U.S. FISH AND WILDLIFE SERVICE
MAINE FIELD OFFICE
SPECIAL PROJECT REPORT: FY07-MEFO-1-EC

Contaminant Assessment of White Suckers from Eight Rivers in the Gulf of Maine Distinct Population Segment for Atlantic Salmon

September 2007

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by

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ABSTRACT

During development of the draft recovery plan for the Atlantic salmon, it was determined that insufficient information existed regarding environmental contaminants in eight Gulf of Maine rivers where the endangered Atlantic salmon is considered a Distinct Population Segment (DPS) under the Endangered Species Act. To address this data gap, white suckers (*Catostomus commersoni*) were collected for tissue residue analyses between 2003 and 2006 from the West Branch of the Sheepscot River, Ducktrap River, Cove Brook, Narraguagus River, Pleasant River, Machias River, East Machias River, and Dennys River. White suckers are a common sentinel species used in state, regional, and national biomonitoring programs to illustrate contaminant conditions and trends. Ninety whole-body white suckers from 27 locations in the eight rivers were separated into 47 samples (22 composites and 25 individuals) and analyzed for organochlorine compounds and trace elements in a screening-level contaminant survey.

Of 22 organochlorine compounds included in the analytical scan only two were detected with any regularity - Total PCBs and p,p'-DDE. Total polychlorinated biphenyl (PCB) was detected in all sucker samples from the Dennys River (mean 0.041 ppm), two fish from the Pleasant River (0.007 ppm, 0.018 ppm), and four composite samples from the East Machias River (mean 0.005 ppm). Total PCBs in suckers from the DPS rivers were similar to levels reported in regional and national biomonitoring programs. Although Total PCB was detected in 25 samples, and suckers from the Dennys River had six-fold higher Total PCB concentrations than fish from two other DPS rivers, Total PCB concentrations in DPS river white suckers did not exceed suggested biological effect levels. DDE, a metabolite of the insecticide DDT, was found in 12 of 28 samples (median 0.003 ppm) from the DPS rivers at levels three to fifteen times lower than levels reported in regional and national biomonitoring programs, and two orders of magnitude below a suggested DDT tissue threshold-effect level of 0.60 ppm.

The mean mercury concentration for all white sucker samples (0.22 ppm) from the DPS rivers was at the suggested tissue effect threshold level (0.20 ppm). Mercury is frequently found in biota at elevated levels in New England. Relative to higher trophic level fish species such as smallmouth bass (*Micropterus dolomieui*), elevated levels of mercury (> 0.50 to 1.00 ppm) are not commonly found in white suckers in New England. Among the DPS rivers, the highest mercury levels were found in white suckers from the Machias River (0.69 ppm) and to a lesser extent in the West Branch of the Sheepscot River (mean 0.35 ppm). In DPS river white suckers, concentrations of 18 other trace elements appeared lower or similar to median values reported in Maine, regional, or national biomonitoring programs.

This screening-level survey partially filled the data gap regarding environmental contamination in eight rivers in the Gulf of Maine DPS. Not all rivers were adequately sampled in this study, and additional tissue residue sampling is recommended for the lower segments of the Pleasant River, Machias River, East Machias River, and mainstem of the Sheepscot River. While organochlorine compounds and trace elements in DPS white suckers were at, or well below, levels associated with adverse biological effects in fish, little is currently known regarding additive or synergistic effects of low-level body burdens of multiple contaminants in fish.

Moreover, tissue residue analyses do not provide information regarding suites of contaminants that are not bioaccumulated (e.g., organophosphates and polycyclic aromatic hydrocarbons). To date, no bioassays have been conducted to determine potential exposure of DPS river fish to these suites of contaminants.

KEYWORDS: tissue, fish, white sucker, Maine

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LIST OF ACRONYMS/ABBREVIATIONS

ACF	Analytical Control Facility
BEST	Biomonitoring of Environmental Status and Trends
CVAA	cold vapor atomic absorption
DDD	dichlorodiphenyldicloroethane
DDE	dichlorodiphenyldichloroethylene
DDT	dichlorodiphenyltriclorophenothane
DEQ	Division of Environmental Quality
DPS	Distinct Population Segment
EMAP	Environmental Monitoring and Assessment Program
EPA	Environmental Protection Agency
ESA	Endangered Species Act
g	grams
GFAA	graphite furnace atomic absorption
ICP-MS	inductively coupled plasma - mass spectrometry
LOD	limit of detection
MASC	Maine Atlantic Salmon Commission
MEFO	Maine Field Office
µg/g	micrograms per gram (or ppm)
µg/L	micrograms per liter
mm	millimeters
MSCL	Mississippi State Chemical Laboratory
NMFS	National Marine Fisheries Service
NCBP	National Contaminant Biomonitoring Program
NRC	National Research Council
OC	organochlorine
PACF	Patuxent Analytical Control Facility
PAH	polycyclic aromatic hydrocarbons
ppm	parts-per-million (or µg/g)
QA/QC	Quality Assurance/Quality Control
REMAP	Regional Environmental Monitoring and Assessment Program
RTI	Research Triangle Institute
SWAT	Surface Water Ambient Toxics Program
TDI	TDI-Brooks International, Inc.
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
WGS	World Geodetic System
ww	wet weight

PREFACE

This report provides information on environmental contaminants in white suckers collected from eight Gulf of Maine rivers where Atlantic salmon are considered an endangered Distinct Population Segment. Analytical work for this project was completed under the following U.S. Fish and Wildlife Service Analytical Control Facility Catalogs:

5100006	PO Numbers: 94420-04-Y334 (RTI), 94420-04-Y335 (MSCL)
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5100014	PO Numbers: 94420-06-Y588 (RTI), PACF-05-007 (PACF)
5100019	PO Numbers: 94420-07Y759 (TDI), 94420-07Y760 (LET)

Questions, comments, and suggestions related to this report are encouraged. Written inquiries should refer to Report Number FY07-MEFO-1-EC and be directed to:

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

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1. Introduction

A Distinct Population Segment (DPS) of anadromous Atlantic salmon (*Salmo salar*) in the Gulf of Maine was listed by the U.S. Fish and Wildlife Service and National Marine Fisheries Service as an endangered species on November 17, 2000 (USFWS and NMFS 2000). The Gulf of Maine DPS encompasses all naturally reproducing populations of Atlantic salmon downstream of the former Edwards Dam site on the Kennebec River northward to the mouth of the St. Croix River. Based on genetic characteristics (NRC 2002), Atlantic salmon in these waters were classified as a DPS. To date, endangered Atlantic salmon populations have been found in eight Gulf of Maine rivers – Sheepscot River, Ducktrap River, Cove Brook, Narraguagus River, Pleasant River, Machias River, East Machias River and Dennys River. For decades, Atlantic salmon have been declining in Maine and Canadian Maritimes rivers and no single cause has been identified. In a review of water quality issues potentially affecting Atlantic salmon in Maine (Haines 2002), it was apparent that, except for the Dennys River, the East Machias River, and Penobscot River (Note: Cove Brook is a tributary of the Penobscot River), fish tissue contaminant data were lacking in six rivers within the Distinct Population Segment. Contaminant information that existed was collected by the USFWS and Maine Department of Environmental Protection. In 1997, the USFWS collected white sucker (*Catostomus commersoni*) and smallmouth bass (*Micropterus dolomieui*) from the upper Dennys River and East Machias River for residue analyses (organochlorines and trace elements) for an ecological risk assessment of the Eastern Surplus Superfund Site (Mierzykowski and Carr 1998). MEDEP had been collecting smallmouth bass and white sucker tissue organochlorine and trace element contaminant data in the Penobscot River annually through their Dioxin Monitoring Program and SWAT (Mower 2001). Clearly, more information was needed to assess contamination in the Gulf of Maine DPS rivers.

Fish are exposed to a number of contaminants in the DPS rivers through consumption of contaminated prey or respiration. Although many reaches of the DPS rivers run through wild, undeveloped areas, sources of contamination do exist. Mercury contamination through atmospheric deposition is an ongoing problem in Maine and the other New England states (Evers *et al*. 2007). A National Priority List Superfund Site exists on the Dennys River and a state-listed hazardous site is located on one of its tributaries. Vehicle-related contaminants from runoff or accidents may enter DPS rivers from several road and bridge crossings. Discharges or runoff from residential, municipal, and commercial developments may also affect DPS rivers. For example, in May 2001, a spill from a residential fuel tank occurred on the Pleasant River (Fannin 2001). Agricultural and silvicultural activities occur throughout the Maine DPS. In the Downeast rivers, a number of pesticides (insecticides, herbicides, fungicides) are applied to commercial lowbush blueberry fields (MEPI 2006). Vast tracks of woodlands are managed within the DPS watersheds and forestry management chemicals are often used (Lansky 2004). Roadside and utility right-of-way vegetation control operations are also possible pesticide-related contaminant sources to the rivers.

Organochlorine compounds or trace elements may affect fish behavior (Magee *et al.* 2001), life stage development and reproduction (Madsen *et al.* 1997), and survival (Zabel *et al.* 1995).

Because of their endangered species status and critically low numbers, it would be difficult to lethally sample Atlantic salmon in the Gulf of Maine DPS rivers for contaminant analysis. However, white suckers exist in all rivers in the Gulf of Maine DPS. To assess contamination in eight rivers in the Gulf of Maine DPS, tissues of stream-resident white suckers were examined for trace elements and organochlorine compounds. Suckers are extremely useful as stream-resident sentinels of contaminant exposure and effects, and have been used in several state, regional, and national biomonitoring programs. White suckers feed on benthic invertebrates, primarily chironomids, cladocerans, and empheropterans (Scott and Crossman 1973, Chen and Harvey 1995). Young Atlantic salmon parr may feed on similar prey as white suckers, but salmon obtain more of their prey during drift feeding than foraging on the substrate (Mills 1991) and have a dietary component of terrestrial insects (Scott and Crossman 1973). Older parr and pre-smolt salmon consume small fish such as dace, minnows, and alewives (Baum 1997). Consequently, suckers are not ideal surrogates for young salmon that develop in streams and rivers, and caution should be used in applying these white sucker contaminant results towards salmon.

2. Study Objective

Determine levels of environmental contaminants in whole-body white suckers from eight rivers within the Gulf of Maine DPS for Atlantic salmon.

3. Study Areas

White suckers were collected from 27 locations on eight rivers in the Gulf of Maine where Atlantic salmon are considered a Distinct Population Segment. The eight rivers in this study were the Sheepscot River (West Branch), Ducktrap River, Cove Brook, Narraguagus River, Pleasant River, Machias River, East Machias River, and Dennys River (Figure 1). Sampling locations were selected by MASC personnel based on their local experience regarding sucker habitat and knowledge of access for backpack or boat electrofishing. Sampling locations were evenly spaced within drainages to the extent practicable, however not all rivers were sampled throughout their lengths. Fish collection location coordinates are listed in Table 1.

3.1 Sheepscot River - The 34-mile Sheepscot River is located in Lincoln and Kennebec Counties and drains an area of 228 square miles (Meister 1982). The West Branch of the Sheepscot River is approximately 15 miles in length (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 2005a). White suckers were collected from four locations on the West Branch of the Sheepscot River. Sampling locations were: L1 - below Branch Pond, L2 - at Smokey's Camp downstream of Route 3, L3 - upstream of Maxcy's Mills Road, and L4 - below Tyler Road.

