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Maine Field Office – Ecological Services **March 2012**

Environmental Contaminants in Shortnose Sturgeon (*Acipenser brevirostrum*) From Bears Bluff National Fish Hatchery, Wadmalaw Island, South Carolina

Fish and Wildlife Service

U.S. Department of the Interior

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Environmental Contaminants in Shortnose Sturgeon from the Bears Bluff National Fish Hatchery, Wadmalaw Island, South Carolina

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Executive Summary

The shortnose sturgeon (*Acipenser brevirostrum*) is a federally-listed endangered species. In 2008, eleven shortnose sturgeon, reared at the Bears Bluff National Fish Hatchery in Wadmalaw, South Carolina, were analyzed to determine environmental contaminant burdens.

The sturgeon were divided into five, year-class specific, composite samples and analyzed for 21 organochlorine compounds and 19 trace metals. Three whole-body fish from the 1.5 year age class were composited and analyzed as a single sample. Skinless, boneless fillets of fish from four older age classes – 2.5 through 5.5 - were also analyzed.

In the organochlorine analytical scan, dichloro-diphenyl-trichloroethane (DDT) metabolites, dieldrin, and mirex were infrequently detected and found at low concentrations compared to levels found in wild fish or to suggested toxicity threshold effect levels. Polychlorinated biphenyl, benzene hexachloride, chlordane compounds, endrin, hexachlorobenzene, and toxaphene were below analytical detection levels.

Several trace metals were detected in sturgeon tissue samples. Arsenic, copper, mercury, selenium, and zinc levels in Bears Bluff NFH fish did not exceed suggested tissue effect thresholds and were low in comparison to wild shortnose sturgeon.

Keywords: shortnose sturgeon, contaminants, Bears Bluff NFH

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PREFACE

This report provides documentation of environmental contaminants in shortnose sturgeon (*Acipenser brevirostrum*) reared at the U.S. Fish and Wildlife Service Bears Bluff National Fish Hatchery in South Carolina. Analytical work was completed under U.S. Fish and Wildlife Service (USFWS) Analytical Control Facility Catalog 5100032 (Purchase Orders 94420-08-Y901 -organics and 94420-08-Y902 - inorganics).

Contaminant analyses were accomplished through capability funding (53411-1130-CAPB) provided by the USFWS Division of Environmental Quality in Arlington, Virginia. Pursuant to the Endangered Species Act of 1973 (ESA; 16 U.S.C. 1531 et seq.), all activities for this investigation were conducted by co-investigators listed under National Marine Fisheries Service (NMFS) ESA Permit Number 1614.

Questions, comments, and suggestions related to this report are encouraged. Written inquiries should refer to Report Number FY09-MEFO-9-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 shortnose sturgeon (*Acipensor brevirostrum*) is a federally-listed endangered species. To assess contaminant concentrations in hatchery-reared fish, eleven shortnose sturgeon from five age classes were obtained in 2008 from the Bears Bluff National Fish Hatchery in South Carolina. These hatchery-reared fish were formed into five, age-specific composites, and analyzed for organochlorine compounds and trace metals.

Elevated body burdens of contaminants in sturgeon species have been related to adverse biological effects (Webb *et al*. 2006). Organic contaminants may present a threat to reproduction and development in fish (Monosson 1999/2000), while exposure to trace elements affects predator avoidance, behavior and development (Berntssen *et al*. 2003, Webber and Haines 2003). Sturgeon accumulate contaminants through the ingestion of prey or sediment and through direct absorption of some water-dissolved contaminants across gill membranes. Hatchery-reared shortnose sturgeon may accumulate contaminants through hatchery feed or water. On occasion, the USFWS will analyze hatchery fish to determine contaminant burdens in brood stock or other life stages (Millard *et al*. 2004).

Due to their protected status and low numbers, lethal collections of shortnose sturgeon for scientific purposes are not possible. However, the use of tissues from salvaged fish is permitted by researchers under an Endangered Species Act Section 10 Permit.

