

GREAT LAKES FISHERY COMMISSION

2000 Project Completion Report¹

Contaminant Burdens in Great Lakes Sea Lamprey: A 1998 Spatial Survey

by:

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A 1998 SPATIAL SURVEY

COMPLETION REPORT

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1998 Survey

ABSTRACT

Fifty seven adult sea lamprey collected from 10 streams flowing into Lakes Superior, Huron, Michigan and Ontario were analysed for total body burdens of mercury, PCB and selected organochlorine pesticides. The highest concentrations of total mercury were found in individuals captured in streams from the Lake Superior basin. Samples from Lake Michigan streams had the highest mean values of total DDT and the major metabolite pp'-DDE. Toxaphene was the generally next most predominant organic contaminant across all sites and maximum concentrations of this compound were detected in lamprey from streams in the Lake Superior basin. Total PCB levels were the greatest in streams flowing into Lake Michigan and the single stream sampled in the Lake Ontario basin. Overall concentrations of contaminants in whole lamprey were approximately 1.2 to 3.4 times greater than concentrations detected in skinless muscle tissue samples. The origin of the suite of contaminants detected in these whole lamprey samples could range from domestic or industrial point sources, atmospheric inputs, remobilization of stored materials in lake depositional basins or natural geological deposits within the individual lake watershed. In summary, lamprey were shown to be very efficient accumulators of a range of environmental contaminants with burdens significantly greater than those found in Great Lakes salmonids, their primary host.

MATERIALS AND METHODS

Fifty seven adult sea lamprey, were captured during their spawning phase migration in 10 rivers and streams flowing into Lakes Ontario, Huron, Michigan and Superior during May and June, 1998 (Fig.1). Lamprey were frozen immediately after collection and stored at -20°C until processing. In the laboratory, measurements of total length and weight were recorded (Table 1). Individual lamprey were cut into 2 cm sections. These sections were then immersed in liquid nitrogen for up to 1 minute. The frozen sections from each individual lamprey were homogenized using a Hobart® meat grinder. Processing equipment and associated glassware

were washed with distilled water and rinsed with distilled in glass (DIG) pesticide grade solvents (Caledon Laboratories Georgetown, ON) prior to use. All tissue homogenates were placed in acetone and hexane rinsed flint glass jars, sealed with an aluminum foil lined, hexane rinsed cap and stored at -20°C for less than six weeks prior to analysis. Individual subsamples were retained for organochlorine contaminant analysis, lipid content and mercury analysis.

Sample Extraction and Cleanup

Table 1 presents a listing of the organochlorine contaminants include in the analytical suite for all 57 samples. Individual thawed whole lamprey homogenates were mixed thoroughly prior to subsampling to recombine the tissues into a homogeneous mixture. Approximately 5 grams of sample was combined with 150g of Na_2SO_4 in a glass mortar and ground manually until homogeneity was achieved. This mixture was then transferred to a glass extraction column and eluted with 300 ml of dichloromethane (DCM). Bulk lipid removal was achieved via automated gel permeation chromatography. Further cleanup and separation was achieved using 3% deactivated silica gel columns. Samples were applied and the columns were eluted with 50 ml 1% DCM in hexane (Fraction A) followed by 70 ml DCM (Fraction B). Fraction A contains PCB's and some organochlorine pesticides while Fraction B holds toxaphene and the majority of the organochlorine pesticides.

Instrumentation

Organochlorine pesticides and total PCB analyses were performed using a Varian 3600 gas chromatograph (GC) with dual electron capture detectors (ECD). Organochlorine pesticide analysis required dual channel confirmation and an RTx-5 60m x .25mm x .25mm column was used with an RTx-1701 60m x .25mm x .25mm as the confirmation column.

Organochlorine compounds were quantified against an eight-point calibration curve, final results were corrected for recoveries and no blank corrections were performed. Total PCB's were quantified using a standard containing a 1:1:1 mixture of Aroclors 1242, 1254 and 1260 at a concentration of 500pg/ul. Total toxaphene was quantified against a 500pg/ul technical standard from Hercules Chemical. Twenty target peaks from the chromatogram were used in

quantification. A detailed description of the extraction process and analytical method for total PCB's and OC's is presented in Huestis et. al. (1995).