3.2 Ducktrap River - The 9-mile Ducktrap River is located in Waldo County and drains an area of approximately 33 square miles (PEARL 2007). Large tracts of riparian habitat and other land in the watershed have been protected by local land trusts. Potential contaminant sources within

the watershed include road runoff and nonpoint sources associated with commercial and residential developments. White suckers were collected from four locations on the Ducktrap River. Sampling locations were: L1 - above Tucker Fall and below the Tanglewood Camp, L3 - below the Route 52 bridge, L4 - above the Route 52 bridge, and L6 - below the Dizkey Mill.

3.3 Cove Brook - Cove Brook is a tributary of the Penobscot River. The 4.5-mile brook is located in 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. Three locations were sampled for white suckers in Cove Brook. Sampling locations were: L1 - west of Route 1A, L2 - north of a gravel pit, and L3 - east of the railroad trestle.

3.4 Narraguagus River - The 43-mile Narraguagus River is located in Hancock and Washington Counties and drains an area of 232 square miles (Baum and Jordan 1982). Potential sources of contaminants include drifts or spills associated with pesticides applications on agricultural fields, faulty septic systems, landfill seepage or runoff, discharge from a municipal sewage treatment facility, individual overboard discharge sewer systems, and road runoff (Arter 2003). White suckers were collected at five locations - two along the west branch and three within the mainstem. Sampling locations were: L1 - along the west branch below Sprague Falls, L2 - on the west branch below the Crane Camp, L3 - at the bulldozer pool in the Town of Cherryfield, L4 - at the inlet of Beddington Lake, and L5 - at the Baker Camp north of Route 9.

3.5 Pleasant River - The 28-mile Pleasant River is located in Washington County and drains an area of 85 square miles (Dube and Jordan 1982). Potential sources of contaminants in the largely undeveloped watershed include drift or spills associated with pesticide applications on agricultural fields, road runoff, and nonpoint sources associated with commercial and residential developments. White suckers were collected at three locations. Sampling locations were: L2 - at Saco Falls, L3 - near the Farrin Camp, and L4 - Pleasant River Lake and its outlet.

3.6 Machias River - The 61-mile Machias River is located in Washington and Hancock Counties and drains an area of over 460 square miles (Fletcher *et al*. 1982). Potential sources of contaminants in the largely undeveloped watershed include drift or spills associated with pesticide applications on agricultural fields or silvicultural treatments, road runoff, and nonpoint sources associated with commercial and residential developments. Four individual white suckers were collected from a single location on the Machias River. The location, L1, was along the 52-00-00 Road south of the Stud Mill Road.

3.7 East Machias River - The 37-mile East Machias River is located in Washington County and drains an area of 251 square miles (Dube and Fletcher 1982). Potential sources of contaminants in the largely undeveloped watershed include road runoff, and nonpoint sources associated with commercial and residential developments. Two locations were sampled on the East Machias River, both north of Route 9. Sampling locations were: L1 - immediately north of Route 9 and L2 - below Pokey Dam, the outlet of Crawford Lake.

3.8 Dennys River - The 20-mile Dennys River is located in Washington County and drains an area of 132 square miles (Beland *et al*. 1982). Potential contaminant sources include the Eastern Surplus Superfund Site (a National Priority List Site with documented PCB contamination), a junkyard located on Dead Stream (tributary to the Dennys River), drifts or spills associated with pesticides applications on agricultural fields, septic systems, and road runoff (Arter 2005b). Five locations were sampled for white suckers in the Dennys River. Sampling locations were: L1 - beside the Eastern Surplus Superfund Site north of Route 191, L2 - in the deadwater below Route 191, L3 - in the mouth of the Dead River at its confluence with the Dennys River, L4 - the Dennys River reach below the Dead Stream confluence, and L5 - north of Gilman Brook.

4. Methods

4.1 Fish Collections - Prior to sampling, scientific collection permits were obtained from the Maine Department of Inland Fisheries and Wildlife. Since collections would occur in rivers with an endangered species, an intra-service Section 7 consultation form was completed and reviewed by Endangered Species Specialists in the Maine Field Office and New England Field Office. Biosecurity and disinfection protocols of the Maine Atlantic Salmon Commission were followed prior to all sampling. Fish collections were accomplished by personnel from the Maine Atlantic Salmon Commission and U.S. Fish and Wildlife Service primarily by electrofishing - backpack and boat. Five fish were captured in trap nets.

4.2 Tissue Residues - White suckers were collected from eight rivers between 2003 and 2006. Individual fish or composites of similar size (by location) were collected in each river and analyzed whole-body (Table 2). Fish were measured for length and weight, examined for abnormalities, wrapped in aluminum foil, and stored on wet ice or dry ice in the field. Upon return from the field, samples were frozen at -20^{o}C until shipped to analytical laboratories. Samples were analyzed for 22 organochlorine compounds and 19 trace elements.

USFWS contract laboratories scanned for the following organochlorine compounds: Total polychlorinated biphenyls (Total PCBs), hexachlorocyclohexanes (alpha, beta, delta, and gamma BHC), alpha chlordane, gamma chlordane, cis-nonachlor, trans-nonachlor, heptachlor expoxide, oxychlordane, o,p'-DDD, o,p'-DDE, o,p'-DDT, p,p'-DDD, p,p'-DDE, p,p'-DDT, hexachlorobenzene, dieldrin, endrin, mirex, and toxaphene. Residues were quantified by megabore column electron capture gas chromatography. Total PCB was determined by the sum of congeners for nearly all samples with exceptions for two rivers. Total PCB was determined by the sum of Aroclors for all sucker samples from the Narraguagus River and two samples (L2, L3) from the Pleasant River. The lower limit of detection (LOD) on a wet weight basis was 0.002 µg/g for most organochlorines, 0.01 µg/g for Total PCBs, and 0.05 µg/g for toxaphene.

USFWS contract laboratories scanned for the following trace elements: aluminum, arsenic, boron, barium, beryllium, cadmium, chromium, copper, iron, mercury, magnesium, manganese, molybdenum, nickel, lead, selenium, strontium, vanadium, and zinc. Most elements were quantified using inductively coupled plasma mass spectrometry (ICP-MS). Arsenic, lead, and

selenium were measured through graphite furnace atomic absorption (GFAA). Mercury levels were determined with cold vapor atomic absorption (CVAA). The lower limits of detection on an element-by-element, sample-by-sample basis can be determined by doubling shaded values in the appendix tables (i.e., shaded values are one-half the detection limit).

USFWS contract laboratories used in this study included the Research Triangle Institute in Research Triangle Park, NC (trace elements), Mississippi State Chemical Laboratory in Mississippi State, MS (organics), TDI-Brooks International, Inc. in College Station, TX (organics), and Patuxent Analytical Control Facility (organics). Dennys River samples were analyzed for the Environmental Protection Agency (EPA) at Alta Analytical Perspectives in Wilmington, NC (PCBs) and Mitkem Corporation in Warwick, RI (trace elements).

4.3 Quality Assurance / Quality Control (QA/QC) - QA/QC procedures for samples used in tissue residue analysis included procedural blanks, duplicates, spike recoveries, and standard reference material. Laboratory analytical packages were reviewed and approved by chemists of the USFWS Analytical Control Facility or EPA.

4.4 Data Presentations - Tissue residue data are presented in µg/g (parts-per-million) on a wet weight basis. Data are summarized by arithmetic mean ± standard deviation. Table 4 summarizes trace element results in suckers from the eight rivers only using samples with detectable concentrations. Table 5 lists Total PCB data for the Dennys River. Table 6 summarizes DDE and Total PCB data in other rivers where the compounds were detected. River-by river trace element tables of concentrations in whole-body white suckers are included in the appendix (Tables A-1 through A-4). If one-half or more of the samples had detectable levels of an element, a mean was calculated. In these calculations, a non-detect was assigned one-half the detection limit.

5. Results

5.1 Fish Metrics and Percent Lipids - Mean white sucker length was 215 ± 72 mm with a range of 85 to 417 mm (n=90). Over 70% of the fish used in tissue residue analyses fell within the 151 to 275 mm range (Figure 2). Among all rivers, fish lengths were smallest in the Ducktrap River and largest in the Machias River ($p < 0.05$, Kruskal-Wallis; Figure 3). Individual fish weights ranged widely from 5 to 735 grams (mean 137 ± 139 grams, n = 90). Fish collected from the Machias River were significantly heavier than fish from the other seven rivers ($p < 0.05$; Figure 3). Dennys River samples were also significantly heavier than fish from the Ducktrap River and Pleasant River. White sucker growth appeared similar among rivers (Figure 4). Percent lipid in the samples ranged from 0.82 to 5.99 (Table 3). Lipid content was highest in rivers where the largest fish were collected - Machias River and Dennys River.

5.2 Organochlorine Compounds

5.2.1 Total Polychlorinated Biphenyls (Total PCBs). Total PCBs were not found above detection limits in whole-body white suckers from five of the eight rivers. Of the remaining

three rivers, 19 individual white sucker samples from four reaches in the Dennys River had a mean Total PCB concentration of 0.041 ± 0.012 µg/g with a range of 0.017 to 0.062 µg/g (Table 5). Two individual fish samples from the Pleasant River had detectable levels of Total PCBs. A fish collected at the outlet of Pleasant River Lake had 0.007 µg/g and a fish collected from the lake had 0.018 µg/g of Total PCBs. Total PCBs were detected in four composite samples from the East Machias River (mean 0.0050 µg/g, range: 0.0041 - 0.0059 µg/g). Total PCB levels were nearly six-fold higher in Dennys River suckers (Table 5) than in suckers from the Pleasant and East Machias Rivers (Table 6), the only other DPS rivers where PCBs were detected.

5.2.2 Dichlorodiphenyldichloroethylene (DDE). The isomer p,p'-DDE was the only other organochlorine compound besides Total PCBs often detected in sucker samples. DDE was detected in 12 of 28 samples (Table 6). DDE was found in all three composite samples from Cove Brook locations (0.004 µg/g above Rt. 1A, 0.005 µg/g beside the gravel pit, 0.004 µg/g near the railroad trestle). In the Pleasant River, one composite sample and two individual fish samples had detectable levels of DDE (0.004 µg/g at the Farrin Camp, 0.001 µg/g at the outlet of Pleasant River Lake, 0.007 µg/g in Pleasant River Lake). Two composite samples from the west branch of the Narraguagus River contained p,p'-DDE (0.003 µg/g below Sprague Falls, 0.003 µg/g below Crane Camp). DDE was detected in all four composite samples from the East Machias River (mean 0.0006 µg/g, range: 0.0004 - 0.0008 µg/g). DDE was not measured in 19 Dennys River individual sucker samples used in this study. In an earlier study (Mierzykowski and Carr 1998), p'p'-DDE in 15 individual whole-body white suckers from the Dennys River ranged from below detection to 0.0078 µg/g with a mean of 0.0021 µg/g.