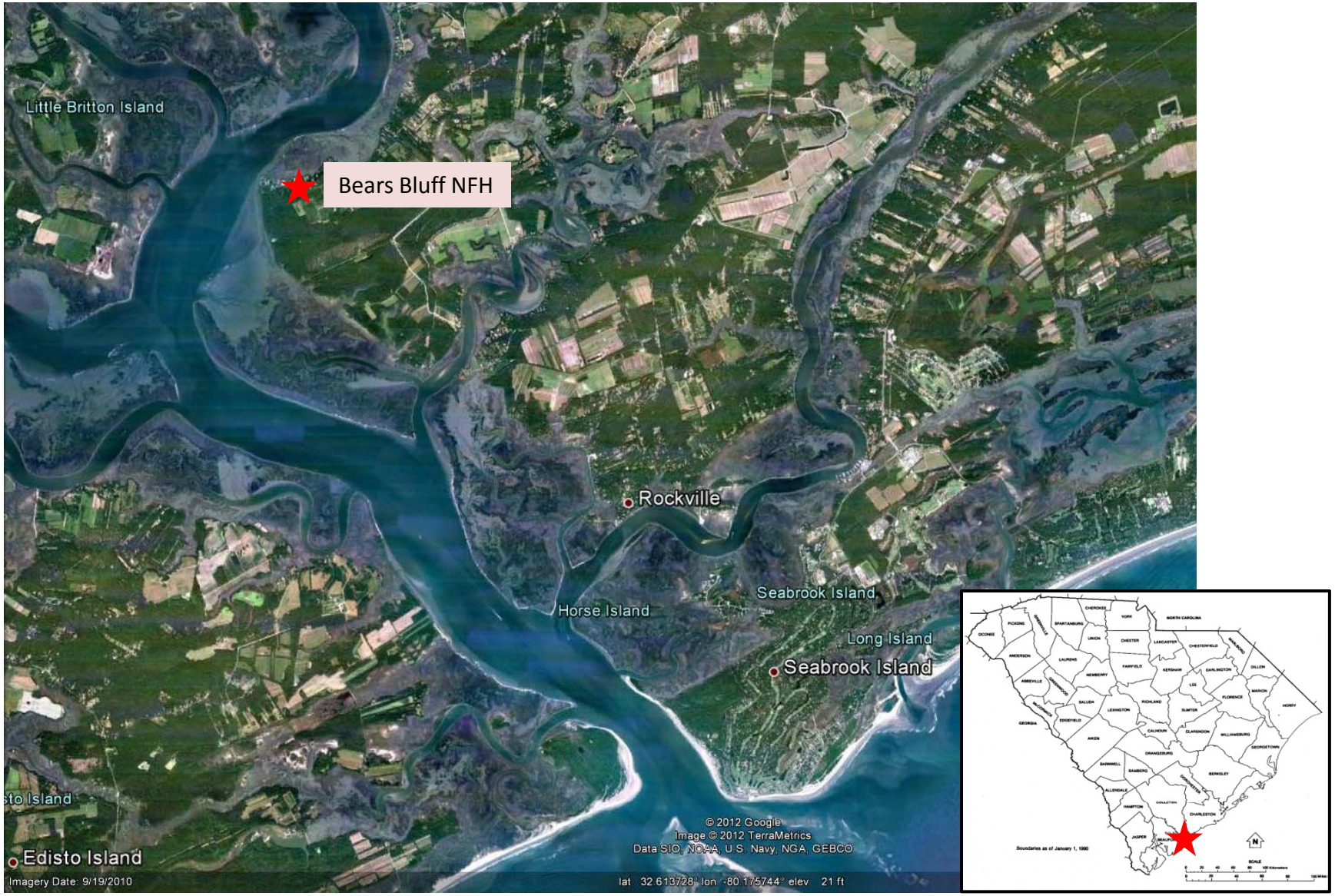
2. Objective

The objective of this study was to determine trace element and organic contaminant residue burdens in tissue samples of shortnose sturgeon from Bears Bluff NFH.

3. Study Area

Bears Bluff National Fish Hatchery in Wadmalaw Island, Charleston County, South Carolina, is a unit of the Warm Springs Fish Technology Center which is a component of the Warm Springs Regional Fisheries Center, in Warm Springs, Georgia. Bears Bluff NFH encompasses 31 acres bordering the North Edisto River south of Charleston, South Carolina (Figure 1). The station can propagate most freshwater and saltwater aquatic species found in the South Atlantic Coastal Region. The hatchery's facilities include nine re-circulated intensive culture systems; three re-circulated egg incubation/larval rearing systems; numerous holding and intensive rearing tanks; and six salt and freshwater ponds (USFWS 2010).

Figure 1. Location of Bears Bluff National Fish Hatchery, Wadmalaw Island, South Carolina



4. Methods

4.1 Endangered Species Act. Pursuant to the Endangered Species Act of 1973 (ESA; 16 U.S.C. 1531 et seq.), all activities for this investigation were conducted by authorized personnel and laboratories listed under NMFS Endangered Species Act Permit Number 1614.

4.2 Fish Processing. Eleven shortnose sturgeon from five age classes were provided by the hatchery in 2008 (Table 1). The fish were collected by hatchery personnel, euthanized with MS-222, packaged, shipped on ice and received frozen at the USFWS Maine Field Office – Ecological Services in Orono, Maine. Fish were partially thawed for processing. Recorded fish metrics included total length (mm), fork length (mm), inter-orbital width (mm), inner mouth width (mm), total body weight (g) and fillet sample weight (g) (Table 2). Total and fork length were measured with a tape measure. Inter-orbital and inner mouth widths were measured with dial calipers. Weights were measured with a calibrated electronic scale.

