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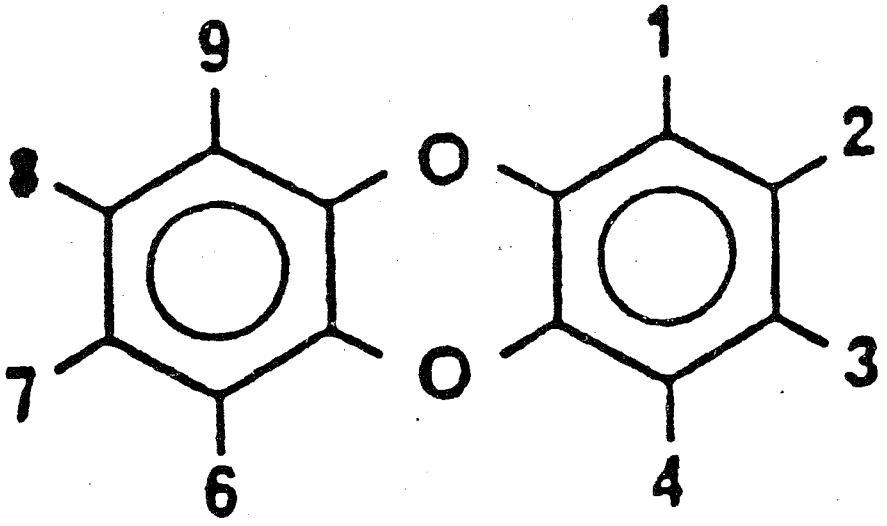
MAINE'S DIOXIN MONITORING PROGRAM
1988-1990



by
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Maine Department of Environmental Protection
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TABLE OF CONTENTS

LIST OF TABLES

INTRODUCTION

The words "dioxin" and "furan" are generic terms for a family of 75 related polychlorinated dibenzodioxins (PCDD) and a family of 135 polychlorinated dibenzofurans (PCDF). Commonly ,"dioxin" is used to refer to the most toxic and carefully studied of these compounds, 2378-tetrachlorodibenzo-p-dioxin (2378-TCDD or TCDD), while "furan" usually is used to refer to 2378-tetrachlorodibenzofuran (2378-TCDF or TCDF) which is a tenth as toxic as 2378-TCDD.

The US Environmental Protection Agency (EPA) considers 2378-TCDD to be the most toxic compound known to man. Doses as low as 0.6 micrograms per kilogram of body weight kill guinea pigs and lower doses are carcinogenic and teratogenic. Yet, animals differ in their sensitivities to this compound. Monkeys and hamsters can tolerate levels 50 and 5000 times higher, respectively, than those that affect guinea pigs. In humans, dioxin has caused chloracne, a severe skin disorder. In addition, exposure to various chemicals contaminated with dioxin has been linked to liver disorders, nerve damage, loss of appetite and weight, loss of sex drive, and many other effects.

Due to lack of adequate data and conflicting studies, it remains unclear if or at what dose 2378-TCDD is a human carcinogen or teratogen. Some evidence exists to suggest that 2378-TCDD is a cancer promoter rather than an initiater. It is known that 2378-TCDD is bioaccumulated in the lipid compartment of animals (including humans), such that very small amounts in rivers can result in significantly greater levels in fish and other aquatic organisms. It is also known that 2378-TCDD is extremely persistent in the environment. For these reasons federal and state agencies consider these compounds extremely hazardous.

In order to determine the extent of dioxin contamination nationwide, EPA initiated its National Dioxin Study (NDS) in 1984. Fish collected by DEP and EPA from the Androscoggin River in Turner, presumed to be a clean control site, contained significantly high levels of 2378-TCDD. Consequently in May 1985, DEP, the Department of Human Services (DHS), and the Department of Inland Fisheries and Wildlife (DIFW) jointly issued a fish consumption advisory for the Androscoggin River. Additional samples from the Androscoggin and other Maine rivers were then collected by DEP and EPA in 1985 and 1986 as part of EPA's National Bioaccumulation Study (NBS). The data, received in 1987, showed significant, albeit lower, levels of contamination in fish in many other rivers particularly below bleached kraft pulp mills, while fish from rivers and lakes with no waste

discharges had no detectable dioxin. As a result the fish consumption advisory was updated and extended to the Kennebec and Penobscot Rivers in July 1987 and to the Presumpscot River later when data became available, and printed in the 1988-1989 and 1990-1991 Open Water Fishing Regulations.

Following the receipt of the results of the National Dioxin Study, in 1985 DEP collected wastewater sludge samples from a number of bleached kraft pulp and paper mills for EPA analysis for 2378-TCDD. Samples of wastewater and sludge as well as material from several internal process lines from 5 mills were collected from June 1986 through January 1987 for analysis for dioxin and furan in the US Environmental Protection Agency/Paper Industry Cooperative Dioxin Screening Study (5 mill study). In 1988 the remaining 104 bleached kraft mills in the US were sampled in the US Environmental Protection Agency/Paper Industry Cooperative Dioxin Study (104 mill study). Results of each of these efforts have consistently showed the presence of 2378-TCDD and 2378-TCDF in export vectors from the bleach plants in most of these mills.

In October 1986, following extensive research and a public hearing involving experts from DEP, EPA, industry and the US Public Health Service, the Board of Environmental Protection promulgated Chapter 567, Rules for the Land Application of Sludge and Residuals (DEP, 1986) designed to prescribe safe methods for utilization of dioxin containing sludges.