5.2.3 Other organochlorine compounds. The following organochlorine compounds were not found above detection limits in all but one of the white sucker samples: hexachlorobenzene (HCB), hexachlorocyclohexanes (alpha BHC, beta BHC, delta BHC, gamma BHC), alpha chlordane, gamma chlordane, cis-nonachlor, trans-nonachlor, heptachlor expoxide, oxychlordane, o,p'-DDD, o,p'-DDE, o,p'-DDT, p,p'-DDD, p,p'-DDT, dieldrin, endrin, mirex, and toxaphene. In the individual whole-body sucker sample collected from Pleasant River Lake, low levels (< 0.0004 µg/g) of alpha chlordane, cis-nonachlor, trans-nonachlor, and HCB were detected.

5.3 Trace elements - In this section the mean, standard deviation, and range are provided for samples with detectable concentrations of trace elements. Table 4 summarizes detectable levels of trace elements in white suckers. For more detailed summaries that include samples with concentrations below detection, four tables in the appendix list trace element concentrations on a river-by-river, sample-by-sample basis in whole-body white suckers (Tables A-1 through A-4).

5.3.1 Aluminum (Al). Aluminum was detected in 29 of 47 samples. Aluminum concentrations ranged from non-detect (Dennys River) to 100.0 µg/g (West Branch of the Sheepscot River). Among samples with detectable concentrations, mean Al was 29.37 ± 22.92 µg/g.

5.3.2 Arsenic (As). Arsenic was detected in 32 of 47 samples. Arsenic was below

detection in all samples from the Narraguagus River and in 10 of 19 samples from the Dennys River. In 32 samples with detectable concentrations, mean As was 0.26 ± 0.25 µg/g and the range was 0.06 to 0.99 µg/g.

5.3.3 Boron (B). Boron was detected in 15 of 28 samples. Boron was below detection in four samples from the single Machias River location and at both East Machias River locations. The mean B concentration was 0.63 ± 0.33 µg/g. Boron was not measured in 19 Dennys River samples.

5.3.4 Barium (Ba). Barium was detected in 39 of 47 samples. Barium was found in all samples except in the Dennys where it was below detection in eight samples. When detected, mean Ba was 1.06 ± 0.88 µg/g with a range between 0.30 and 3.76 µg/g.

5.3.5 Beryllium (Be). Beryllium was measured in 47 samples but detected in only two samples, both from the West Branch of the Sheepscot River (0.04 µg/g and 0.13 µg/g).

5.3.6 Cadmium (Cd). Cadmium was detected in one-half the samples (22/44, Note: three samples from the Dennys River failed QA/QC and were excluded from data analyses). Mean Cd was 0.03 ± 0.02 µg/g. The highest Cd concentration was found in the Dennys River at the Dead Stream confluence (0.06 µg/g).

5.3.7 Chromium (Cr). Chromium was detected in 27 of 47 samples. At the Baker Camp location on the Narraguagus River, Cr was highest at 2.81 µg/g. The mean for all samples with detectable concentrations was 0.72 ± 0.83 µg/g.

5.3.8 Copper (Cu). Copper was found in 21 of 47 samples. The Cu mean was 1.17 ± 1.59 µg/g and the range was 0.51 to 7.96 µg/g. The highest concentration was found on the West Branch of the Sheepscot River, but the other three samples from this river were below detection.

5.3.9 Iron (Fe). Iron was detected in all samples with a range between 6 µg/g (Dennys River below Dead Stream confluence) and 182 µg/g (West Branch of the Sheepscot River near Smokey's Camp downstream of Rt. 3). Mean Fe was 41 ± 37 µg/g.

5.3.10 Mercury (Hg). Mercury was detected in all samples with a mean of 0.22 ± 0.17 µg/g. The lowest Hg concentration was found in a sample from the Ducktrap River above Tucker Falls (0.08 µg/g) and the highest was found at the sole Machias River location along the 52-00-00 Road between Route 9 and the Stud Mill Road (0.93 µg/g).

5.3.11 Magnesium (Mg). Magnesium was detected in all samples (n=47) with a mean of 456 ± 237 µg/g. The highest Mg concentration was found in a sample from the Machias River (1260 µg/g) and the lowest level was found on the Dennys River (223 µg/g).

5.3.12 Manganese (Mn). Manganese was also detected in all samples (n=47) with a mean of 24.3 ± 22.7 µg/g. The Mn range was large with a low of 3.1 µg/g (Dennys River) and a

high of 105.0 µg/g (West Branch of Sheepscot River).

5.3.13 Molybdenum (Mo). Molybdenum was detected in 9 of 28 samples. The mean was 0.13 ± 0.06 µg/g with a range of 0.05 to 0.24 µg/g. None of the samples from the Ducktrap River, Cove Brook, Pleasant River, and East Machias River had detectable levels of Mo. Molybdenum was not measured in 19 Dennys River samples.

5.3.14 Nickel (Ni). Nickel was detected in 20 of 44 samples (Note: three samples from the Dennys River failed QA/QC). The range was 0.02 to 0.84 µg/g and the mean was 0.18 ± 0.28 µg/g. Nickel was not detected in any samples from the West Branch of the Sheepscot River, Ducktrap River, Cove Brook, Pleasant River, Machias River, and East Machias River. All samples from the Narraguagus River (n=5) had detectable levels of Ni and it was found in 15 of 19 samples from the Dennys River.

5.3.15 Lead (Pb). In samples with detectable concentrations (11 of 47), mean Pb was 0.12 ± 0.08 µg/g and the range was 0.04 to 0.26 µg/g. Lead was detected in all samples from the West Branch of the Sheepscot River; single samples from the Ducktrap River, Pleasant River, and East Machias River; and in all four samples from the single collection location on the Machias River.

5.3.16 Selenium (Se). Selenium was detected in all samples (n=47) with a mean of 0.59 ± 0.26 µg/g and a range of 0.25 to 1.39 µg/g.

5.3.17 Strontium (Sr). Strontium was found all samples analyzed for the element (n=28, Note: 19 samples from the Dennys River were not analyzed for Sr). Mean Sr was 20.30 ± 10.01 µg/g. The highest level was found in a sample from the single collection location on the Machias River (49.40 µg/g) and the lowest was found in the Narraguagus River (8.45 µg/g at the inlet of Beddington Lake).

5.3.18 Vanadium (V). Vanadium was found in 29 of 47 samples. The highest V concentration, 0.45 µg/g, was found in the sample collected from the west branch of the Narraguagus River below the Crane Camp. Among samples with detections, mean V was 0.11 ± 0.13 µg/g.

5.3.19 Zinc (Zn). The highest Zn concentration was detected in the sample from the West Branch of the Sheepscot River at Smokey's Camp downstream of Route 3 (51.9 µg/g). The lowest Zn concentration was found in the Dennys River in a sample collected below the confluence with Dead Stream (11.9 µg/g). Zinc was detected in all samples (n=47) with a mean of 22.2 ± 10.4 µg/g.

6. Discussion

Contaminant concentrations in white suckers from the eight Gulf of Maine DPS rivers were *qualitatively* compared to previously collected fish tissue data from these rivers and to suggested

biological effects thresholds. Median and 90th percentile white sucker concentrations are listed in Table 7 and compared to similar percentiles reported in the Maine DEP Surface Water and Ambient Toxics monitoring program (SWAT; MEDEP 2005), EPA's Environmental Monitoring and Assessment Program for the northeastern U.S. (EMAP and REMAP; Yeardley *et al*. 1998, EPA 2006) and the USGS Biomonitoring of Environmental Status and Trends Program (BEST; Hinck J. 2007. Personal communication). These state, regional, and national biomonitoring programs examined contaminant concentrations in white suckers and several other species at higher trophic levels (e.g., largemouth bass, smallmouth bass, brown trout, brook trout, etc.) from large rivers or lakes. The 50th and 90th percentiles listed for these biomonitoring programs in Table 7 represent contaminant levels in all species combined. Consequently, comparisons among white sucker data from the eight, small DPS rivers and the state, regional, and national datasets should be viewed with caution.

6.1 Total Polychlorinated Biphenyls (Total PCBs) – Polychlorinated biphenyls are synthetic halogenated aromatic hydrocarbons that were used extensively as insulating or cooling agents in transformers and capacitors (Eisler and Belisle 1996). In 1979, the use of PCBs was banned in all applications in the United States by the Environmental Protection Agency. PCBs are lipophilic compounds that bioconcentrate in organisms and biomagnify in food chains (Eisler 1986). Although banned for decades, PCBs persist in the environment and are readily detected in biota.

Total PCB was found above detection limits in sucker tissue from three Gulf of Maine DPS rivers – the Pleasant, East Machias, and Dennys. The highest levels were detected in white suckers from the Dennys River. The nearly six-fold higher level of Total PCB in Dennys River white suckers (Table 5) compared to suckers from the Pleasant and East Machias Rivers (Table 6) likely reflects the influence of the Eastern Surplus Company Superfund Site in Meddybemps on Dennys River biota. Much of the Superfund site has been remediated, but groundwater extraction and treatment activities are ongoing.

Limited Total PCB data are available from previous fish tissue investigations on the DPS Rivers. In 1996, MEDEP measured Total PCBs in two 3-fish composite samples of brook trout skinless fillets (0.0053 µg/g, 0.0058 µg/g) and one 3-fish whole-body composite sample of white sucker (0.0086 µg/g from the Pleasant River (Mower, B. 2005. Personal communication). In a 1997 fish study, mean Total PCB concentration in white suckers was 0.046 µg/g (n=15, range: 0.014 to 0.092 µg/g) in the Dennys River and 0.012 µg/g in white suckers from the East Machias River (n=5, range: 0.004 to 0.023 µg/g; Mierzykowski and Carr 1998). These data indicated that PCBs may occur in the DPS river fish, and in the case of the Dennys (Table 5), that Total PCB levels in white suckers have not changed substantially between 1997 (mean 0.046 ± 0.024 µg/g) and 2003 (mean 0.041 ± 0.012 µg/g).

Compared to the BEST biomonitoring program (Table 7), Total PCB concentrations in white suckers from the Dennys River (median 0.041 µg/g, 90th percentile 0.059 µg/g) were not highly elevated. If the PCB data from the Pleasant River and East Machias River are added to the Dennys River data, the 50th and 90th percentiles for the DPS rivers drop to 0.033 µg/g and 0.057

µg/g, respectively. In the BEST program, the 50th and 90th percentile Total PCBs concentrations were 0.067 µg/g and 0.630 µg/g, respectively (Table 7). Total PCB levels in suckers from the DPS rivers were within 0.01 µg/g of the 50th percentile (0.033 µg/g vs. 0.024 µg/g) and 80th percentile (0.047 µg/g vs. 0.039 µg/g) found in all Maine fish collected for the Regional EMAP program.

Niimi (1996) reported that fish from higher trophic levels in uncontaminated freshwater environments had PCB concentrations in the low parts-per-billion range, while higher trophic level fish from contaminated water had PCB levels in the low parts-per-million range. Fish tissue PCB concentrations >100 µg/g may be lethal or affect reproduction in females, while concentrations >50 µg/g may reduce growth and survival of progeny (Niimi 1996). Compared to Niimi's (1996) suggested benchmarks, white suckers from the Gulf of Maine DPS rivers did not have highly elevated body burdens of Total PCBs.