Prior to extracting each tissue sample, stainless-steel scalpels and scissors were decontaminated with a wash of biodegradable soap and tap water followed by a rinse with de-ionized water. Scalpels and scissors were used to remove skinless, boneless fillets from year classes 2.5 through 5.5. Year class 1.5 fish (n =3) were submitted as a whole-body composite. Skinless, boneless fillet samples were composited for the other four year classes (two fish per age class), wrapped in aluminum foil with the dull side towards the sample, placed in labeled, plastic zip-loc bags, and frozen until shipped to the analytical laboratories. Fresh, wet sample weights are listed in Table 2.

4.3 Contaminant Analyses. Five tissue samples were submitted for analytical quantification of 21 organochlorine compounds, 19 trace elements, percent moisture, and percent lipids.

Organochlorine analyses were conducted at the GPL Laboratories LLC in Frederick, Maryland. Quantification of residues was determined by megabore column electron gas chromatography. Compounds in the organochlorine scan included polychlorinated biphenyl (Total), benzene hexachloride (*alpha* BHC, *beta* BHC, *gamma* BHC; also known as hexachlorocyclohexanes), chlordane compounds (*alpha* chlordane, *gamma* chlordane, oxychlordane, heptachlor epoxide, *cis*-nonachlor, *trans*-nonachlor), dichloro-diphenyl-trichloroethane (DDT) metabolites and isomers (*o*,*p*'-DDD, *o*,*p*'-DDE, *o*,*p*'-DDT, *p*,*p*'-DDD, *p*,*p*'-DDE, *p*,*p*'-DDT), dieldrin, endrin, hexachlorobenzene (HCB), mirex, and toxaphene. Wet weight detection limit for organochlorine compounds was 1 ng/g, except for PCB-Total, *cis*-nonachlor and oxychlordane with detection limits of 5 ng/g.

Trace metal 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 0.02 µg/g for beryllium, cadmium, and mercury; 0.05 µg/g for arsenic, barium, lead, selenium, and strontium; 0.07 µg/g for copper; 0.10 µg/g for chromium, manganese, nickel, vanadium, and zinc; and 0.50 µg/g for boron, iron, magnesium, molybdenum and aluminum.

4.4 Quality Assurance/Quality Control (QA/QC). Standard procedures of the USFWS Analytical Control Facility in Shepherdstown, West Virginia, were used by the analytical laboratories for quality assurance and quality control (USFWS 2007). QA/QC procedures include duplicates, procedural blanks, spikes, and certified reference material. QA/QC results of the two laboratories were deemed acceptable by the USFWS Analytical Control Facility.

4.5 Data presentations. Organochlorine compound concentrations are expressed in ng/g (nanograms per gram or parts-per-billion) on a wet weight basis (Table 3). Trace metals are expressed and discussed in µg/g (microgram per gram or parts-per-million) on a wet weight (Table 4). Since some papers in the scientific literature present trace metal results on a dry weight basis, a second table with trace metal dry weight results is also provided (Table 5).

Table 1. Bears Bluff NFH shortnose sturgeon year class and size

Fish Number	Year Class	Age*	Total Length (mm)	Total Weight (g)
BBSN-1	YC 2007	1.50	271	66
BBSN-2	YC 2007	1.50	242	51
BBSN-3	YC 2007	1.50	231	43
BBSN-4	YC 2006	2.50	507	479
BBSN-5	YC 2006	2.50	477	511
BBSN-6	YC 2005	3.50	596	1289
BBSN-7	YC 2005	3.50	650	1122
BBSN-8	YC 2004	4.50	622	1041
BBSN-9	YC 2004	4.50	661	1529
BBSN-10	YC 2003	5.50	619	1247
BBSN-11	YC 2003	5.50	620	1145