In 1988 the Maine legislature enacted 38 MRSA Section 420-A, which established Maine's Dioxin Monitoring Program (DMP, Appendix 1). The purpose was "to determine the nature of dioxin contamination in the waters and fisheries of the State". The act required DEP to sample sludge once a quarter for one year from and fish once below no more than 12 representative municipal or bleached pulp mills, selected on the basis of known or suspected contamination of their discharged effluent. Furthermore the act required DEP to coordinate the effort with other ongoing programs conducted by DEP, EPA, or industry and report the results to the joint standing committee of the legislature having jurisdiction over natural resources by December 1, 1990. The final report was to "contain the DEP's conclusions regarding the levels of contamination in the sample subjects and likely scope of dioxin contamination in the State's waters". This report fulfills that requirement, and also reports all other dioxin data known to have been collected in the State of Maine. Some of these data were received in March 1990 and were used by DHS to update the fish consumption advisory. The recommended consumption was reduced for the Androscoggin River and Kennebec River and an advisory was issued for the West Branch of the Sebasticook River below Hartland.

METHODS

Upon passage of the act staff members from the sludge spreading program in the Bureau of Solid Waste Management, and Division of Licensing and Enforcement and Division of Environmental Evaluation and Lake Studies in the Bureau of Water Quality Control were consulted in design of the program to ensure that the goals of the act would be met. Selected sites included all 7 bleached kraft mills. Also one sulfite mill that uses chlorine, Fraser Paper in Madawaska, and a mill that recycles bleached paper, Statler Tissue in Augusta, were chosen. Two publically owned treatment works (POTW's) whose waste was more than 80% tannery waste (Berwick Sewer District and Town of Hartland wastewater treatment facility) and textile mill waste (Corinna Sewer District) were also chosen since previously collected data had indicated the presence of dioxin or furan in sludge from each of those types of facilities. The state toxicologist in the Bureau of Health, DHS was consulted regarding sample size. DIFW assisted in designating endemic species of fish.

Weekly composite sludge samples were collected by mill personnel approximately quarterly for one year beginning in the first quarter of FY89 (July 1-Sept. 30) and transferred to DEP and frozen for shipment to Triangle Laboratories in North Carolina via UPS Next Day Air for analysis. DEP supplied pre-cleaned bottles and sampling devices to each facility prior to each sampling event. Exceptions were those facilities that were already collecting samples quarterly as part of a sludge spreading permit monitoring requirement and the bleached kraft mills, which had already or were in the process of collecting one sludge sample as part of the 104 mill study. For those facilities data collected for those other programs was used in partial fulfillment of the requirements of this program and are reported here. Table 1 shows the facilities and sludge sampling frequencies. The sampling protocols were those given in DEP's sludge spreading rules, Chapter 567, and the US EPA/Paper Industry Cooperative Dioxin Study (104 mill study) Sludge Sampling Guidance.

Target species of fish and locations were determined with the assistance of DIFW (Table 1). To document risk to human consumers, ten predators were specified to be analyzed individually as skinless fillets. To determine variability among species, document ambient contaminations, and provide data to help estimate effects on fish and wildlife consumers, 10 bottom feeders were specified to be analyzed as two five-fish composites. Target species and numbers were not always captured. Lower numbers or alternate species had to be used at some locations (Appendix 2). Locations were chosen to fill gaps in the existing EPA data

rather than to try to duplicate the EPA study for the sake of making comparisons.

TABLE 1. Facilities, sludge sampling schedule, fish species and sampling locations for Maine's Dioxin Monitoring Program 1988-1990.

FACILITY	SLUDGE	FISH SAMPLING SITE	SPECIES
Berwick Sewer District Berwick	4 qtrs	Salmon Falls R S Berwick	bass sucker
Boise Cascade Rumford	3 qtrs	Androscoggin R Jay	bass
Corinna Sewer District Corinna	ongoing	E Br Sebasticook R Newport	bass sucker
Fraser Paper Ltd. Madawaska	4 qtrs	St John R Madawaska	brook trout sucker
Georgia Pacific Corp Woodland	3 qtrs	St Croix R Woodland	bass sucker
Hartland (Town) Hartland	4 qtrs	W Br Sebasticook R Palmyra	bass sucker
International Paper Co Jay	3 qtrs	Androscoggin R Lisbon	brown trout
James River Corp Old Town	3 qtrs	Penobscot R Veazie	bass sucker
Lincoln Pulp and Paper Co Lincoln	3 qtrs	Penobscot R S Lincoln	bass sucker
SD Warren Co Skowhegan	3 qtrs	Kennebec R Fairfield	brown trout sucker
SD Warren Co Westbrook	3 qtrs	Presumpscot R Westbrook	bass sucker
Statler Tissue Corp Augusta	4 qtrs	Kennebec R Augusta	brown trout sucker

Fish samples were collected during the period 1988-1990 by DEP and/or DIFW. The Penobscot Indian Nation supplied all 1988 and 1989 data for the Penobscot River (Fay and Westra, 1989; Fay, 1990) and collected the 1990 South Lincoln fish. The Atlantic Sea Run Salmon Commission collected the fish from Veazie in 1990. Several anglers provided fish throughout the project particularly members of Kennebec

Valley Trout Unlimited. Sampling methods followed EPA's Sampling Guidance Manual for the National Dioxin Study (EPA, 1984). Fish were captured, killed as soon as possible, rinsed in river water, wrapped in aluminum foil (shiny side out), labelled, and frozen for shipment to the lab for analysis. Fish were shipped to Triangle Laboratory in North Carolina via UPS Next Day Air and always arrived at the lab still frozen.