6.2 Dichlorodiphenyldichloroethylene (DDE) – DDT, an organochlorine pesticide, was banned from use in the United States in the early 1970s. However, breakdown metabolites of DDT, particularly p,p'-DDE, continue to be found in tissues of Maine fish species including brook trout (Haines 1983, USFWS unpublished data), yellow perch (Mierzykowski *et al*. 2000), and brown bullhead (Mierzykowski and Carr 2004). Levels of DDE in white suckers from Cove Brook, the Pleasant River, the west branch of the Narraguagus River, and East Machias River (Table 6) were three to ten times lower than those reported in fish nationally (BEST) and regionally (REMAP, Table 7).

A comparison of white sucker DDE levels in the four Gulf of Maine DPS rivers noted above to levels reported for white suckers collected in 1997 from the Dennys River and the East Machias River (Mierzykowski and Carr 1998) indicate that DDE levels remain essentially unchanged over the last decade.

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 white suckers from the eight DPS rivers were well below the DDT tissue threshold effect level.

6.3 Mercury (Hg) - Mercury contamination through atmospheric deposition and from local or regional sources is an ongoing problem in Maine and the other New England states (Evers *et al*. 2007). Maine sport fishes, particularly bass, pickerel and white perch, contain elevated concentrations of Hg (medians of nine species ranged from 0.23 – 0.93 µg/g, Stafford and Haines 1997). Mercury was detected in all white sucker samples from the Gulf of Maine DPS rivers with a median value of 0.15 µg/g and a 90th percentile of 0.38 µg/g. The median white sucker Hg concentration in the DPS was similar to medians reported in the BEST, Northeastern EMAP, and SWAT biomonitoring programs (Table 7).

Beckvar *et al*. (2005) suggested that a Hg whole-body tissue threshold-effect level (t-TEL) of 0.20 µg/g would be protective of juvenile and adult fish. Among the eight rivers where suckers

were collected, the 0.20 µg/g t-TEL was exceeded at the West Branch of the Sheepscot River (0.35 µg/g) and Machias River (0.69 µg/g). A compilation of available fish tissue data for eight rivers within the Maine DPS reveals elevated (i.e., > 0.20 µg/g) Hg concentrations for the West Branch of the Sheepscot River (whole-body white suckers), Pleasant River (fillets of brook trout), Machias River (whole-body white suckers), East Machias River (fillet and whole-body smallmouth bass), and Dennys River (fillet of smallmouth bass; Figure 5).

6.4 Other trace elements - Trace elements are naturally occurring and regularly found in soil, sediment, water, and biota (e.g., magnesium, manganese, iron, etc.). Some trace elements are essential nutrients for biota, but may be hazardous at elevated levels. Seven elements are discussed below: arsenic, cadmium, copper, nickel, lead, selenium, and zinc. Aluminum and chromium concentrations are not discussed since samples were wrapped in aluminum foil prior to analyses.

6.4.1 Arsenic (As). In suckers with detectable concentrations, the median As level (0.15 µg/g) was similar to values reported in the BEST (0.19 µg/g) and Maine SWAT (0.20 µg/g) biomonitoring programs, but the As 90th percentile for DPS white suckers (0.66 µg/g) was twice as high as the 90th percentiles in other biomonitoring programs (Table 7). Among the eight rivers sampled, the highest As concentrations were detected in suckers from the West Branch of the Sheepscot River (mean 0.78 µg/g, max. 0.99 µg/g; Table A-1). Arsenic was below detection in all samples from the Narraguagus (Table A-2) and more than one-half the samples from the Dennys (Table A-4). When detected, As levels in Gulf of Maine DPS river suckers were more than five-fold lower than the As concentration range (5.4 - 11.6 µg/g) that may affect survival in some fish species (Jarvinen and Ankley 1999).

6.4.2 Cadmium (Cd). Cadmium was below detection in the majority of samples collected from seven Gulf of Maine DPS rivers. Fourteen of 16 samples from the Dennys River had detectable levels of Cd. Median (0.03 µg/g) and 90th percentile (0.05 µg/g) Cd levels in DPS white suckers were similar to 50th and 90th percentiles reported in Maine, regional, and national biomonitoring programs. Cadmium, when detected in DPS fish, was about one-half the reported effect concentration range (0.12 - 15.6 µg/g) for reduced growth and survival in fish (Jarvinen and Ankley 1999).

6.4.3 Copper (Cu). Copper was detected in 21 of 47 white sucker samples. The median Cu concentration in DPS white suckers (0.70 µg/g) was similar to the 50th percentiles for the BEST program (0.86 µg/g) and SWAT program (0.63 µg/g), and appeared higher than the EMAP program (0.44 µg/g). Copper was below detection limits in the Machias and Dennys Rivers and in three of four samples from the West Branch of the Sheepscot River (Tables A-1 through A-4). Copper is a fish neurotoxin that is found in fungicides, algaecides, vehicle exhaust and brake pad wear (Sandahl *et al*. 2004). Exposure to waterborne copper (2 µg/L) impairs juvenile salmon sensory physiology and predator avoidance (Sandahl *et al*. 2007). The impact of Cu body burdens to fish, however, is not known.

6.4.4 Nickel (Ni). Nickel was detected in 20 of 44 white sucker samples. Median Ni in

DPS suckers (0.04 µg/g) was below the medians found in the BEST (0.30 µg/g) and northeastern EMAP programs (0.14 µg/g; Table 7). Of the eight rivers, Ni was only detected in the Narraguagus (mean 0.60 µg/g; Table A-2) and Dennys River (mean 0.04 µg/g; Table A-4). Similar to Cu, the impact of Ni body burdens to fish is not known. Jenkins (1980) suggested a preliminary estimate of Ni in freshwater fish from uncontaminated areas of < 0.20 to 2.00 µg/g, but cautioned that more data were needed. Nickel concentrations in white suckers from the Narraguagus and Dennys Rivers fell within this range.

6.4.5 Lead (Pb). Lead was detected in 11 of 47 white sucker samples. White suckers from the DPS had 50th (0.09 µg/g) and 90th (0.24 µg/g) percentile Pb concentrations similar to percentiles reported in the BEST program and lower than the SWAT program (Table 7). The northeastern EMAP median Pb value (0.04 µg/g) appeared lower than the median found in the DPS. Lead was below detection in sucker samples from Cove Brook, the Narraguagus, and Dennys Rivers. Only one sample from the Ducktrap River, Pleasant River, and East Machias River had detectable Pb. Lead was detected in all sucker samples from the West Branch of the Sheepscot River (mean 0.13 µg/g) and Machias River (mean 0.11 µg/g). The suggested Pb effects threshold in fish is >0.40 µg/g (Jarvinen and Ankley 1999). None of the white suckers collected in this study exceeded the effects threshold.

6.4.6 Selenium (Se). Selenium was detected in all samples (n=47). Median Se in white suckers from the Gulf of Maine DPS rivers (0.55 µg/g) was similar to the BEST program (0.53 µg/g), and appeared lower than the northeastern EMAP (0.31 µg/g) and SWAT programs (0.16 µg/g). The low to high order of Se levels in white suckers from the DPS rivers was: East Machias, Cove, Pleasant, Ducktrap, Narraguagus, Dennys, West Branch of the Sheepscot, and Machias; suggesting no geographic trend. A proposed Se fish toxicity threshold is 1 µg/g (Lemly 1996; converted from 4 µg/g dry weight based on 75% moisture). A higher Se 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). White suckers from the Gulf of Maine DPS rivers have Se levels one-half to five-fold below the suggested Se threshold levels.

6.4.7 Zinc (Zn). Zinc was detected in all Gulf of Maine DPS river white sucker samples (median 18.1 µg/g, 90th percentile 43.3 µg/g) at levels similar to fish analyzed in the northeastern EMAP program (median 18.8 µg/g). Compared to fish from large rivers (e.g., Penobscot, Kennebec, Androscoggin) monitored in the SWAT program, suckers from the DPS rivers appeared to have three-fold higher Zn concentrations (Table 7). At the national scale (BEST), Zn levels were nearly twice as high as level in DPS river suckers. Together, these comparisons suggest that except for Maine's large rivers, Zn levels in Gulf of Maine DPS river suckers are typical for the region (i.e., EMAP) and lower than the national median (BEST). Citing several sources, Murphy *et al*. (1978) reported average Zn whole fish concentrations from uncontaminated areas ranging from 12 to 43 µg/g. The median and 90th percentile concentrations in whole-body white suckers from the eight Gulf of Maine DPS study rivers fall within this range.

7. Summary and Management Recommendations

A screening-level survey of organochlorine compounds and trace elements in whole-body white sucker tissue was conducted to assess contamination in eight Gulf of Maine DPS rivers. Of 22 organochlorine compounds included in the analytical scan only two were detected with any regularity - Total PCBs and p,p'-DDE. Several trace elements were detected in fish tissue.

Total PCBs were detected in 25 of 47 DPS fish samples, and suckers from the Dennys River had six-fold higher Total PCB concentrations than fish from the other DPS rivers. Total PCB levels in suckers from the Gulf of Maine DPS rivers were similar to concentrations reported in the regional EMAP and nationwide BEST biomonitoring programs. Fish tissue PCB concentrations >100 µg/g may be lethal or affect reproduction in females, while concentrations >50 µg/g may reduce growth and survival of progeny (Niimi 1996). Compared to Niimi's (1996) suggested benchmarks, white suckers from the Gulf of Maine DPS rivers did not have highly elevated body burdens of Total PCBs.

DDE, a metabolite of the insecticide DDT, was found in 12 of 28 samples (median 0.003 µg/g) from the DPS rivers at levels three to fifteen times lower than levels reported in regional and national biomonitoring programs, and two orders of magnitude below a suggested DDT tissue threshold-effect level of 0.60 µg/g (Beckvar *et al*. 2005).

The mean mercury concentration for all white sucker samples (0.22 µg/g) from the eight rivers was at the suggested tissue effect threshold level (0.20 µg/g, Beckvar *et al.* 2005). Typically, and relative to higher trophic level fish species such as smallmouth bass (*Micropterus dolomieui*, Stafford and Haines 1997, Kamman *et al*. 2005), highly elevated levels of mercury (0.75 – 1.00 µg/g) are not found in white suckers. Elevated mercury levels (i.e., > 0.20 µg/g), however, were found in white suckers from the Machias River (0.69 µg/g) and to a lesser extent in the West Branch of the Sheepscot River (mean 0.35 µg/g). In white suckers from the DPS rivers, concentrations of 18 other trace elements included in the analytical scan were similar to median values reported in Maine, regional, or national biomonitoring programs.

An insufficient number of samples were collected and an insufficient number of locations were sampled to adequately assess contamination in three of the Downeast rivers (i.e., Pleasant, Machias, and East Machias). Moreover, samples were only collected from the West Branch of the Sheepscot River - not the mainstem. Additional sampling from more locations in the mainstem Sheepscot, Pleasant, Machias, and East Machias Rivers is recommended.