Mercury Determination

One gram of lamprey tissue was weighed out into a volumetric flask. The tissue was then dissolved in 15 ml of sulphuric acid. Organic and inorganic mercury compounds, if present, were decomposed using nitric acid, potassium permanganate and potassium persulphate. Mercuric ions were reduced to the elemental state with stannous chloride. Mercury vapour is subsequently removed from solution by aeration and total mercury was determined via cold vapour, flameless atomic absorption using a LDC Milton-Roy elemental mercury monitor. The detection limit for total mercury is 0.01 mg/kg. A complete description of the extraction and analysis procedures for mercury are presented in Environment Canada (1994).

RESULTS

Table 2 presents a summary of the data associated with the 1998 sample collections. More than 50% of the samples came from 5 streams in the Lake Superior basin. Conversely only 5 lamprey were collected and analysed from the single Lake Ontario site. The 32 individual lamprey collected from the Lake Superior basin were on average the smallest (weight and total length) and leanest (lipid content) of any other lamprey collected from the remaining 3 lake basins surveyed. This is despite the fact that all samples were collected within a 2 week period (Table #3) as part of the spring spawning run of adults. Lipids content is a significant variable in determining the capacity for biological tissues to accumulate organochlorine contaminants. Data presented in table #4 for four of the major contaminants detected, identifies the significantly higher mercury and toxaphene burdens in samples from the Lake Superior basin streams. Lake Michigan and Lake Ontario samples consistently had the highest burdens of total PCB while maximum levels of total DDT were routinely found in Lake Michigan samples and frequently in samples from the single Lake Ontario site. Table #5 provides a more detailed breakdown of the inter-site comparison of total body burdens for the same 4 major contaminant groups. Maximum mean concentrations of mercury, total PCB, total DDT and toxaphene all occurred in samples collected from the Lake Superior Rock River site. The 5 samples from this site also had the highest mean concentration of lipid which positively influences the extent of

accumulation of all of the above contaminants. There were significant differences in the total body burden concentration of contaminants accumulated in the samples from each of the 5 Lake Superior sites. Similarly the two Lake Michigan sites had significantly different mean body burden concentrations of toxaphene and total DDT. With the exception of total mercury concentrations, the two Lake Huron sites had similar levels of the remaining four major contaminant groups measured.

Therefore, each of the lakes has its unique contaminants issue as identified by this survey. Comparison of these data sets to similar information from lake trout contaminant burden surveys carried out across the basin, indicates that lamprey are in some cases more efficient accumulator of contaminants. Levels of PCB in lamprey from Lake Superior and Lake Huron are on average higher or at least as high as those detected in whole lake trout samples. Similarly toxaphene levels in Lake Superior lamprey and lake trout are equivalent. Mercury levels are consistently great in whole lamprey samples from all lakes when compared to concentrations determined in whole lake trout homogenates from corresponding lakes. In Lake Superior, mercury levels are as much as a factor of 10 greater than those found in the primary host, lake trout. Preliminary analysis has also indicated that methyl mercury, the organic toxic form of mercury comprises > 95% of the total mercury in lamprey. This compares to 85% as the proportion of methyl mercury to mercury found in typical freshwater fish species.

In summary, the analysis of adult spawning lamprey from streams throughout the Great Lakes basin has provided an excellent tool to describe inter and intra-lake differences in contaminant burdens and perhaps assist in the description of varying contaminant loadings and sources. These data combined with information from fish community contaminant monitoring programs will provide an excellent indicator of the success of pollution abatement programs and perhaps act as an early warning indicator of emerging contaminant problems.