RESULTS

A summary (Table 2) of all fish tissue results (raw data, Appendix 2) and all results of sludge analysis (Table 3) for Maine document the level of 2378-TCDD and 2378-TCDF in both matrices at each site.

Androscoggin River

Gilead- EPA's NDS showed significant levels of 2378-TCDD in white suckers collected at Gilead in 1985. Subsequently, the highest levels of 2378-TCDD and 2378-TCDF in sludge of all the mills in New England in the 104 mill study were from the James River Corp. bleached kraft pulp mill in Berlin, New Hampshire. There are no other known significant sources of 2378-TCDD and 2378-TCDF upriver from Gilead.

Jay- Smallmouth bass from the Riley Impoundment at Jay had the highest levels of 2378-TCDD and 2378-TCDF in predator fillets of all the sites. Although there are no earlier data from the EPA study from this site with which to compare, the level of 2378-TCDD was four times greater than the level of 2378-TCDD found in largemouth bass fillets from Gulf Island Pond in 1984. Levels were higher than those found here in whole white suckers in 1985 and higher than those found at Gilead. This site is the first impoundment, approximately 21 miles, below Boise Cascade's bleached kraft pulp and paper mill in Rumford. The level of 2378-TCDD found in Boise's sludge in 1988 was the highest found in the 104 mill study in New England, although data collected in 1989 showed levels much reduced.

Turner- In EPA's NDS/NBS, largemouth bass, white suckers, and brown bullheads from N. Turner and Gulf Island Pond in Turner had some of the highest levels of 2378-TCDD found in fish in Maine. In addition to discharges from James River and Boise Cascade, the discharge from International Paper Co.'s bleached kraft pulp and paper mill enters the river in Jay, above this reach. Data from the 5 mill study collected in 1987 showed the highest level of 2378-TCDD ever seen in sludge from mills in New England in sludge from International Paper Co.'s mill. More recent data show levels greatly reduced.

TABLE 2. DIOXIN AND FURAN LEVELS IN MAINE FISH (pg/g)

WATER/STATION	SPECIES	TYPE	EPA NDS/NBS 1984-86	DEP DMP 1988-90		
			TCDD	TCDD	TCDF	TEQ
ANDROSCOGGIN R						
Gilead	sucker	f/w	1.8/6.5			
Jay-Riley Dam	sucker	f/w	<2.1/13.0			
	bass	f		17.6	30.5	20.7
N Turner	sucker	f/w	6.2/30.0			
Turner-GIP	sucker	f/w	8.3/29.0			
	bullhead	f/w	7.8/29.6			
	bass	f/w	3.7/24.0			
Lisbon Falls	sucker	f/w	5.1/12.0			
	bass	f		4.5	4.9	5.0
	trout	f		5.3	6.1	5.9
Brunswick	carp	f	11.0			
	sucker	w	19.0			
BEARCE LAKE						
Baring	pickerel	f	<0.1			
KENNEBEC R						
Fairfield	sucker	w	6.4	10.3	32.8	13.6
	trout	f		6.2	5.6	6.8
Sidney	sucker	f/w	1.2/11.4			
	bass	w	20.3			
Augusta	sucker	w		5.0	13.4	6.3
	trout	f		2.2	2.1	2.4
NARRAGUAGUS R						
Cherryfield	fallfish	w	<1.0			
NORTH POND						
Chesterville	sucker	w	0.37			
	pickerel	f	<0.1			

f=fillet
w=whole
TEQ = toxic equivalents = 2378-TCDD + 0.1 x 2378 TCDF

TABLE 2. (cont.)

WATER/STATION	SPECIES	TYPE	EPA NDS/NBS 1984-86 TCDD	DEP DMP 1988-90 TCDD	DEP DMP 1988-90 TCDF	DEP DMP 1988-90 TEQ
PENOBSCOT R						
East Branch	sucker	w		<0.1	0.8	<0.4
	bass	f		<0.4	<0.2	<0.4
E Millinocket	sucker	w		0.7	24.3	3.1
	bass	f		<0.2	3.6	<0.6
N Lincoln	sucker	w		<0.5/20.8	17.6/104	2.3/31.2
	bass	f		<0.4	1.6	<0.4
S Lincoln	sucker	w		37.0	201.2	57.0
	bass	f	5.0	1.7	3.2	2.0
Passadumkeag	sucker	w		2.8	37.4	6.6
	bass	f		1.8	6.7	2.4
Milford	sucker	w		9.7	74.1	17.1
	bass	f		0.9	3.8	1.3
Veazie	sucker	f/w	2.6/7.6	/5.9	/25.0	/7.4
	bass	f/w	/4.6	1.9/	2.5/	2.1/
Owls Head	mussels	w	<0.8			
PISCATAQUIS R						
Howland	bass	f		<0.2	0.2	<0.2
PRESUMPSCOT R						
Westbrook	sucker	w	5.2	5.1	11.5	6.2
	bass	f		1.8	2.2	2.0
	pickerel	f		<2.6	0.5	<2.6
	w perch	f		1.2	4.2	1.6
ST CROIX R						
Calais	sucker	w	<0.7	0.6	2.3	0.8
Woodland	bass	f		0.3	0.5	0.3
ST JOHN R						
Madawaska	y perch	f		<0.5	0.7	<0.6

TABLE 2. (cont.)