Although highly elevated levels of organics and inorganics were not detected in whole-body white suckers, potential hazards to fish in the eight DPS rivers may still exist. Organophosphates, such as several of the pesticides used in agriculture and silviculture, do not accumulate in fish tissue and were not included in the analytical scans. Bioassays or toxicity tests would be required immediately after pesticide applications to detect adverse effects from these contaminants in fish. Similarly, polycyclic aromatic hydrocarbons (PAHs) are associated with petroleum products and often detected in fish collected near bridges, roads, and waste

facilities. As in the case of organophosphates, PAHs are rapidly metabolized in fish and do not accumulate in fish tissue. Bioassays or bile analyses would be required to determine PAH contamination in fish. Finally, although low levels of organochlorine and trace elements were detected in DPS suckers, little is currently known regarding additive or synergistic effects of low-level body burdens of multiple contaminants in fish.

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Figure 1. Rivers in the Maine DPS where suckers were collected

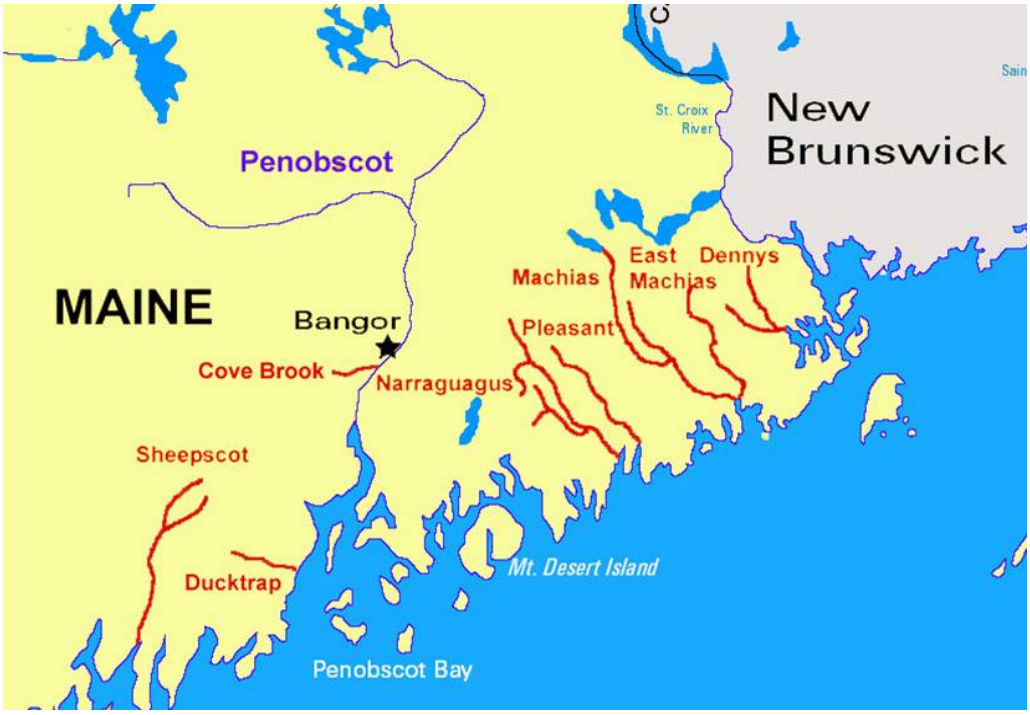

Figure 2. Length-frequency distribution of white suckers collected (n = 90)

