Fish	Mere Brook 2007[b] 3 Composite Samples (9 fish) and 3 Individual Fish
	Ave. Length 161 mm	Ave. Length 171 mm	Ave. Length 161 mm	Ave. Length 153 mm	Ave. Length 176 mm
	Mean ± Standard Deviation	Mean ± Standard Deviation	Mean ± Standard Deviation	Mean ± Standard Deviation	Mean ± Standard Deviation
Al	9.46 ± 11.25	10.03 ± 7.03	4.86 ± 2.84	NR	NR
As	0.09 ± 0.04	0.12 ± 0.12	NC	0.03 ± 0.01	0.05 ± 0.03
B	BDL	NC	BDL	NR	NR
Ba	0.10 ± 0.04	0.33 ± 0.10	0.82 ± 0.38	NR	NR
Be	NC	BDL	BDL	BDL	NR
Cd	BDL	NC	0.03 ± 0.01	0.03 ± 0.01	0.05 ± 0.04
Cr	NC	NC	NC	0.29 ± 0.15	1.25 ± 0.95
Cu	2.33 ± 1.99	1.86 ± 1.16	1.91 ± 0.56	1.77 ± 0.74	1.46 ± 0.52
Fe	24 ± 22	17 ± 5	12 ± 3	NR	NR
Hg	0.08 ± 0.02	0.06 ± 0.02	NC	0.09 ± 0.03	0.08 ± 0.01
Mg	355 ± 17	323 ± 19	306 ± 18	NR	NR
Mn	7.7 ± 3.6	4.9 ± 1.2	8.3 ± 2.8	NR	NR
Mo	BDL	BDL	BDL	NR	NR
Ni	NC	NC	NC	NC	0.74 ± 0.70
Pb	NC	BDL	NC	0.08 ± 0.03	0.09 ± 0.04
Se	0.44 ± 0.09	0.48 ± 0.11	0.28 ± 0.05	0.53 ± 0.07	0.67 ± 0.12
Sr	9.50 ± 1.79	5.53 ± 1.83	14.52 ± 5.95	13.36 ± 1.11	7.50 ± 2.33
V	BDL	BDL	BDL	0.09 ± 0.04	1.15 ± 0.87
Zn	26.9 ± 2.9	25.1 ± 2.8	23.1 ± 3.7	22.3 ± 1.5	19.3 ± 2.2

µg/g = micrograms per gram (parts-per-million); mm = millimeters. Mere Brook fish analyzed whole-body. Trout from Cove, Finn, and Weaver Brooks were analyzed whole-body minus liver and one gill arch.

NC = not calculated (i.e., one-half or more samples below detection); BDL = all samples below detection limits; NR = not reported

[a] Mierzykowski *et al*. 1997 (data for adult brook trout only; data for young of year samples not included)

[b] EPA 2008 (data for adult brook trout only; data for young of year samples not included)

Note: Mere Brook located in Brunswick, Cumberland County, Maine. Collections conducted at the U.S. Naval Air Station.

Table 8. Mean and median trace element concentrations in brook trout compared to the BEST and EMAP-NE programs, µg/g wet weight.

Element	BKT[1] Mean	BEST Mean	EMAP-NE Mean	BKT[1] Median	BEST Median	EMAP-NE Median
Al	8.45	NR	8.26	6.80	NR	3.47
As	0.09	0.11	0.08	0.07	0.19	0.05
B	NC	NR	NR	NC	NR	NR
Ba	0.34	NR	NR	0.19	NR	NR
Be	NC	NR	NR	NC	NR	NR
Cd	NC	0.03	0.02	NC	0.04	0.02
Cr	NC	0.76	0.19	NC	0.60	0.08
Cu	2.11	0.80	0.89	1.75	0.86	0.44
Fe	19.2	NR	34.8	14.5	NR	21.1
Hg	0.06	0.13	0.17	0.06	0.13	0.11
Mg	335	NR	NR	334	NR	NR
Mn	7.2	NR	NR	6.6	NR	NR
Mo	BDL	NR	NR	BDL	NR	NR
Ni	NC	0.30	0.21	NC	0.30	0.14
Pb	NC	0.07	0.09	NC	0.10	0.04
Se	0.41	0.59	0.37	0.39	0.53	0.31
Sr	9.76	NR	NR	9.25	NR	NR
V	BDL	NR	NR	BDL	NR	NR
Zn	25.5	35.2	21.1	25.2	36.0	18.8