WATER/STATION	SPECIES	TYPE	EPA NDS/NBS 1984-86 TCDD	DEP DMP 1988-90 TCDD	TCDF	TEQ
SACO R						
Dayton	sucker	w	<0.3			
SALMON FALLS R						
S Berwick	sucker	w		1.5	1.7	1.7
	bass	f		0.4	0.4	0.4
	pickerel	f		0.2	0.3	0.3
SANDY P						
N Anson	bass	f	<1.0			
SEBAGO L						
Naples	bass	w	<0.6			
SEBASTICOOK R						
E Br. Newport	bass	f	<0.2			
	w perch	f		1.0	4.4	1.4
W Br. Palmyra	sucker	w	1.57	3.3	1.6	3.5
	pickerel	f	<0.1			
	bass	f		1.2	0.4	1.2

TABLE 3. DIOXIN AND FURAN IN SLUDGE FROM MAINE WASTEWATER TREATMENT PLANTS
(pg/g dry weight)

LOCATION	DATE	%MOIST	TCDD	TCDF	TEQ
AUGUSTA SANITARY	900409		1.2	<1.3	1.3
DISTRICT	900607		<3.9	2.5	<4.2
	900914		<20.0	E20.0	<22.0
BERWICK SEWER DISTRICT	861111		<2.5	<4.0	<2.9
	890301	76.4	3.3	4.7	3.8
	890927	75.3	<3.0	<3.0	<3.3
	891208	87.5	144	109	155
BOISE CASCADE CORP	850621		32.0		
RUMFORD	880602		105.0	674.0	171.4
	890108	77.1	26.2	130.4	39.2
	890407	73.1	12.5	49.6	17.5
	890628	76.8	E2.3	31	E5.4
CORINNA SEWER DISTRICT	861106		<0.5	<2.5	<0.7
	871117		<3.6		
	880501		<3.0	E8.5	<3.8
	890222		<13.0	<54.0	<18.4
	890510		<5.0	E41.0	<9.1
	900131		2.3	127	15.0
	900606		<4.0	E130	<17.0
			<4.9	E169	<21.8
FRASER PAPER LTD	880903	68.3	4.4	73.9	11.8
MADAWASKA	890106	79.1	E4.9	42.6	E9.2
	890406	71.3	E1.1	3.7	1.5
	890930	80.1	1.0	E5.3	1.5
GEORGIA PACIFIC CO					
MILLINOCKET	850618		<0.4		
	891217		0.94	3.2	2.4
WOODLAND	880602		<1.9	7.3	<2.6
	890113	75.8	<1.5	<0.86	1.6
	890424	74.7	<0.16	1.2	<1.4
	890718	66.0	<0.6	4.4	<1.0
HARTLAND WASTEWATER	881007	65.0	<1.0	<0.6	<1.0
TREATMENT PLANT	881221	65.5	<2.5	E2.1	<2.7
	890312	64.3	<0.1	2.0	<0.3
	890627	63.3	<0.5	2.4	<0.7

TABLE 3. (cont)

LOCATION	DATE	%MOIST	TCDD	TCDF	TEQ
HAWK RIDGE COMPOST UNITY	1989-90	compost mean of 6 samples	6.6	15.9	8.2
INTERNATIONAL PAPER CO	850621		51.3W		
JAY	870115		190	760	266
	880218		24	130	39
	880219		23	121	34.1
	880223		14	75	21.5
	880225		57	250	82
	880226		15	79	22.9
	880227		13	79	20.9
	881231		16.6W	143W	30.9W
	890124		15W	77W	22.7W
	890126		28	112	39.2
	890214	ash		0.1	0.2
	890323		7.7W	42.6W	12.0W
	890417		24	150	39.0
	890714	ash	0.07	0.02	0.1
	891012	ash	0.14	0	2.63
	891231	ash	0.06	0	0.06
	900205		<18.7	150	<33.7
	900402	ash	0.04	0	0.05
	900501	ash	0	0.002	0.002
	900614	ash	0	0	0
JAMES RIVER CORP	880801		12.0	34.0	15.4
OLD TOWN	881225	78.6	64.5	206	85.1
	890423	78.7	80.9	255	106.4
	890718	68.8	15.8	149	30.7
BERLIN, NH	88		104	2930	397
KENNEBEC SANITARY	870713				38.5
TREATMENT DISTRICT	871105				10.2
WATERVILLE	880118				7.2
	880322				5.4
	880518				18.1
	880921				3.6
	890711				42.2
	891011				106.9
	900410		E7.9	121	20.0
	900824		3.3	54.0	12.7
LEWISTON-AUBURN	871231		<1.0	mean for year (n=4)	
TREATMENT PLANT	881031		0.04		

TABLE 3. (cont.)

LOCATION	DATE	%MOIST	TCDD	TCDF	TEQ
LINCOLN PULP & PAPER CO	881119		48	223	70.3
LINCOLN	890123	80.9	228	909	318.9
	890407	85.1	49.5	219	71.4
	890831	8305	41.3	294	70.7
ORONO TREATMENT PLANT	901004		E3.5	9.2	E4.4
PORTLAND WATER DISTRICT	861205				3.8
PORTLAND	870402				4.1
	871124				1.0
	891205		E1.2	11.3	3.6
WESTBROOK	861205				0.5
	870402				4.9
	871119				0.2
	891205		E1.6	14.5	4.9
REGIONAL WASTE SYSTEMS	890111	ash	5.5	28	8.3
PORTLAND	890112	ash	6	24	8.4
	890113	ash	10	50	15
	890114	ash	10	20	12
	890121	ash	6	90	15
	900211	ash	E20	210	E41
ROBINSON MANUFACTURING	870113		10.1	17.5	18.5
OXFORD	880419		<0.4	<0.2	<0.4
	881004		<7.3	<9.6	<8.2
	890119		<2.1	<1.1	<2.2
SCOTT PAPER CO	871008		36		49.8
WINSLOW			31		48.8
	871201		13.5		23.7
	880331		25	219	52.8
	880630		19	177	38.6
	880930		22	189	4308
	881231		17	181	37.1
	890301	ash	9.7	89	20.3
	890331		18	177	38.5
	890630		14	89	25.1
		ash	7.4	58	14.1
		ash	9.5	63	17.5
	890930		11	67	17.7

TABLE 3. (cont.)