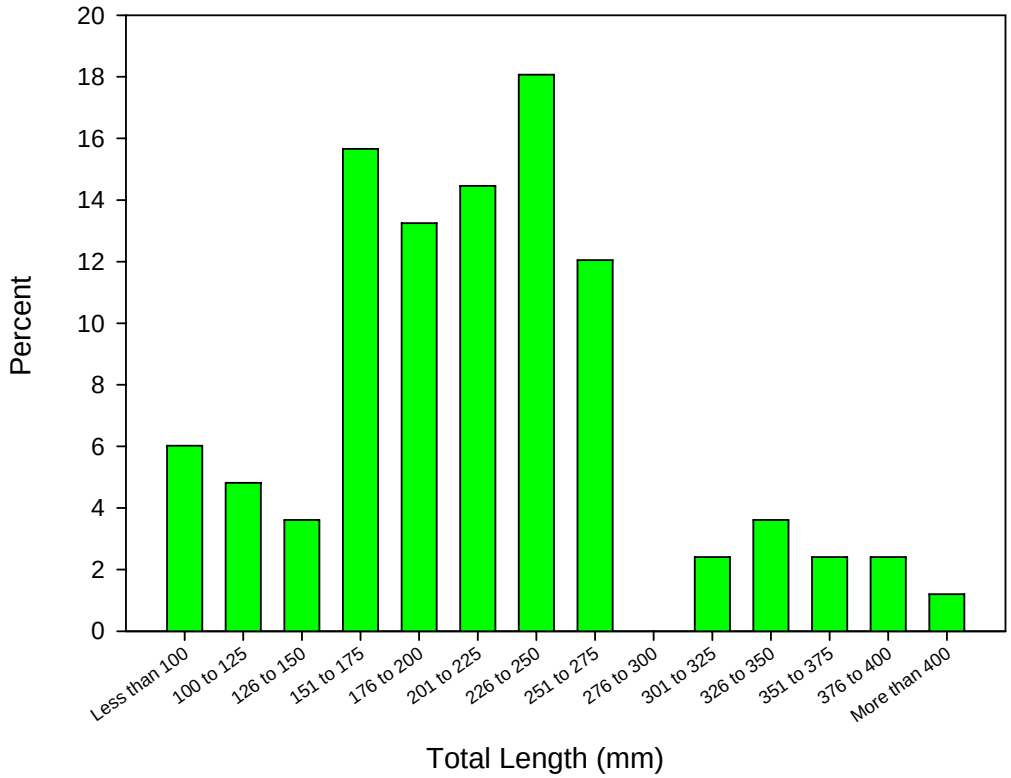

Figure 3. Length and weight of white suckers by river

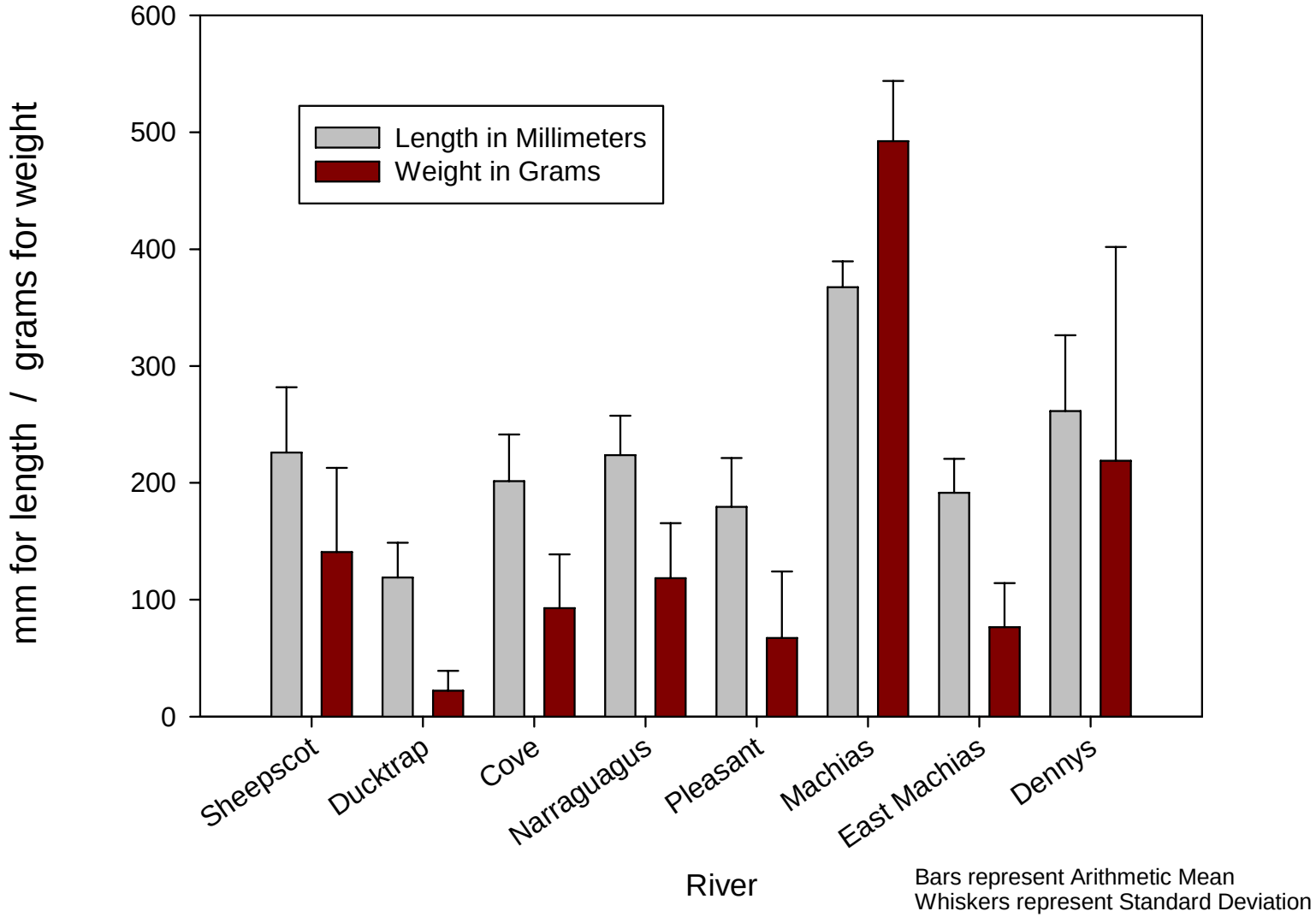

Figure 4. White sucker length vs. weight for all rivers

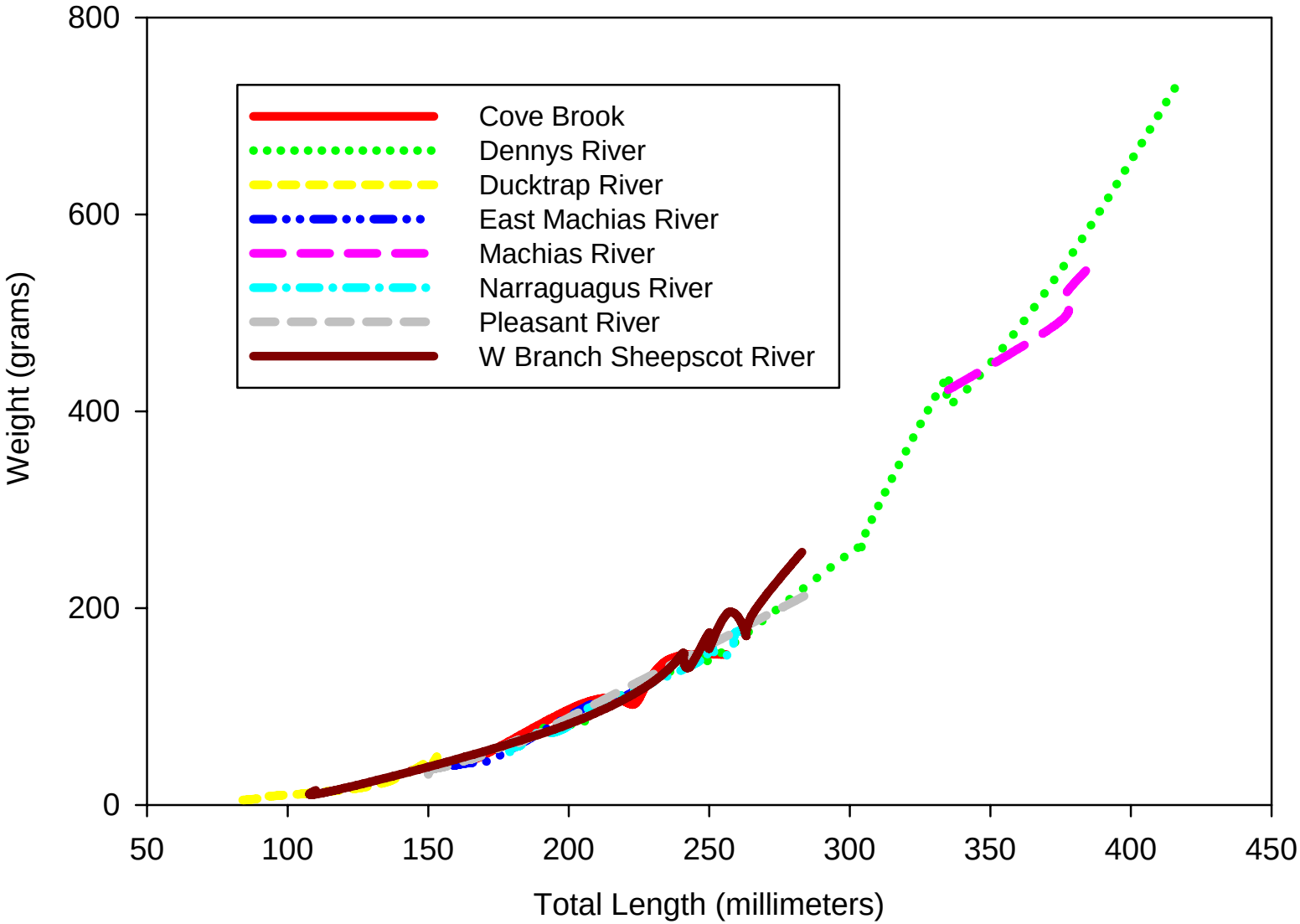

Figure 5. Mercury concentrations in fish from eight rivers in the DPS, ug/g wet weight

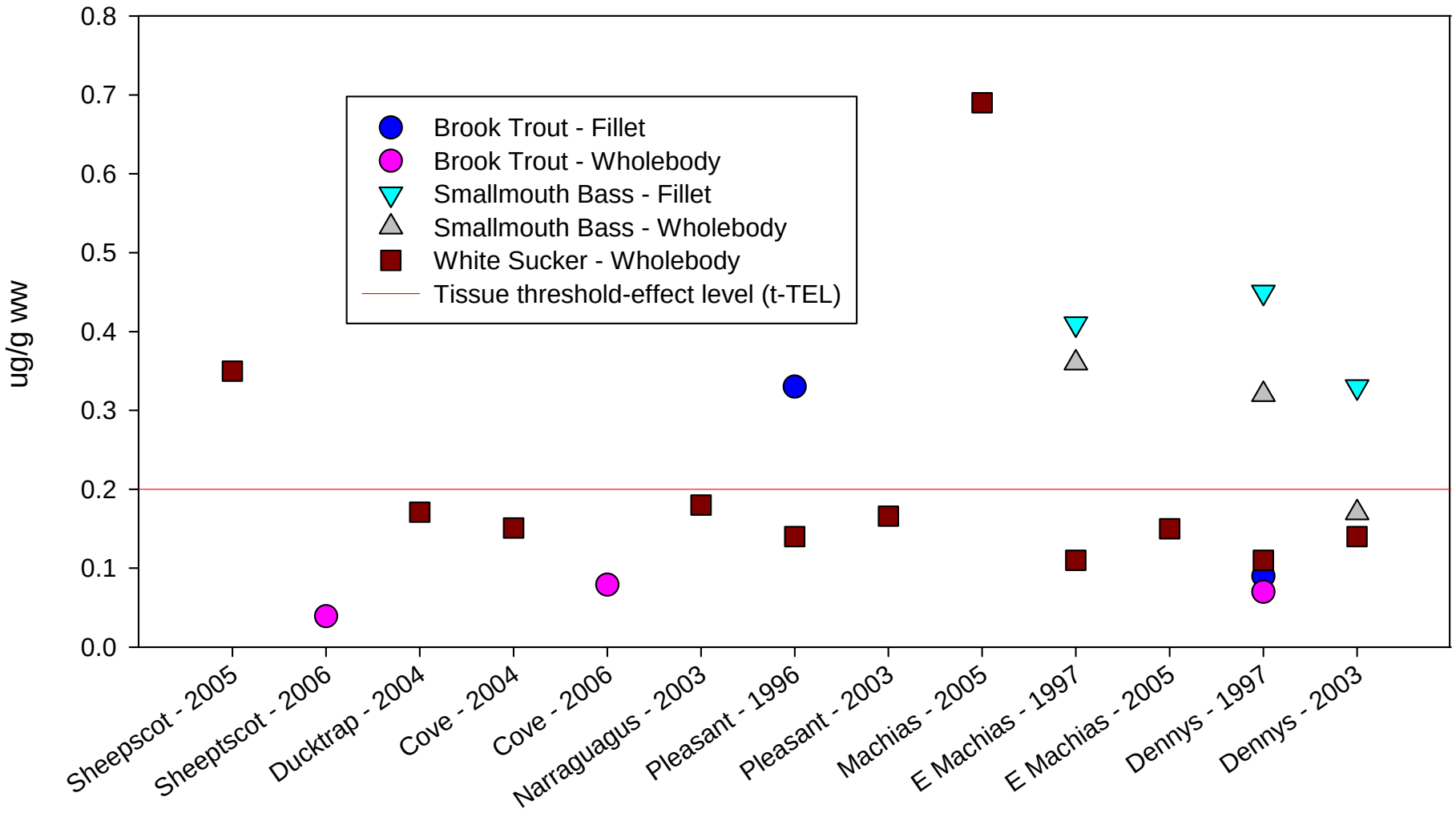

Table 1. Coordinates of white sucker collection locations.

River	Location	Site	Latitude	Longitude
Sheepscot	L1	W Branch Below Branch Pond	44° 24' 29.7"	069° 28' 30.6"
	L2	W Branch Smokey's Camp	44° 23' 35.5"	069° 29' 43.0"
	L3	W Branch Maxcy's Mills	44° 17' 26.2"	069° 33' 49.5"
	L4	W Branch Weeks Mills	44° 21' 31.4"	069° 32' 26.7"
Ducktrap	L1	Below Tanglewood	44° 18' 59.2"	069° 01' 58.1"
	L2	Below Rt. 52 Bridge	44° 19' 35.0"	069° 03' 27.4"
	L4	Above Rt. 52 Bridge	44° 19' 52.6"	069° 03' 51.1"
	L6	Below Dickey Mill	44° 21' 22.1"	069° 06' 13.8"
Cove	L1	Above Rt. 1A	44° 41' 36.8"	068° 50' 58.0"
	L2	Gravel Pit	44° 40' 52.3"	068° 52' 28.7"
	L3	Railroad Trestle	44° 40' 34.6"	068° 52' 28.7"
Narraguagus	L1	W Branch Below Sprague Falls	44° 38' 24.0"	067° 59' 15.1"
	L2	Below Crane Camp	44° 37' 29.4"	067° 57' 33.1"
	L3	Bulldozer Pool	44° 36' 19.2"	067° 55' 40.6"
	L4	Inlet Beddington Lake	44° 49' 41.6"	068° 03' 44.6"
	L5	Baker Camp	44° 54' 55.5"	068° 06' 21.5"
Pleasant	L2	Saco Falls	44° 41' 51.7"	067° 47' 13.5"
	L3	Farrin Camp	44° 43' 59.9"	067° 53' 49.1"
	L4	Pleasant River Lake & Outlet	44° 50' 08.1"	067° 57' 45.4
Machias	L1	52-00-00 Road	44° 58' 48"	067° 51' 45"
E. Machias	L1	Rt. 9 Apple Tree Turn-off	44° 00' 02.5"	067° 26' 09.3"
	L2	Pokey Dam	45° 00' 44.3"	067° 35' 11.8"
Dennys	L1	E Surplus Site	45° 02' 24.0"	067° 21' 23.1"
	L2	Deadwater below Rt. 191	45° 02' 15.3"	067° 21' 25.9"
	L3	Dennys/Dead Confluence	45° 00' 07.0"	067° 21' 34.9"
	L4	Below Dead Confluence	45° 00' 03.4"	067° 21' 15.5"
	L5	Lower Dennys	44° 58' 55.0"	067° 20' 08.9"

Map Datum: WGS 84

Table 2. White sucker sample numbers and fish metrics.

Location	Site	Sample No.	Length (mm)	Weight (g)
West Branch of the Sheepscot River (4 composite samples)				
L1	Below Branch Pond	WSHE-L1	257	196
			250	175
			241	154
L2	Smokey's Camp	WSHE-L2	195	77
			120	17
			110	15
L3	Maxcy's Mills	WSHE-L3	283	257
			265	192
			243	140
L4	Weeks Mills	WSHE-L4	263	173
			234	134
			250	159
Ducktrap River (4 composite samples)				
L1	Below Tanglewood	DUCK-L1	104	11
			115	14
			94	9
L2	Below Rt. 52 Bridge	DUCK-L2	161	43
			136	24
L4	Above Rt. 52 Bridge	DUCK-L4	91	7
			92	9
			93	9
			84	5
L6	Below Dickey Mill	DUCK-L6	153	49
			154	42
			152	45
Cove Brook (3 composite samples)				
L1	Above Rt. 1A	COVE-L1	170	51
			157	42
			144	35
L2	Gravel Pit	COVE-L2	204	102
			256	154
			235	148
L3	Railroad Trestle	COVE-L3	225	108
			220	105

Table 2 (continued). White sucker sample numbers and fish metrics.

Location	Site	Sample No.	Length (mm)	Weight (g)
Narraguagus River (five composite samples)				
L1	W Branch - Sprague Falls	NARR-L1	249	159
			264	176
			259	174
L2	W Branch - Crane Camp	NARR-L2	249	151
			252	154
			258	155
L3	Bulldozer Pool	NARR-L3	205	96
			201	85
			186	72
L4	Inlet Beddington Lake	NARR-L4	251	164
			244	142
			195	74
L5	Baker Camp	NARR-L5	180	59
			183	61
			179	54
Pleasant River (2 composite and 2 individual samples)				
L2	Saco Falls	PLEA-L2	185	70
			156	39
L3	Farrin Camp	PLEA-L3	164	46
			151	36
			150	31
			168	49
			165	47
L4	Pleasant River Lake & Outlet	PLEA-L4-01	190	74
		PLEA-L4-02	285	214
Machias River (4 individual samples)				
L1	52-00-00 Road	MACH-L1-01	335	422
		MACH-L1-02	375	492
		MACH-L1-03	376	513
		MACH-L1-04	384	543

Table 2 (continued). White sucker sample numbers and fish metrics.