*Age assumes spring spawned in year-class year and fall collection in 2008

Table 2. Bears Bluff NFH shortnose sturgeon metrics and sample designations

Fish Number	Total Length (mm)	Fork Length	Inter-orbital Width (mm)	Interior Mouth Width (mm)	Total Weight (g)	Sample Type	Tissue Weight (g)	Composite Sample Number	Composite Sample Weight (g)	Percent Lipid (%)
BBSN-1	271	nm	nm	nm	66	Wholebody	66.0	**BBSN1W** (Whole-body BBSN 1, 2, & 3)	160.0	2.70
BBSN-2	242	nm	nm	nm	51	Wholebody	51.0			
BBSN-3	231	nm	nm	nm	43	Wholebody	43.0			
BBSN-4	507	430	34.7	24.6	479	Skinless, boneless fillet	82.8	**BBSN2F** (Fillets from BBSN 4 & 5)	155.1	1.90
BBSN-5	477	416	28.2	22.4	511	Skinless, boneless fillet	72.3			
BBSN-6	596	542	41.2	39.5	1289	Skinless, boneless fillet	148.6	**BBSN3F** (Fillets from BBSN 6 & 7)	272.6	3.60
BBSN-7	650	572	39.8	29.8	1122	Skinless, boneless fillet	123.6			
BBSN-8	622	546	42.6	28.1	1041	Skinless, boneless fillet	124.4	**BBSN4F** (Fillets from BBSN 8 and 9)	319.9	17.00
BBSN-9	661	560	42.3	27.4	1529	Skinless, boneless fillet	195.5			
BBSN-10	619	535	41.4	29.1	1247	Skinless, boneless fillet	144.0	**BBSN5F** (Fillets from BBSN 10 and 11)	277.9	2.30
BBSN-11	620	545	37.4	28.4	1145	Skinless, boneless fillet	133.9			

nm = not measured

5. Results

5.1 Lipid Content. Lipid content was fairly consistent in four of five samples ranging from 1.90% to 3.60%, but one sample (BBSN4F) had an anomalous lipid content reported at 17.00%. It is possible this anomalous value is a laboratory transcription error and the actual sample lipid content is 1.70%.

5.1 Organochlorine compounds. Organochlorine compound results are listed in Table 3. Total polychlorinated biphenyl (PCB), benzene hexachloride (*alpha* BHC, *beta* BHC, *gamma* BHC), chlordane compounds, endrin, hexachlorobenzene (HCB), and toxaphene were below analytical detection limits in all samples.

5.1.1 Dichloro-diphenyl-trichloroethane (DDT) – *Para*, *para* isomers of all three DDT metabolites were detected in sturgeon tissue samples - *p*,*p*'-DDD, *p*,*p*'-DDE, and *p*,*p*'-DDT. *Ortho*, *para* isomers of all three metabolites were below detection limits (< 1.00 ng/g). ΣDDT (the sum of all isomers and metabolites) ranged from 1.4 ng/g to 9.9 ng/g.

5.2.3 Dieldrin – Dieldrin was only detected in the 1.5 year class whole-body composite sample with a concentration of 1.1 ng/g.

5.2.3 Mirex – Mirex was detected in three of five samples with concentrations ranging from 1.4 to 3.3 ng/g.

WET WEIGHT

Table 3. Organochlorine compounds in shortnose sturgeon from Bears Bluff NFH, ng/g wet weight

Sample No. Sample Type	BBSN-1W Whole-body	BBSN-2F Fillets	BBSN-3F Fillets	BBSN-4F Fillets	BBSN-5F Fillets
Compound					
PCB-TOTAL	< 5.00	< 5.00	< 5.00	< 5.00	< 5.00
alpha BHC	< 1.00	< 1.00	< 1.00	< 1.00	< 1.00
beta BHC	< 1.00	< 1.00	< 1.00	< 1.00	< 1.00
gamma BHC	< 1.00	< 1.00	< 1.00	< 1.00	< 1.00
alpha chlordane	< 1.00	< 1.00	< 1.00	< 1.00	< 1.00
gamma chlordane	< 1.00	< 1.00	< 1.00	< 1.00	< 1.00
cis-nonachlor	< 5.00	< 5.00	< 5.00	< 5.00	< 5.00
trans-nonachlor	< 1.00	< 1.00	< 1.00	< 1.00	< 1.00
oxychlordane	< 5.00	< 5.00	< 5.00	< 5.00	< 5.00
heptachlor epoxide	< 1.00	< 1.00	< 1.00	< 1.00	< 1.00
o,p'-DDD	< 1.00	< 1.00	< 1.00	< 1.00	< 1.00
o,p'-DDE	< 1.00	< 1.00	< 1.00	< 1.00	< 1.00
o,p'-DDT	< 1.00	< 1.00	< 1.00	< 1.00	< 1.00
p,p'-DDD	1.9	2.2	< 1.00	1.2	< 1.00
p,p'-DDE	4.9	3.2	1.4	3.4	1.7
p,p'-DDT	3.1	2.5	< 1.00	4.5	1.5
ΣDDT	9.9	7.9	1.4	9.1	3.2
dieldrin	1.1	< 1.00	< 1.00	< 1.00	< 1.00
endrin	< 1.00	< 1.00	< 1.00	< 1.00	< 1.00
HCB	< 1.00	< 1.00	< 1.00	< 1.00	< 1.00
mirex	3.0	3.3	< 1.00	1.4	< 1.00
toxaphene	< 1.00	< 1.00	< 1.00	< 1.00	< 1.00

ng/g = parts-per-billion

Values in red preceded by the < symbol indicate non-detects and detection limits

5.2 Trace metals. Trace metal results are listed in Table 4 (wet weight) and Table 5 (dry weight). The text below describes analytical results on a wet weight basis. Aluminum, boron, beryllium, cadmium, molybdenum, and nickel were below detection limits in all samples.