LOCATION	DATE	%MOIST	TCDD	TCDF	TEQ
SD WARREN CO	850711		<1.95	pulp mill sludge	
SKOWHEGAN			2.9	paper mill sludge	
	871201		60		60.1
	880331		27	88	39
	880628		33.0	106	43.6
			6.9	29	9.8
			39.0	149	53.9
			67.0	330	100.0
	881207		40	98	52.1
	881231		54	177	76.5
	890331		54	91	65.6
WESTBROOK	850620		17.2		
	870929		31		31.1
	871231		21	135	34.7
	880331		5.6	21	7.7
	880401		8.7	3.9	14.9
	880630		13	55	18.5
	881207		19	127	34.2
			19	69	27.5
	890106		<1.8	31	<4.9
	890331		6.2	18	8.6
	890731		5	37	16
	890831		8	40	14.9
	890931		9	60	17.8
	891031		5	30	12.9
	891131		3	30	15.5
	891231		7	50	15.2
	900131		6	20	14.0
	900231		2.7	24.6	7.7
	900331		5.1	33.6	17.1
	900431		5.9	34.6	14.9
	900531		5.3	25.8	10.5
	900631		19.0	26.0	29.5
	900831		2.9	12.1	9.8
S PORTLAND STP	900314		<5.3	3.5	<5.6
STATLER TISSUE CO	880930	62.6	13.8	155	29.3
AUGUSTA	881223	61.4	14.5	126	27.1
	890403	61.6	13.3	93	22.6
	890628	65.5	6.1	143	20.4

Lisbon Falls- Levels of 2378-TCDD lower than those from upriver were found in white suckers in EPA's NBS and in brown trout and smallmouth bass in the DMP at Lisbon Falls. Suckers had higher levels than predators. Levels in bass and brown trout were similar even though bass were native and brown trout were stocked. Brown trout collected had resided in the river for at least one year. There is no additional source of 2378-TCDD known within this river reach. Analysis of sludge from the Lewiston-Auburn wastewater treatment facility in 1987 and 1988 showed levels to be below detection at 1 ppt (part per trillion).

Brunswick- A carp collected in Brunswick in EPA's NDS in 1984 showed a level of 2378-TCDD similar to those of other bottom feeders in upriver sites. Two small mills, International Paper Co.'s Lisbon mill and St. Raymond in Topsham, are located on this river reach. International Paper Co.'s mill makes insulation board and St. Raymond's Pejepscot mill was a groundwood mill and is currently not in operation. Neither has been tested as they do not use chlorine for bleaching pulp.

Kennebec River

Fairfield- Although lower than those found in the Androscoggin River, significant levels of 2378-TCDD and 2378-TCDF were found in brown trout and white suckers collected from the Kennebec River near Shawmut Dam in Fairfield below SD Warren's Somerset Mill in Skowhegan. Levels in suckers were higher than those found in EPA's NBS at this site. Significant levels of 2378-TCDD were found in sludge from this bleached kraft pulp and paper mill in the 104 mill study. Madison Paper Industries also discharges upriver of this site, but does not use chlorine bleach. No other sources are known that could affect this reach.

Sidney- Samples of whole smallmouth bass collected in Sidney in EPA's NBS had the highest levels of any species on the Kennebec. Levels in white suckers were similar to those at Shawmut. Additional sources of 2378-TCDD entering this reach are the Scott Paper Co.'s paper mill at Winslow and Kennebec Sanitary Treatment District's (KSTD) wastewater treatment plant in Waterville, both of which have significant levels of 2378-TCDD in their sludge. KSTD treats municipal waste and waste from Keyes Fiber Co. which uses bleached pulp in making fiber food containers and other paper products.

Augusta- Lower, but significant, levels of 2378-TCDD than were found upriver were found in brown trout and white suckers below the Edwards Dam in Augusta. One additional source affecting this reach is Statler Tissue Corp. in

Augusta, which recycles white paper. Levels of 2378-TCDD in Statler's sludge were low but detectable and quite constant.

Penobscot River

East Branch- As part of the study conducted by the Penobscot Indian Nation (PIN) in 1988, smallmouth bass and white suckers were collected from various locations along the East Branch of the Penobscot River for analysis. The results show that 2378-TCDD is below detection for all samples and 2378-TCDF is below dection for bass and approaching the dection limit for suckers. The results are not unexpected since these samples were chosen to represent clean samples from unaffected control sites. There are no discharges on the East Branch.

East Millinocket- Also as part of the PIN study, smallmouth bass and white suckers were collected from the Rocabema Impoundment in the West Branch of the Penobscot River below Georgia Pacific's (formerly Great Northern Paper Co.) Millinocket and East Millinocket mills. A trace amount of 2378-TCDD was detected in suckers and larger levels of 2378-TCDF were detected in both bass and suckers. Levels of 2378-TCDF in suckers would be significant for anyone eating them. Neither mill uses chlorine for bleaching. Until 1990 the East Millinocket mill bought a small amount of bleached kraft pulp. The town of East Millinocket discharges chlorine disinfected primary treated municipal effluent into Georgia Pacific's treatment lagoon. One sludge sample from the Millinocket mill collected by EPA in 1985 showed no detectable amount of 2378-TCDD; nevertheless, it appears that one or both of these mills is a source of small amounts of 2378-TCDF.