Location	Site	Sample No.	Length (mm)	Weight (g)
East Machias River (4 composite samples)				
L1	Rt. 9 Apple Tree Turn-off	EMAC-L1-01	176	51
			159	40
			166	43
		EMAC-L1-02	135	22
			120	17
			119	16
L2	Pokey Dam	EMAC-L2-01	207	101
			234	133
			207	91
		EMAC-L2-02	175	52
			170	49
Dennys River (19 individual samples)				
L1	E Surplus Site	ESWSW01	417	735
L2	Deadwater below Rt. 191	DWWSW01	226	117
		DWWSW02	255	156
		DWWSW03	246	145
		DWWSW04	227	121
		DWWSW05	221	116
L3	Dennys/Dead Confluence	DWSSW01	245	148
		DWSSW02	248	151
		DWSSW03	205	84
		DWSSW04	302	260
		DWSSW05	305	272
L4	Below Dead Confluence	DCWSW01	213	103
		DCWSW02	191	78
		DCWSW03	213	103
		DCWSW04	196	82
		DCWSW05	216	105
L5	Lower Dennys	LDWSW01	334	432
		LDWSW02	336	408
		LDWSW03	375	543

Table 3. Lipid content (%) in samples by river and location

	West Branch Sheepscot River (4 loc.)	Ducktrap River (4 loc.)	Cove Brook (3 loc.)	Narraguagus River (5 loc.)	Pleasant River (3 loc.)	Machias River (1 loc.)	E. Machias River (2 loc.)	Dennys River (5 loc.)
	L1 - 3.32	L1 - 1.59	L1 - 3.14	L1 - 1.96	L2 - 1.46	L1 - 5.24[a]	L1 - 1.28	L1 - 5.99
	L2 - 1.81	L3 - 1.88	L2 - 4.06	L2 - 1.38	L3 - 1.65		L2 - 1.88	L2 - 4.04[a]
	L3 - 3.84	L4 - 0.82	L3 - 3.81	L3 - 2.16	L4 - 3.37			L3 - 4.16[a]
	L4 - 2.35	L6 - 0.82		L4 - 2.35				L4 - 3.82[a]
				L5 - 0.91				L5 - 5.82[a]
Average	2.83	1.28	3.67	1.75	2.16	5.24	1.58	4.77
Std Dev	0.92	0.54	0.48	0.59	1.05	nc	nc	1.05

loc. = locations

[a] Mean lipid content calculated when fish analyzed individually at a location

nc = not calculated

Table 4. Summary of organochlorine compounds and trace elements in white suckers from Gulf of Maine DPS rivers, ug/g wet weight.

Compound or Element	# > LOD of # Samples Analyzed	Low Conc.	High Conc.	Mean of Samples > LOD	Standard Deviation
Total PCBs	25 of 47	0.004	0.062	0.033	0.018
p,p'-DDE	12 of 28[a]	< 0.001	0.007	0.003	0.002
Aluminum (Al)	29 of 47	2.26	100	29.37	22.92
Arsenic (As)	32 of 47	0.06	0.99	0.26	0.25
Boron (B)	15 of 28[a]	0.30	1.68	0.63	0.33
Barium (Ba)	39 of 47	0.30	3.76	1.06	0.88
Beryllium (Be)	2 of 47	0.04	0.13	0.08	0.07
Cadmium (Cd)	22 of 44[b]	0.01	0.06	0.03	0.02
Chromium (Cr)	27 of 47	0.10	2.81	0.72	0.83
Copper (Cu)	21 of 47	0.51	7.96	1.17	1.59
Iron (Fe)	47 of 47	6	182	41	37
Mercury (Hg)	47 of 47	0.08	0.93	0.22	0.17
Magnesium (Mg)	47 of 47	223	1260	456	237
Manganese (Mn)	47 of 47	3.1	105.0	24.3	22.7
Molybdenum (Mo)	9 of 28[a]	0.05	0.24	0.13	0.06
Nickel (Ni)	20 of 44[b]	0.02	0.84	0.18	0.28
Lead (Pb)	11 of 47	0.04	0.26	0.12	0.08
Selenium (Se)	47 of 47	0.25	1.39	0.59	0.26
Strontium (Sr)	28 of 28[a]	8.45	49.40	20.30	10.01
Vanadium (V)	29 of 47	0.01	0.45	0.11	0.13
Zinc (Zn)	47 of 47	11.9	51.9	22.2	10.4

ug/g = parts-per-million, LOD = Limit of Detection

[a] p,p'-DDE, Boron, Molybdenum, and Strontium were not included in analyses for the Dennys River samples (n = 19).

[b] Three samples rejected during QA/QC.

Table 5. Contaminants in white suckers from the Gulf of Maine DPS rivers compared to other biomonitoring programs, ug/g wet weight.

Element	White Suckers from the Maine DPS			Biomonitoring Programs: National BEST		Regional EMAP - Northeast [a,b]		Maine SWAT 1994	
	# > LOD / n	50th	90th	50th	90th	50th	80th	50th	90th
Total PCBs	25 / 47	0.033	0.057	0.067	0.630	0.024	0.038	n/a	n/a
p,p'-DDE	12 / 28[c]	0.003	0.005	0.045	0.500	0.011	0.039	n/a	n/a
Arsenic	32 / 47	0.15	0.66	0.19	0.29	0.05	0.13	0.20	0.28
Cadmium	22 / 44[d]	0.03	0.05	0.04	0.12	0.02	0.03	0.03	0.05
Chromium	27 / 47	0.41	2.36	0.60	3.67	0.08	0.22	0.24	0.59
Copper	21 / 47	0.70	1.31	0.86	1.40	0.44	0.77	0.63	2.28
Mercury	47 / 47	0.15	0.38	0.13	0.34	0.11	0.25	0.17	0.73
Nickel	20 / 44[d]	0.04	0.62	0.30	0.87	0.14	0.30	n/a	n/a
Lead	11 / 47	0.09	0.24	0.10	0.29	0.04	0.10	0.33	0.73
Selenium	47 / 47	0.55	0.91	0.53	1.42	0.31	0.43	0.16	0.26
Zinc	47 / 47	18.1	43.3	36.0	82.0	18.8	24.1	6.34	17.7

> LOD / n = number of samples greater than the level of detection / number of samples analyzed

50th, 80th, and 90th indicate percentiles

n/a = data not available

BEST = USGS Biomonitoring of Environmental Status and Trends Program (Hinck J. 2007. Personal communication); percentiles for detectable conc.

[a] EPA Regional Environmental Monitoring and Assessment Program - organics (EPA 2006); percentiles for detectable con.

[b] EPA Environmental Monitoring and Assessment Program - Northeast, trace elements (Yeardley *et al*. 1998)

[c] Nineteen samples from Dennys River not analyzed for DDE.

[d] Three samples rejected during QA/QC

SWAT = MEDEP Surface Water Ambient Toxic Monitoring Program (MEDEP 2005); percentiles for detectable conc.

Note: BEST, NCBP, NE - EMAP percentiles include data for multiple species including white suckers

Table 6. Total PCBs in whole-body white suckers from the Dennys River, 2003.
(1997 data included for comparison)

Sample Number	Location	Total PCB 2003 (ug/g ww)[a]	Mean by Location 2003	Mean by Location 1997[b]
ESWSW01	ES-Dennys beside Superfund Site	0.031	0.031	0.054
			n=1	n=5
DWWSW01	DW-Deadwater	0.061		
DWWSW02		0.017		
DWWSW03		0.053	0.043	0.052
DWWSW04		0.039		n=5
DWWSW05		0.043		
DSWSW01	DS-Dennys/Dead Confluence	0.041		
DSWSW02		0.033		
DSWSW03		0.031	0.042	0.032
DSWSW04		0.049		n=5
DSWSW05		0.059		
DCWSW01	DC-Dennys below Dead Confluence	0.047		
DCWSW02		0.027		
DCWSW03		0.033	0.041	not sampled
DCWSW04		0.037		
DCWSW05		0.062		
LDWSW01	LD-Lower Dennys	0.030		
LDWSW02		0.046	0.041	not sampled
LDWSW03		0.046		
Grand Mean (all sites)		0.041		0.046
Standard Deviation		0.012		0.024
50th Percentile		0.041		0.038
90th Percentile		0.059		0.083

[a] Collections by USFWS, Analyses by EPA [b] Collections and Analyses by USFWS (Mierzykowski and Carr 1998)

Table 7. DDE and Total PCBs in white suckers from Cove Brook, Narraguagus River, Pleasant River, and East Machias River, ug/g wet weight.

	p,p'-DDE	Total PCBs
COVE-L1	0.004	0.0050
COVE-L2	0.005	0.0050
COVE-L3	0.004	0.0050
Mean	0.004	ND
Standard Deviation	0.001	
NARR-L1	0.003	0.0050
NARR-L2	0.003	0.0050
NARR-L3	0.0010	0.0050
NARR-L4	0.0010	0.0050
NARR-L5	0.0010	0.0050
Mean	NC	ND
PLEA-L2	0.0010	0.0050
PLEA-L3	0.004	0.0050
PLEA-L4-01	0.001	0.007
PLEA-L4-02	0.007	0.018
Mean	0.003	NC
Standard Deviation	0.003	
EMAC-L1-01	0.0005	0.005
EMAC-L1-02	0.0004	0.004
EMAC-L2-01	0.0008	0.005
EMAC-L2-02	0.0008	0.006
Mean	0.0006	0.005
Standard Deviation	0.0002	0.001

ug/g = parts-per-million
Shaded cells indicate non-detect. Value in cell is one-half the detection limit
ND = non-detect (i.e., all values below detection limit).
NC = not calculated (i.e., one-half or more of the samples were below detection limit)

Table A-1. Trace elements in white suckers from the West Branch of the Sheepscot River and the Ducktrap River, ug/g wet weight.

	Al	As	B	Ba	Be	Cd	Cr	Cu	Fe	Hg	Mg	Mn	Mo	Ni	Pb	Se	Sr	V	Zn
West Branch of the Sheepscot River																			
WSHE-L1	43.70	0.691	1.680	3.220	0.130	0.055	0.785	0.147	99.6	0.381	805	70.00	0.236	0.015	0.256	0.898	19.70	0.240	45.5
WSHE-L2	100.00	0.990	0.692	3.760	0.009	0.009	0.999	7.960	182.0	0.335	1150	80.60	0.115	0.015	0.152	0.868	42.40	0.317	51.9
WSHE-L3	24.00	0.820	0.282	2.460	0.008	0.008	0.621	0.141	61.4	0.386	977	105.00	0.046	0.014	0.061	0.742	26.80	0.080	44.1
WSHE-L4	25.20	0.614	0.663	2.880	0.037	0.007	0.739	0.123	53.6	0.316	916	78.30	0.083	0.012	0.060	0.606	26.80	0.097	42.7
Mean	48.23	0.779	0.829	3.080	NC	NC	0.786	NC	99.2	0.355	962	83.48	0.120	ND	0.132	0.779	28.93	0.183	46.1
Ducktrap River																			
Duck-L1	34.40	0.127	0.583	0.641	0.009	0.009	0.179	0.626	52.8	0.080	293	29.60	0.045	0.027	0.045	0.356	10.10	0.023	17.7
Duck-L3	20.70	0.162	0.496	0.620	0.013	0.013	0.474	1.710	50.3	0.232	375	12.40	0.063	0.038	0.242	0.500	13.70	0.032	20.2
Duck-L4	76.60	0.188	0.744	1.820	0.011	0.011	0.304	0.746	115.0	0.126	392	24.50	0.055	0.033	0.055	0.420	22.70	0.113	22.5
Duck-L6	7.34	0.134	0.174	0.431	0.012	0.012	0.218	0.600	24.3	0.248	404	33.00	0.058	0.035	0.058	0.471	15.20	0.029	20.4
Mean	34.76	0.153	0.499	0.878	ND	ND	0.294	0.921	60.6	0.171	366	24.88	ND	ND	NC	0.437	15.43	NC	20.2

ug/g = parts-per-million

Shaded cells indicate non-detect. Value in cell is one-half the detection limit.