5.2.1 Arsenic (As) – Arsenic was detected in all samples. The mean As concentration in fillets was 0.51 ± 0.10 µg/g (range: 0.37 – 0.58 µg/g). A lower As level was recorded in the 1.5 year class whole-body composite sample, 0.19 µg/g.

5.2.2 Barium (Ba) – Barium was also detected in all samples. The Ba concentration in the 1.5 year class whole-body composite sample of 7.32 µg/g was considerably higher than the Ba levels found in fillets (mean 0.24 ± 0.18 µg/g, range: 0.10 – 0.50 µg/g).

5.2.3 Chromium (Cr) – Chromium was only detected in the 1.5 year class whole-body composite sample with a concentration of 0.35 µg/g.

5.2.4 Copper (Cu) – Copper was detected in all samples. The mean Cu concentration in fillets was 0.30 ± 0.04 µg/g (range: 0.24 – 0.33 µg/g). The 1.5 year class whole-body composite sample had a Cu concentration of 1.40 µg/g.

5.2.5 Iron (Fe) – Iron was detected in all samples. The Fe level in the 1.5 year class whole-body composite sample (717.0 µg/g) was orders of magnitude higher than Fe concentrations detected in fillets (mean 2.8 ± 0.2 µg/g, range: 2.6 – 3.0 µg/g).

5.2.6 Mercury (Hg) – Mercury was below the detection limit (< 0.02 µg/g) in the year 1.5 age class whole-body composite samples and detected at the same concentration, 0.03 µg/g, in all four fillet samples.

5.2.7 Magnesium (Mg) – Magnesium levels were consistent among fillet samples (mean 249 ± 8 µg/g, range: 239 – 256 µg/g) and higher in the whole-body composite sample (396 µg/g).

5.2.8 Manganese (Mn) – Similar to Mg, Mn levels were consistent among fillet samples (mean 0.37 ± 0.05 µg/g, range: 0.30 – 0.41 µg/g) and higher in the whole-body composite sample (3.10 µg/g).

5.2.9 Lead (Pb) – Lead was only detected in the 1.5 year class whole-body composite sample with a concentration of 0.05 µg/g.

5.2.10 Selenium (Se) – Selenium concentrations were generally consistent among all samples. The Se concentration in the 1.5 year class whole-body composite sample was 0.22 µg/g and the mean in fillets from the older age classes was 0.26 ± 0.01 µg/g (range: 0.25 – 0.27 µg/g).

5.2.11 Strontium (Sr) – Strontium was detected in all samples. The Sr level in the 1.5 year class whole-body composite sample (501.00 µg/g) was orders of magnitude higher than Sr concentrations detected in fillets (mean 1.98 ± 0.38 µg/g, range: 1.60 – 2.30 µg/g).

5.2.12 Vanadium (V) – Vanadium was only detected in the 1.5 year class whole-body composite sample with a concentration of 0.10 µg/g.

5.2.13 Zinc (Zn) – Zinc was nearly 8-fold higher in the whole-body composite sample of 1.5 age class fish (31.7 µg/g) than the fillet samples of the older age classes (mean 4.1 ± 0.1 µg/g, range: 4.0 – 4.3 µg/g).

WET WEIGHT

Table 4. Trace metals in shortnose sturgeon from Bears Bluff NFH, µg/g wet weight

Sample No.	BBSN-1W	BBSN-2F	BBSN-3F	BBSN-4F	BBSN-5F	Fillet
Sample Type	Whole-body	Fillet	Fillet	Fillet	Fillet	Mean ± StdDev
Trace Metal						
Aluminum (Al)	< 0.400	< 0.400	< 0.500	< 0.500	< 0.500	BDL
Arsenic (As)	0.19	0.37	0.55	0.55	0.58	0.51 ± 0.10
Boron (B)	< 0.400	< 0.400	< 0.500	< 0.500	0.80	nc
Barium (Ba)	7.32	0.50	0.16	0.10	0.20	0.24 ± 0.18
Beryllium (Be)	< 0.0200	< 0.0200	< 0.0200	< 0.0200	< 0.0300	BDL
Cadmium (Cd)	< 0.0200	< 0.0200	< 0.0200	< 0.0200	< 0.0300	BDL
Chromium (Cr)	0.35	< 0.100	< 0.100	< 0.100	< 0.100	BDL
Copper (Cu)	1.40	0.24	0.32	0.31	0.33	0.30 ± 0.04
Iron (Fe)	717.0	2.6	3.0	2.6	2.9	2.8 ± 0.2
Mercury (Hg)	< 0.0200	0.03	0.03	0.03	0.03	0.03 ± 0.00
Magnesium (Mg)	396	239	246	253	256	249 ± 8
Manganese (Mn)	3.10	0.41	0.30	0.40	0.37	0.37 ± 0.05
Molybdenum (Mo)	< 0.400	< 0.400	< 0.500	< 0.500	< 0.500	BDL
Nickel (Ni)	< 0.100	< 0.100	< 0.100	< 0.100	< 0.100	BDL
Lead (Pb)	0.05	< 0.0400	< 0.0500	< 0.0500	< 0.0500	BDL
Selenium (Se)	0.22	0.25	0.27	0.25	0.27	0.26 ± 0.01
Strontium (Sr)	501.00	2.30	2.30	1.60	1.70	1.98 ± 0.38
Vanadium (V)	0.10	< 0.100	< 0.100	< 0.100	< 0.100	BDL
Zinc (Zn)	31.7	4.0	4.1	4.1	4.3	4.1 ± 0.1