North Lincoln- Smallmouth bass and white suckers were collected in 1988 and 1989 from the river near North Lincoln above the discharge from Lincoln Pulp and Paper Co. as part of the PIN study. The results showed only insignificant amounts of 2378-TCDF with the exception of one sample of suckers in 1988 which showed levels similar to those collected below the discharge from Lincoln Pulp and Paper Co., a bleached kraft pulp and paper mill. For this reason fish were sampled again in 1989. Although only bass were sampled in 1989, results confirmed that levels were insignificant. DEP and the PIN believe that the suckers with the high values may have migrated up to the N. Lincoln site from below Lincoln Pulp and Paper Co.'s discharge downriver.

South Lincoln- As part of its NBS, EPA found significant levels of 2378-TCDD in smallmouth bass from the Penobscot River below the discharge from Lincoln Pulp and Paper Co.. The PIN study and this study found slightly lower levels of

2378-TCDD and low levels of 2378-TCDF in bass both of which were significant and higher than found at North Lincoln. Levels of both compounds in white suckers were the highest found in fish anywhere in Maine. Results of testing in the DMP were consistent with the results of the 104 mill study and showed moderately high concentrations of both 2378-TCDD and 2378-TCDF in Lincoln Pulp and Paper Co.'s sludge.

Passadumkeag and Milford-The PIN study documented somewhat lower but significant levels of both compounds at these downriver stations than at South Lincoln. Levels in smallmouth bass were slightly lower at the Milford site which is below Passadumkeag but levels in white suckers were higher. There are no new sources entering the river between these sites and South Lincoln. There is an impoundment in this reach which may result in removal of sediment and associated dioxin and furan and thereby prevent the transport of these compounds down river to some extent.

Veazie- In this study concentrations of 2378-TCDD in smallmouth bass were elevated at Veazie compared to Milford while concentrations of 2378-TCDF in bass and concentrations of both pollutants in white suckers were lower than at Milford. The concentration of 2378-TCDD in suckers was similar to and concentrations in bass lower that found in whole bass in EPA's NDS at Eddington, across the river from Veazie. All levels were significant. This site is below James River's bleached kraft mill at Old Town. Sludge from this mill consistently contained detectable amounts of both pollutants as demonstrated by the 104 mill study and this study.

Piscataquis River

Howland- In 1989 the PIN collected smallmouth bass from the Piscataquis River just above the confluence with the Penobscot River. Because some sludge samples from some textile mills in Maine had been found to contain dioxin and furan, the purpose of these samples was to detect any contamination from Guilford Industries textile mill in Guilford. Levels of 2378-TCDD were below detection and levels of 2378-TCDF approached the detection limit and were not significant.

Presumpscot River

Westbrook- Only three smallmouth bass were captured from the Presumpscot River below SD Warren's bleached kraft mill in Westbrook in this study. To fill the quota of ten predators a chain pickerel and six white perch were captured and analyzed. There was not much difference in concentrations of either pollutant among these species.

Values were low but significant. Levels in white suckers were higher than those in the predators and similar to those found in EPA's NBS. Testing of sludge from SD Warren's mill as part of the 104 mill study and as a monitoring requirement for a DEP sludge spreading permit has consistently shown detectable levels of both 2378-TCDD and 2378-TCDF. Most recent data show levels are lower than they were formerly. There are no other known sources discharging to the river.

St. Croix River

Woodland- Neither EPA's NBS nor the DMP was able to detect significant amounts of 2378-TCDD or 2378-TCDF in samples of white suckers collected just above the Milltown bridge in Calais. Nor were significant levels of either pollutant found in smallmouth bass collected from the American side of the river below the discharge from Georgia Pacific's bleached kraft mill in Woodland. Analyses of sludge samples from Georgia Pacific's mill as part of EPA's 104 mill study and this study showed no detectable 2378-TCDD and only small amounts of 2378-TCDF. This was the only bleached kraft mill in Maine to have no significant amounts of either pollutant in its sludge.

St. John River

Madawaska- Fraser Paper Ltd. operates a bleached sulfite mill in Edmunston, New Brunswick with its paper mill on the American side in Madawaska. Only yellow perch were captured from the St. John River below Fraser Paper Ltd.'s discharges in this study. No 2378-TCDD and only insignificant amounts of 2378-TCDF were found. There are no data for bottom feeders from this river.

Salmon Falls River

S. Berwick- The desired number of target species was not collected from the Salmon Falls River below the Berwick Sewer District's wastewater treatment facility in S. Berwick in this study. Only two smallmouth bass, two largemouth bass, three chain pickerel, and ten white suckers were collected. Average concentrations of both pollutants were similar for all predators and were not significant. Values for suckers were higher and would be significant for anyone eating those fish. Upriver the Berwick Sewer District's wastewater treatment facility discharges wastewater comprised of sanitary and tannery (>85% of total volume) waste. Sludge testing results from this program were variable, ranging from non-detect to quite high levels of 2378-TCDD and 2378-TCDF. Additionally there was a tannery

(which closed in 1978) and two fiber mills (which closed 1980 and 1987) which discharged to the river in New Hampshire and may be historical sources.