ND = non-detect (i.e., all values below detection limit). NC = not calculated (i.e., one-half or more of the samples were below detection limits).

Table A-2. Trace elements in white suckers from Cove Brook and the Narraguagus River, ug/g wet weight.

	Al	As	B	Ba	Be	Cd	Cr	Cu	Fe	Hg	Mg	Mn	Mo	Ni	Pb	Se	Sr	V	Zn
Cove Brook																			
Cove-L1	30.20	0.200	0.451	0.297	0.013	0.013	0.224	0.701	48.6	0.090	387	21.10	0.067	0.040	0.067	0.314	11.10	0.033	20.4
Cove-L2	65.50	0.213	0.785	0.385	0.013	0.013	0.293	0.591	117.0	0.162	408	41.40	0.066	0.040	0.066	0.394	10.70	0.033	18.2
Cove-L3	46.80	0.172	0.759	0.384	0.014	0.014	0.209	0.712	92.8	0.201	371	43.10	0.068	0.041	0.068	0.339	8.84	0.034	18.1
Mean	47.50	0.195	0.665	0.355	ND	ND	0.242	0.668	86.13	0.151	389	35.20	ND	ND	ND	0.349	10.21	ND	18.9
Narraguagus River																			
NARR-L1	31.20	0.057	0.401	0.581	0.017	0.032	2.770	1.270	53.8	0.203	364	17.60	0.057	0.842	0.057	0.548	12.80	0.344	18.8
NARR-L2	37.50	0.057	0.561	0.746	0.017	0.036	2.380	1.310	59.7	0.126	426	30.50	0.182	0.605	0.057	0.614	23.00	0.447	20.9
NARR-L3	34.70	0.058	0.511	1.010	0.017	0.034	2.350	1.300	62.5	0.149	389	26.00	0.058	0.789	0.058	0.522	23.40	0.349	23.1
NARR-L4	21.80	0.055	0.300	0.460	0.016	0.032	0.702	1.280	41.3	0.233	309	12.30	0.055	0.197	0.055	0.516	8.45	0.235	21.6
NARR-L5	12.50	0.052	0.372	0.414	0.016	0.035	2.810	1.120	40.0	0.190	362	23.40	0.052	0.575	0.052	0.634	12.90	0.277	18.3
Mean	27.54	ND	0.429	0.642	ND	0.034	2.202	1.256	51.5	0.180	370	21.96	NC	0.602	ND	0.567	16.11	0.330	20.5

ug/g = parts-per-million

Shaded cells indicate non-detect. Value in cell is one-half the detection limit.

ND = non-detect (i.e., all values below detection limit). NC = not calculated (i.e., one-half or more of the samples were below detection limits).

Table A-3. Trace elements in white suckers from the Pleasant River and Machias River, ug/g wet weight.

	Al	As	B	Ba	Be	Cd	Cr	Cu	Fe	Hg	Mg	Mn	Mo	Ni	Pb	Se	Sr	V	Zn
Pleasant River																			
PLEA-L2	30.60	0.182	0.458	0.541	0.012	0.012	0.240	0.637	53.9	0.150	410	8.78	0.059	0.035	0.059	0.284	15.40	0.029	17.2
PLEA-L3	19.80	0.111	0.165	0.678	0.011	0.011	0.186	0.523	30.6	0.161	405	6.58	0.055	0.033	0.055	0.280	16.80	0.028	18.6
PLEA-L4-01	15.00	0.070	0.200	1.000	0.010	0.06	0.200	0.580	20.0	0.260	419	19.20	0.200	0.050	0.04	0.390	23.70	0.050	23.0
PLEA-L4-01	0.25	0.060	0.250	1.600	0.015	0.015	0.050	0.550	12.0	0.093	437	15.50	0.250	0.050	0.025	0.510	26.80	0.050	17.5
Mean	16.41	0.106	NC	0.95	ND	NC	0.169	0.573	29.1	0.166	418	12.52	ND	ND	NC	0.366	20.68	ND	19.1
Machais River																			
MACH-L1-01	59.40	0.663	0.398	2.300	0.012	0.012	0.810	0.199	110.0	0.643	1260	63.90	0.126	0.020	0.099	1.390	49.40	0.134	47.3
MACH-L1-02	3.67	0.443	0.278	1.160	0.008	0.008	0.410	0.139	29.5	0.521	738	33.20	0.118	0.014	0.087	1.230	25.10	0.037	36.0
MACH-L1-03	2.26	0.412	0.306	1.960	0.009	0.009	0.433	0.153	28.3	0.672	787	39.10	0.126	0.015	0.076	0.980	31.50	0.015	33.0
MACH-L1-04	4.31	0.488	0.277	2.320	0.008	0.008	0.472	0.138	39.6	0.934	828	42.60	0.110	0.014	0.184	1.090	32.60	0.052	44.8
Mean	17.41	0.502	ND	1.94	ND	ND	0.531	ND	51.9	0.693	903	44.70	0.12	ND	0.111	1.173	34.65	0.060	40.3

ug/g = parts-per-million

Shaded cells indicate non-detect. Value in cell is one-half the detection limit.

ND = non-detect (i.e., all values below detection limit). NC = not calculated (i.e., one-half or more of the samples were below detection limits).

Table A-4. Trace elements in white suckers from the East Machias River and Dennys River, ug/g wet weight.

	Al	As	B	Ba	Be	Cd	Cr	Cu	Fe	Hg	Mg	Mn	Mo	Ni	Pb	Se	Sr	V	Zn
East Machias River																			
EMAC-L1-01	35.00	0.090	0.200	1.200	0.010	0.040	0.200	0.770	30.0	0.140	396	29.20	0.200	0.050	0.080	0.250	17.30	0.05	22.4
EMAC-L1-02	18.00	0.100	0.200	1.000	0.010	0.010	0.200	0.650	20.0	0.150	374	20.90	0.200	0.050	0.020	0.310	16.50	0.05	20.5
EMAC-L2-01	6.20	0.070	0.200	0.510	0.010	0.010	0.200	0.520	13.0	0.140	350	14.80	0.200	0.050	0.020	0.270	14.40	0.05	15.7
EMAC-L2-02	8.30	0.100	0.200	0.490	0.010	0.010	0.100	0.510	12.0	0.170	370	15.20	0.200	0.050	0.020	0.270	11.30	0.05	17.3
Mean	16.88	0.090	ND	0.800	ND	NC	0.175	0.613	18.8	0.150	373	20.03	ND	ND	NC	0.275	14.88	ND	19.0
Dennys River																			
ESWSW01	17.50	0.035		0.480	0.004	0.046	0.095	0.295	50.2	0.120	299	7.50		0.069	0.034	0.700		0.035	14.8
DWWSW01	2.15	0.098		0.235	0.004	0.023	0.075	0.285	16.3	0.140	329	6.70		0.033	0.036	0.470		0.038	15.9
DWWSW02	0.75	0.038		0.245	0.004	0.032	0.140	0.310	12.0	0.120	337	10.00		0.039	0.023	0.420		0.017	15.5
DWWSW03	0.70	0.071		0.580	0.004	0.016	0.195	0.370	14.2	0.110	347	7.30		0.035	0.039	0.530		0.032	17.5
DWWSW04	2.35	0.110		0.950	0.003	0.041	0.060	0.255	15.9	0.130	300	14.70		0.043	0.043	0.350		0.029	15.2
DWWSW05	0.33	0.034		0.200	0.003	0.018	0.110	0.320	10.0	0.092	273	5.30		0.030	0.014	0.360		0.005	17.7
DSWSW01	0.26	0.035		0.550	0.003	0.007	0.185	0.265	10.3	0.100	314	3.30		0.058	0.033	0.740		0.014	11.9
DSWSW02	0.95	0.034		0.420	0.003	0.010	0.065	0.295	12.9	0.150	299	7.40		0.032	0.026	0.810		0.022	17.5
DSWSW03	0.90	0.034		0.460	0.003	0.016	0.060	0.325	14.9	0.230	299	8.80		0.034	0.021	0.870		0.014	13.9
DSWSW04	1.15	0.034		0.300	0.003	0.005	0.070	0.265	11.8	0.120	327	3.70		0.024	0.020	0.780		0.015	12.8
DSWSW05	0.14	0.036		0.070	0.004	0.058	0.040	0.245	21.4	0.160	223	3.10		0.018	0.017	0.930		0.005	14.7
DCWSW01	0.55	0.110		0.250	0.003	R	0.060	0.280	11.8	0.096	313	8.00		R	0.018	0.640		0.031	15.1
DCWSW02	5.65	0.036		0.230	0.004	0.034	0.060	0.400	32.7	0.110	294	6.70		0.046	0.028	0.670		0.028	14.3
DCWSW03	0.07	0.130		0.560	0.003	0.003	0.060	0.245	7.5	0.130	331	5.60		0.016	0.022	0.640		0.025	28.7
DCWSW04	0.07	0.034		0.170	0.003	0.002	0.055	0.160	5.7	0.140	309	5.70		0.015	0.020	0.590		0.004	11.9
DCWSW05	1.70	0.150		0.700	0.004	R	0.105	0.220	14.1	0.100	398	15.00		R	0.041	0.580		0.029	16.8
LDWSW01	6.35	0.110		0.910	0.002	0.051	0.075	0.340	22.9	0.140	495	27.20		0.007	0.050	0.390		0.075	18.1
LDWSW02	2.25	0.200		0.730	0.004	R	0.160	0.265	17.5	0.170	549	23.60		R	0.070	0.640		0.058	16.3
LDWSW03	19.50	0.150		0.220	0.004	0.051	0.075	0.395	66.7	0.300	311	13.30		0.058	0.043	0.680		0.070	17.3
Mean	NC	NC		0.435	ND	0.026	ND	ND	19.4	0.140	334	9.63		0.035	ND	0.621		0.029	16.1

ug/g = parts-per-million

Shaded cells indicate non-detect. Value in cell is one-half the detection limit. R indicates rejected data (i.e., did not meet QA/QC).

ND = non-detect (i.e., all values below detection limit). NC = not calculated (i.e., one-half or more of the samples were below detection limits).