µg/g = micrograms per gram (parts-per-million)

[1] BKT = brook trout; includes all samples from Cove Brook, Finn Brook, and Weaver Brook

NC = not calculated (i.e., one-half or more samples below detection); **BDL** = all samples below detection limits; **NR** = not reported

BEST = Biomonitoring of Environmental Status and Trends Program (Hinck *et al*. 2008); includes multiple fish species.

EMAP-NE = Environmental Monitoring and Assessment Program - Northeast (Yeardley *et al*. 1998); includes multiple fish species.

Table 9. Trace element concentrations in brook trout and white suckers from Cove Brook, µg/g wet weight.

Element	Brook Trout (BKT) 18 individual Samples		White Suckers (WS) 3 Composite Samples (8 fish)		Species with potentially higher mean concentration[1]
	Mean	Std Dev	Mean	Std Dev	
Al	9.46	11.25	47.50	17.66	WS
As	0.09	0.04	0.20	0.02	WS
B	BDL		0.67	0.19	WS
Ba	0.10	0.04	0.36	0.05	WS
Be	**BDL**		**BDL**		
Cd	**BDL**		**BDL**		
Cr	**NC**		0.24	0.04	WS
Cu	2.33	1.99	0.67	0.07	**BKT**
Fe	24	22	86	35	WS
Hg	0.08	0.02	0.15	0.06	WS
Mg	355	17	389	19	WS
Mn	7.7	3.6	35.2	12.2	WS
Mo	**BDL**		**BDL**		
Ni	**NC**		**BDL**		
Pb	**NC**		**BDL**		
Se	0.44	0.09	0.35	0.04	**BKT**
Sr	9.50	1.79	10.21	1.21	WS
V	**BDL**		**BDL**		
Zn	26.9	2.9	18.9	1.3	**BKT**

µg/g = parts-per-million
NC = not calculated (i.e., more than one-half of the samples were below detection limits)
BDL = below detection limit
[1] Gross comparison; datasets for trout and sucker are too dissimilar for statistical comparisons
White suckers collected in 2004 and analyzed whole-body. Brook trout collected in 2006 and analyzed whole-body minus liver and one gill arch.

Table 10. Trace element concentrations in brook trout and white suckers from Sheepscot River tributaries, µg/g wet weight.

Element	Brook Trout (BKT) 18 individual Samples		White Suckers (WS) 4 Composite Samples (12 fish)		Species with potentially higher mean concentration[1]
	Mean	Std Dev	Mean	Std Dev	
Al	7.44	5.84	48.23	35.68	WS
As	**NC**		0.78	0.16	WS
B	**NC**		0.83	0.60	WS
Ba	0.57	0.37	3.08	0.55	WS
Be	**BDL**		**NC**		
Cd	**NC**		**NC**		
Cr	**NC**		0.79	0.16	WS
Cu	1.89	0.88	NC		**BKT**
Fe	14	5	99	59	WS
Hg	0.04	0.02	0.35	0.03	WS
Mg	314	20	962	144	WS
Mn	6.6	2.7	83.5	15.1	WS
Mo	**BDL**		0.12	0.08	WS
Ni	**NC**		**BDL**		
Pb	**NC**		0.13	0.09	
Se	0.38	0.13	0.78	0.13	WS
Sr	10.03	6.29	28.93	9.59	WS
V	**BDL**		0.18	0.11	WS
Zn	24.1	3.3	46.1	4.1	WS

µg/g = parts-per-million
NC = not calculated (i.e., more than one-half of the samples were below detection limits)
BDL = below detection limit
[1] Gross comparison; datasets for trout and sucker are too dissimilar for statistical comparisons
White suckers collected in 2005 from four locations on the West Branch. Suckers analyzed whole-body.
Brook trout collected in 2006 from Finn Brook and Weaver Brook. Trout analyzed whole-body minus liver and one gill arch.