µg/g = parts-per-million, StdDev = standard deviation
Fillets were skinless and boneless
Values in red preceded by the < symbol indicate non-detects and detection limits
BDL = below detection limit, nc = not calculated

DRY WEIGHT

Table 5. Trace metals in shortnose sturgeon from Bears Bluff NFH, µg/g dry weight

Sample No.	BBSN-1W	BBSN-2F	BBSN-3F	BBSN-4F	BBSN-5F	Fillet
Sample Type	Whole-body	Fillet	Fillet	Fillet	Fillet	Mean ± StdDev
Trace Metal						
Aluminum (Al)	< 2.00	< 2.00	< 2.00	< 2.00	< 2.00	BDL
Arsenic (As)	0.89	1.90	2.20	2.20	2.30	2.15 ± 0.17
Boron (B)	< 2.00	< 2.00	< 2.00	< 2.00	3.00	nc
Barium (Ba)	33.40	2.50	0.65	0.50	0.81	1.12 ± 0.93
Beryllium (Be)	< 0.100	< 0.100	< 0.100	< 0.100	< 0.100	BDL
Cadmium (Cd)	< 0.100	< 0.100	< 0.100	< 0.100	< 0.100	BDL
Chromium (Cr)	1.60	< 0.500	< 0.500	< 0.500	< 0.500	BDL
Copper (Cu)	6.30	1.20	1.30	1.20	1.30	1.25 ± 0.06
Iron (Fe)	3270	13	12	10	12	12 ± 1
Mercury (Hg)	< 0.100	0.10	0.10	0.10	0.10	0.10 ± 0.00
Magnesium (Mg)	1810	1200	993	1030	1010	1058 ± 96
Manganese (Mn)	14.0	2.1	1.0	1.6	1.0	1.4 ± 0.5
Molybdenum (Mo)	< 2.00	< 2.00	< 2.00	< 2.00	< 2.00	BDL
Nickel (Ni)	< 0.500	< 0.500	< 0.500	< 0.500	< 0.500	BDL
Lead (Pb)	0.20	< 0.200	< 0.200	< 0.200	< 0.200	BDL
Selenium (Se)	1.00	1.20	1.10	1.00	1.10	1.10 ± 0.08
Strontium (Sr)	2290.00	12.00	9.20	6.60	6.70	8.63 ± 2.55
Vanadium (V)	0.70	< 0.500	< 0.500	< 0.500	< 0.500	BDL
Zinc (Zn)	145.0	20.0	16.0	17.0	17.0	17.5 ± 1.7

µg/g = parts-per-million, StdDev = standard deviation
Fillets were skinless and boneless
Values in red preceded by the < symbol indicate non-detects and detection limits
BDL = below detection limit, nc = not calculated

6. Discussion

6.1 Organochlorine compounds. The analytical suite included 21 organochlorine compounds. Most of the compounds in the scan such as polychlorinated biphenyl (PCB), benzene hexachlorides (BHCs), chlordane compounds, cyclodiene pesticides (e.g., aldrin, endrin), were below detection limits (< 1 ng/g or < 5 ng/g, Table 3) and will not be discussed. Three organochlorine compounds with detectable concentrations are discussed – total dichloro-diphenyl-trichloroethane (ΣDDT), dieldrin, and mirex.

6.1.1 Total Dichloro-diphenyl-trichloroethane (ΣDDT) - ΣDDT levels in Bears Bluff NFH shortnose sturgeon (range: 1.4 to 9.9 ng/g) were substantially lower than the whole-body tissue threshold-effect level of 600 ng/g suggested by Beckvar *et al*. (2005). Lethal concentrations of ΣDDT in whole-body fish range from 290 to 113,000 ng/g with a mean of 2,380 ng/g (Beckvar and Lotufo 2011). Reduced sex steroid production can occur in adult fish with *p*,*p*'-DDE residues of 400 to 600 ng/g (Beckvar and Lotufo 2011). Bears Bluff NFH sturgeon ΣDDT concentrations were well below these effects threshold.