Sebasticook River

East Branch at Newport- In the DMP only white perch were collected at this site which was at the inlet to Sebasticook Lake. Both 2378-TCDD and 2378-TCDF were detected at low but significant levels. These results are in contrast with those of EPA's NBS in which no detectable amounts of 2378-TCDD were found in a sample of largemouth bass at this site. This site is downstream from the discharge from the Corinna Sewer District's wastewater treatment facility in Corinna. This discharge is composed of more than 80% waste from the Eastland Woolen Mill also in Corinna. Although results of sludge testing showed both pollutants below detection (except for one sample for 2378-TCDF) when tested as part of a monitoring requirement for the sludge spreading program, detection levels were so high that it cannot be assured that levels are of no concern.

West Branch at Palmyra- EPA's NBS found no 2378-TCDD in chain pickerel but did find amounts that would be significant to human consumers in white suckers at this site. In the DMP slightly higher levels were found in suckers and significant levels were found in smallmouth bass at this site. Upriver the Town of Hartland's wastewater treatment facility discharges effluent that is composed of more than 85% waste from Irving Tanning Co.. Testing of Hartland's sludge showed no detectable 2378-TCDD but did show detectable levels of 2378-TCDF in two of the four sam ples. There are no other known sources of these pollutants on this river.

Control sites- To determine natural background levels of 2378-TCDD, as part of EPA's NDS/NBS, fish and shellfish were collected from presumably clean control sites with no industrial or municipal discharges. These included mussels from Penobscot Bay at Owls Head and fish from Bearce Lake in Barring, the Narraguagus River in Cherryfield, North Pond in Chesterville, Saco River at Union Falls, Sandy Pond at N. Anson, and Sebago Lake. Levels were all below detection and/or insignificant. Sludge samples from a number of municipal wastewater treatment facilities with no significant industrial input have shown low levels of 2378-TCDD and 2378-TCDF in other data collected by DEP.

Both 2378-TCDD and 2378-TCDF have been found at other sites in Maine. Ash from municipal incinerators (Maine Energy Recovery Co. in Biddeford, Penobscot Energy Recovery Co. in Orrington, and Regional Waste Systems in Portland) has been

found to contain both pollutants (Table 3). At two hazardous waste sites dioxin and furan have also been found. At Union Chemical Co. in Hope levels of 2378-TCDD equivalents from 2-13,000 ppt were found in residues within the incinerator equipment, while none was detected in soil samples collected from adjacent areas of predicted fallout. Nevertheless, because of discrepancies in the results of modelling exercises additional samples will be collected. At Industrial Box and Lumber Co. in Parsonsfield other dioxin and furan congeners were detected in a concrete basin filled with wood preservatives. Although 2378-TCDD and 2378-TCDF were below detection, the detection levels were quite high. In groundwater samples from the site, no 2378-TCDD and only a trace of 2378-TCDF were found at low detection levels. Higher amounts of other less toxic congeners and other pollutants were found in these samples.

CONCLUSIONS

Results of EPA's NBS/NDS and Maine's DMP, have shown that 2378-TCDD and/or 2378-TCDF are present in significant amounts in fish from rivers below the discharge from the Hartland Wastewater Treatment Plant's discharge and 6 out of 7 of Maine's bleached kraft pulp and paper mills (Boise Cascade Corp. in Rumford, International Paper Co. in Jay, James River Corp. in Old Town, Lincoln Pulp and Paper Co. in Lincoln, and SD Warren Co. mills in Skowhegan and Westbrook). As a consequence the Maine Department of Human Services (DHS), has issued fish consumption advisories for those rivers (Table 4). More recently, data showing significanyly high levels of these pollutants in fish below the discharge from the Corinna Sewer District have been received by DEP and forwarded to DHS for review. Testing of sludge on the EPA/Paper Industry cooperative 5 mill and 104 mill studies and Maine's DMP, have documented the presence of these compounds in wastewater sludges from these facilities in significant amounts.

The federal Clean Water Act (CWA) and Maine's Water Classification Program, 38 MRSA Article 4-A, require that all classified bodies of water in the state be suitable for the designated use of "fishing". Implied within the definition of fishing is that the fish be suitable for human consumption. The existence of the fish consumption advisories on 5 rivers documents non-attainment of the classification of those waters. Section 304L of the CWA required that DEP report waterbodies not attaining their classification and associated pollution sources to EPA in 1989. Using the information known at the time, DEP listed 4 of these 5 rivers (excluding the West Branch of the Sebasticook River) and the St. Croix River and all 7 bleached kraft mills. The St. Croix River was included since

the 104 mill Study data showed detectable amounts of of 2378-TCDD and 2378-TCDF in effluent and sludge respectively. Consequently EPA and DEP are modifying existing wastewater discharge permits to include, for the first time, effluent limits for 2378-TCDD and 2378-TCDF. All permits have been drafted and final NPDES permits have been issued by EPA for Georgia Pacific's Woodland mill and for SD Warren's Skowhegan mill. The basis for the effluent limits would be Maine's water quality criterion for 2378-TCDD if in existence or EPA's criterion if there was no state criterion. The Board of Environmental Protection adopted EPA's criteria for toxic pollutants in 1989, but in 1990, when it adopted EPA's criteria by statute, the Maine Legislature delayed the effective date for adoption of the EPA criterion for 2378-TCDD until July 1991. In the meantime DEP and EPA are using performance based interim limits with final limits based on the EPA criterion not taking effect until June 1992.