1998 Lamprey Collection Sites

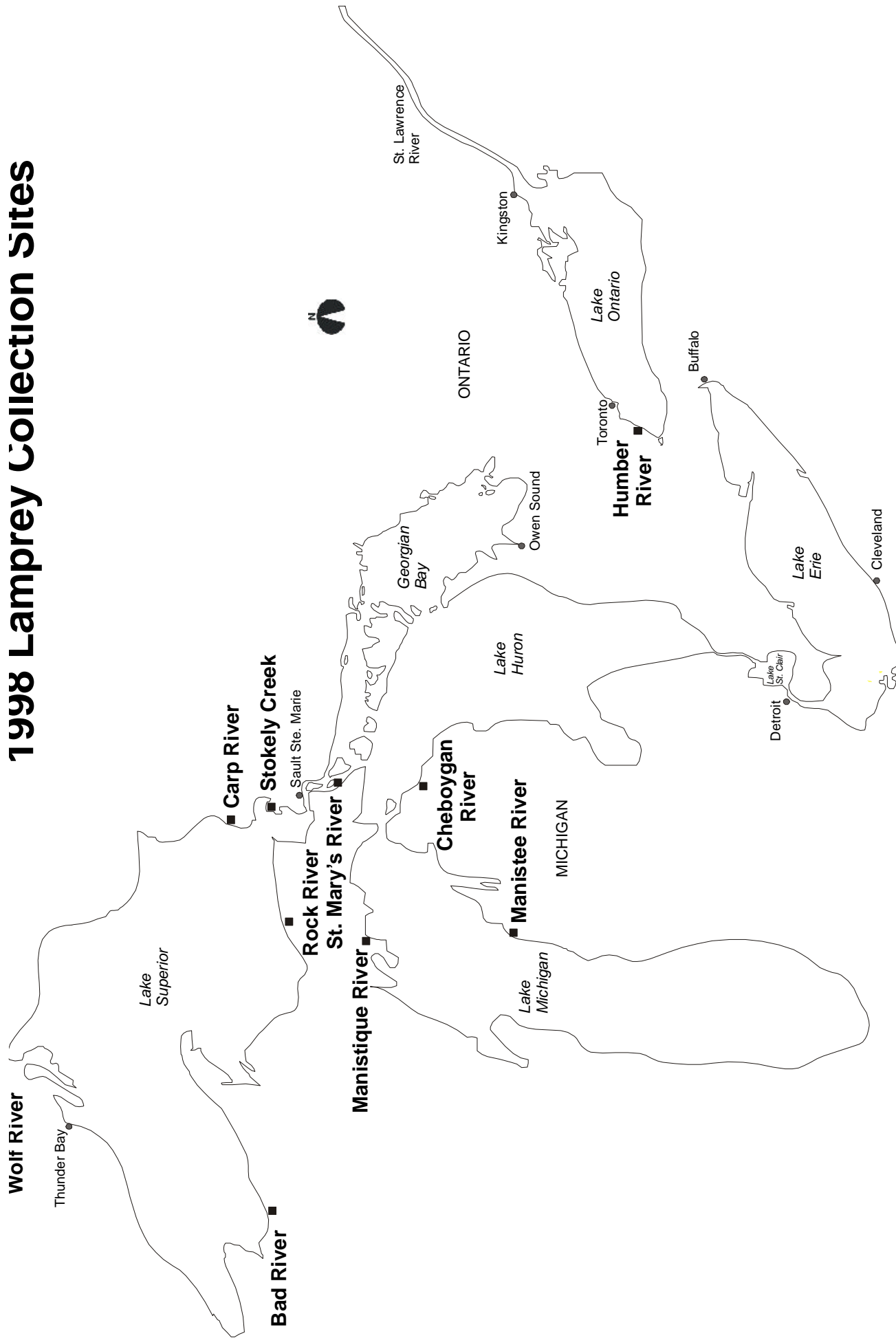


Table 1**ORGANOCHLORINE ANALYTES FOR LAMPREY SAMPLES**

p,p'-DDE	Heptachlor
p,p'-TDE	Heptachlor Epoxide (B)
o,p'-DDT	Heptachlor Epoxide (A)
p,p' DDT	Total Hept. Epoxide
o,p'DDE	Endrin
Total DDT	Beta Endosulfan
alpha BHC	pp'- methoxychlor
beta BHC	Mirex
gamma BHC	Photo-Mirex
delta BHC	Alpha Chlordane
Octachlorostyrene	Gamma Chlordane
Dieldrin	Total Chlordane
Aldrin	Oxychlordane
Total PCB	Trans-Nonachlor
HCB	Cis-Nonachlor
Toxaphene	

Table 2. 1998 Sea Lamprey Sample Collection Data - ($8 \pm$ S.E.)