Hatchery sturgeon ΣDDT levels also appeared lower than wild fish from Maine and Pennsylvania. Wild shortnose sturgeon collected from two Maine rivers in 2006 and 2009 had ΣDDT levels ranging from 5.5 to 55.1 ng/g in fillets (Mierzykowski 2012). Two shortnose sturgeon from the Delaware River in 2001 had ΣDDT fillet concentrations (sum of p,p'-DDD and p,p'-DDE) of 190 ng/g and 250 ng/g (ERC 2002).

6.1.2 Dieldrin - Dieldrin was only detected in one Bears Bluff NFH shortnose sturgeon at a concentration of 1.1 ng/g. This is a low dieldrin level. In two studies, whole-body dieldrin residues of 5,900 ng/g were lethal to juvenile rainbow trout and behavioral effects were found in goldfish and bluegill with whole-body concentrations of 3,700 ng/g (Beckvar and Lotufo 2011). The dieldrin level in the Bears Bluff NFH shortnose sturgeon was similar to levels found in wild fish. In five shortnose sturgeon fillet samples collected from the Kennebec Rivers in Maine in 2009, dieldrin was detected in four samples (range: 0.4 – 0.7 ng/g), while four shortnose sturgeon fillet samples collected from the Penobscot River in 2006 were below the detection limit (< 1.00 ng/g, Mierzykowski 2012).

6.1.3 Mirex – A toxicity threshold value for mirex in fish has not been proposed. Muscle mirex residues of 15 ng/g reduced catfish survival, while whole-body residues of 350 to 950 ng/g resulted in histological changes in gill lamellae in sheepshead minnow (Beckvar and Lotufo 2011). Mirex was detected in three of five Bears Bluff NFH shortnose sturgeon samples (range: 1.4 to 3.3 ng/g). By comparison, mirex was detected in seven of nine shortnose sturgeon fillet samples from the Penobscot and Kennebec Rivers in Maine samples (mean of detects 2.8 ng/g, range: 0.1 – 12.0 ng/g, Mierzykowski 2012). Mirex concentrations in Bears Bluff NFH shortnose sturgeon were well below reported effect levels (Beckvar and Lotufo 2011).

6.2 Trace Metals. Trace metals 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 19 trace metals were included in the analytical scan (Table 4), only five are discussed below – arsenic, copper, mercury, selenium, and zinc. Aluminum, boron, beryllium, cadmium, chromium, molybdenum, nickel, 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 and strontium levels in fish tissue are not available.

6.2.1 Arsenic (As) – Gilderhus (1966) exposed bluegill to arsenite and demonstrated reduced survival and growth at a whole-body residue of 11.6 µg/g, while juvenile bluegill exhibited reduced survival and growth at whole-body As residues between 2.2 and 11.7 µg/g. Another suggested toxicity threshold level for As in whole-body fish is 9.0 µg/g (USDOI 1998a, converted from dry weight to wet weight based on 75% moisture). Mean As in five Bears Bluff NFH shortnose sturgeon fillet samples was 0.51 µg/g, while the single whole-body sample had 0.19 µg/g. Arsenic in fillets of wild shortnose sturgeon from Maine ranged from 0.73 to 3.10 µg/g (Mierzykowski 2012). Compared to suggested toxicity thresholds and concentrations reported in wild fish, As in shortnose sturgeon from the hatchery was not elevated.

6.2.2 Copper (Cu) – One suggested toxicity threshold level for Cu in whole-body fish is 3.3 µg/g (USDOI 1998b, converted from dry weight to wet weight based on 75% moisture). Copper in the whole-body composite sample from the hatchery was 1.40 µg/g. Lower Cu levels were detected in the hatchery fillet samples (mean 0.30 ± 0.04 µg/g). Copper in fillets of wild shortnose sturgeon from Maine ranged from 0.24 to 0.61 µg/g (Mierzykowski 2012). Two muscle samples from shortnose sturgeon collected from the Delaware River in 2001 had Cu concentrations of 0.80 µg/g and 0.90 µg/g (ERC 2002). Fillet samples from hatchery sturgeon had lower Cu levels than wild fish and were well below suggested threshold concentrations. The single whole-body composite sample from the hatchery had a higher Cu concentration than fillets from hatchery fish or muscle samples from wild fish, but the whole-body concentration was also well below the suggested effect thresholds.