Lake (N =No. of Samples)	Number of Collection Sites	Length (mm)	Weight (g)	% Lipid
SUPERIOR N=32	5	406.187	176.653	5.753
		6.747	9.460	0.464
MICHIGAN N=10	2	461.700	259.970	8.440
		11.205	17.302	0.976
HURON N=10	2	464.600	270.270	8.568
		11.651	22.283	0.812
ONTARIO N=5	1	464.600	264.660	5.994
		12.040	19.846	1.058

Table 3

1988 Collection Sites & Sample Sizes

LAKE	SITE	COLLECTION DATE	No. of SAMPLES
SUPERIOR	BAD RIVER	15 May 98	12
	ROCK RIVER	19 May 98	5
	WOLF RIVER	19 May 98	5
	STOKELY CREEK	25 MAY 98	5
	CARP RIVER	29 May & 1 June 98	5
HURON	CHEBOYGAN RIVER	17 MAY 98	5
	St. MARY'S RIVER	29 June 98	5
MICHIGAN	MANASTIQUE RIVER	17 MAY 98	5
	MANISTEE	19 May 98	5
ONTARIO	HUMBER RIVER	Not Available	5

Table 4

Mean Contaminant Burdens In Great Lakes Sea Lamprey ⁽¹⁾
(8 ± S.E. as µg/g wet weight)

Lake	Mercury	Toxaphene	Total DDT	Total PCB
SUPERIOR	2.532	1.836	0.298	0.602
	0.208	0.159	0.065	0.075
MICHIGAN	1.295	0.575	0.870	1.546
	0.199	0.077	0.015	0.204
HURON	0.460	0.450	0.316	0.674
	0.191	0.054	0.046	0.077
ONTARIO	0.930	0.169	0.700	1.440
	0.071	0.015	0.115	0.136

(1) Whole Lamprey

Table 5: Site Specific Mean Contaminant Burdens for Great Lakes Sea Lamprey⁽¹⁾

Lake	Site	Sample Size	(as $\mu\text{g/g}$ - \pm S.E.)				
			% Lipid	Toxaphene	Σ DDT	PCB	Mercury
Superior	Bad River	12	4.458	1.510	0.189	0.471	2.719
			0.391	0.158	0.030	0.066	0.294
Superior	Rock River	5	8.888	2.618	0.637	0.873	3.037
			1.942	0.614	0.381	0.373	0.410
Superior	Wolf River	5	7.086	1.761	0.199	0.485	1.727
			1.142	0.194	0.039	0.054	0.486
Superior	Stokely Creek	5	5.276	2.051	0.270	0.517	2.797
			0.544	0.473	0.117	0.168	0.558
Superior	Carp River	5	4.872	1.362	0.196	0.624	1.883
			0.363	0.321	0.038	0.115	0.755
Michigan	Manistique River	5	8.256	0.709	1.048	1.594	1.313
			1.077	0.13	0.245	0.381	0.356
Michigan	Manistee River	5	8.624	0.377	0.575	1.389	1.277
			1.764	0.076	0.206	0.340	0.265
Huron	Cheboygan River	5	7.154	0.441	0.290	0.718	0.317
			0.838	0.071	0.019	0.076	0.127
Huron	St. Marys River	5	9.982	0.511	0.363	0.666	0.603
			1.127	0.107	0.112	0.163	0.382
Ontario	Humber River	5	5.994	0.176	0.734	1.474	0.930
			1.058	0.016	0.135	0.162	0.071

⁽¹⁾ Whole Lamprey