6.2.3 Mercury (Hg) – A suggested Hg tissue threshold-effect level considered protective of juvenile and adult whole-body fish is 0.20 µg/g (Beckvar *et al*. 2005). Sub-lethal effects of Hg on freshwater fish, including changes in reproductive health, have been observed in laboratory and field studies of fish with having approximately 0.50 µg Hg/g wet weight or greater in the fillet (Sandheinrich and Wiener 2011). Low levels of Hg, much lower than the thresholds noted above, were found in sturgeon from the hatchery. The Hg concentration in sturgeon fillets from Bears Bluff NFH was 0.03 µg/g in each sample. Mercury was below the detection limit (< 0.02 µg/g) in the whole-body composite sample from the hatchery.

Flesh samples from 24 shortnose sturgeon collected from the Saint John estuary in New Brunswick in between 1973 and 1975 had Hg levels ranging from 0.10 to 3.58 µg/g (mean 1.17

µg/g, Dadswell 1975). Two muscle samples from shortnose sturgeon collected from the Delaware River in 2001 had Hg concentrations of 0.06 µg/g and 0.11 µg/g (ERC 2002). A muscle sample from a shortnose sturgeon killed during dredging operations in the Kennebec River in Maine in 2003 had a Hg level of 0.26 µg/g (ERC 2003). Mercury in nine shortnose sturgeon fillets collected in 2006 and 2009 from the Penobscot and Kennebec Rivers in Maine ranged from 0.19 to 1.00 µg/g (mean 0.48 µg/g, Mierzykowski 2012). Compared to suggested threshold effect levels and concentrations reported in wild fish, Hg levels were low in shortnose sturgeon from Bears Bluff NFH.

6.2.4 Selenium (Se) – A recommended Se threshold for whole-body fish is 2.0 µg/g (converted from 8 µg/g dry weight based on 75% moisture; DeForest and Adams 2011). Considerably lower Se levels were detected in sturgeon from Bears Bluff NFH. Fillet samples (mean 0.26 ± 0.01 µg/g) and the whole-body sample (0.22 µg/g) of shortnose sturgeon from the hatchery had similar Se concentrations. These levels were also low compared to Se residues found in wild fish. Selenium concentrations in wild shortnose sturgeon fillets from Maine ranged from 0.64 to 0.71 µg/g in the Penobscot River in 2006 (n = 4, mean = 0.68 µg/g), and from 0.32 to 2.40 µg/g in the Kennebec River in 2009 (n = 5, mean = 0.95 µg/g) (Mierzykowski 2012).

6.2.5 Zinc (Zn) – Citing several sources, Murphy *et al*. (1978) reported average Zn whole-body concentrations from uncontaminated areas ranging from 12 to 43 µg/g. Zinc concentrations in four shortnose sturgeon fillet samples from the hatchery showed little variation (mean 4.1 ± 0.1 µg/g, range: 4.0 – 4.3 µg/g), but the whole-body sample had a Zn level of 31.7 µg/g. In comparison, two muscle samples from shortnose sturgeon collected from the Delaware River in 2001 had zinc concentrations of 5.8 µg/g and 8.8 µg/g (ERC 2002). A muscle sample from a shortnose sturgeon killed during dredging operations in the Kennebec River in Maine in 2003 had a Zn level of 6.0 µg/g (ERC 2003). Zinc in nine shortnose sturgeon fillets collected in 2006 and 2009 from the Penobscot and Kennebec Rivers in Maine ranged from 3.7 to 4.6 µg/g (mean 4.1 µg/g, Mierzykowski 2012). Fillet samples from hatchery shortnose sturgeon did not have elevated Zn concentrations compared to wild fish and the zinc level in the whole-body composite sample was below the range reported by Murphy *et al*. (1978).

7. Summary

Eleven shortnose sturgeon, reared at the Bears Bluff National Fish Hatchery in Wadmalaw, South Carolina, were analyzed to determine environmental contaminant burdens. The sturgeon were divided into five, year-class specific, composite samples and analyzed for 21 organochlorine compounds and 19 trace metals. Three whole-body fish from the 1.5 year age class were composited and analyzed as a single sample. Skinless, boneless fillets of fish from four older age classes – 2.5 through 5.5 - were also analyzed.

In the organochlorine analytical scan, dichloro-diphenyl-trichloroethane (DDT) metabolites, dieldrin, and mirex were infrequently detected and found at low concentrations compared to levels found in wild fish or to suggested toxicity threshold effect levels. Polychlorinated biphenyl, benzene hexachloride, chlordane compounds, endrin, hexachlorobenzene, and toxaphene were below analytical detection levels.

Several trace metals were detected in sturgeon tissue samples. Arsenic, copper, mercury, selenium, and zinc levels in Bears Bluff NFH fish did not exceed suggested tissue effect thresholds and were low in comparison to wild shortnose sturgeon.

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