Already many of the mills have reduced the wastewater discharge of 2378-TCDD and 2378-TCDF significantly (Appendix 3). In time levels in fish are expected to decline as well. It is difficult to predict how many years it will take before the fish consumption advisory can be removed. The half-life of 2378-TCDD and 2378-TCDF in fish has been reported to range from days to months in laboratory studies. However, laboratory studies may not be good models for predicting depuration in the natural environment since highly organic sediments may act as a continued source of 2378-TCDD for a significant period of time after discharges have been reduced. In one field study concentrations of 2378-TCDD in fish from the Tittabawassee River below Dow Chemical Co. in Midland, Michigan have been reported to have declined 90% in 7 years following cessation of discharge, but the sample size was too small to be sure. Furthermore, fish from the Tittabawassee River had levels up to 10 times higher initially than levels found in Maine fish. Finally, sediments were low in organic carbon (in which the dioxin is thought to be held) compared to probable levels in impoundments in Maine Rivers. In order to determine the organic carbon content and the 2378-TCDD and 2378-TCDF content and decay rate of Androscoggin River sediments and to compare to data collected by EPA in 1985, DEP and EPA will collect sediments from several sites during 1991 for analysis for 2378-TCDD and 2378-TCDF. Data will be used in a model to predict decline in concentrations in fish. In order to determine actual declines, DEP will continue to monitor concentrations of 2378-TCDD and 2378-TCDF in fish from affected rivers through Maine's DMP, amended by the Maine legislature in 1990 to an annual program through 1995, or monitoring requirements in the waste discharge license.

Table 4. Fish Consumption Advisory for Maine Rivers

Joint Statement: March 19, 1990:
Department of Human Services
Department of Environmental Protection
Department of Inland Fish and Wildlife
Contact
Robert Frakes, D.H.S., 289-5378

FOR IMMEDIATE RELEASE:

DIOXIN LEVELS PROMPT NEW FISH ADVISORY....

(AUGUSTA)--State officials today revised a 1987 public health advisory concerning fish from Maine's industrial rivers. Recent tests show significantly higher levels of (TCDD) dioxin concentration than previously recorded. The contamination prompted a stiffer warning to pregnant women, nursing mothers and the general population.

"New data indicates that pregnant women and nursing mothers should not eat fish caught in the Androscoggin, the Kennebec below Skowhegan, Penobscot below Lincoln, Presumpscot below Westbook, and West Branch of the Sebasticook below Hartland," said State Toxicologist Robert Frakes. "Furthermore, we are advising the general public to limit themselves to two fish meals a year from the Androscoggin and five from that section of the Kennebec. These warnings reflect the best information we have to date and may themselves be revised as additional data becomes available."

Today's advisory differs from the earlier one in that it includes the Sebasticook River in the warning to pregnant women and, for the first time, specifically cautions the public-at-large about Kennebec fish. In addition, the recommended consumption limit for Androscoggin fish is lowered from 12 meals per year to 2. A "meal" is considered to be 8 ounces.

Detectible dioxin concentrations in Maine fish were first discovered in 1984. Because even very low levels of TCDD has been linked to increased cancer rates and reproductive problems in laboratory animals, health advisories were issued in 1985 and 1987.

The most recent tests of fish from five Maine industrial rivers show mean TCDD equivalent levels ranging from 0.2 parts per trillion (Penobscot above Lincoln) to 20.7 ppt (Androscoggin) in fillets of smallmouth bass.

References

EPA, 1987. The National Dioxin Study, Tiers 3,5,6,and 7 Office of Water Regulations and Standards, Environmental Protection Agency, Washington, DC. EPA 440/4-87-003

EPA, 1988. US EPA/Paper Industry Cooperative Dioxin Screening Study. Office of Water Regulations and Standards, Environmental Protection Agency, Washington, DC. EPA 440/1-88-025

Fay,CW and HJ Westra, 1989. Summary Report-Levels of Selected Contaminants in Tissue from Smallmouth Bass and White Suckers Collected from the Penobscot River, 1988. Penobscot Nation, Old Town, Maine.

Fay, CW 1990. Penobscot Nation, Old Town, Maine. Letter of 20 August 1990 and personal communication.

APPENDIX 1

MAINE DIOXIN MONITORING PROGRAM

APPROVED
APR 22'88
BY GOVERNOR

CHAPTER
762
PUBLIC LAW

STATE OF MAINE

IN THE YEAR OF OUR LORD
NINETEEN HUNDRED AND EIGHTY-EIGHT

H.P. 1562 - L.D. 2129

AN ACT to Prohibit the Release of Dioxins in any State Rivers, Streams or Lakes.

Be it enacted by the People of the State of Maine as follows:

Sec. 1. 38 MRSA §420-A is enacted to read:

§420-A Dioxin monitoring program

In order to determine the nature of dioxin contamination in the waters and fisheries of the State, the department shall conduct a one-year monitoring program as described in this section.

1. Dioxin defined. As used in this section, the term "dioxin" means any polychlorinated dibenzo-para-dioxins, PCDD's, and any polychlorinated dibenzo-para-furans, PCDF's.

2. Monitoring locations and subjects. The department shall:

A. Select a representative sample of wastewater treatment plant sludges from municipal wastewater treatment plants and bleached pulp mills. These facilities shall be selected on the basis of known or likely dioxin contamination of their discharged effluent. The total number of facilities shall not exceed 12;

B. Sample and test the sludge of these facilities for dioxin contamination at least once during each

season of the year. The department shall specify which cogeners of dioxin will be analyzed; and

C. Sample and test for dioxin contamination a selection of fish representative of those species present in the receiving waters. Sufficient numbers of fish will be analyzed to provide a reasonable estimate of the level of contamination in the population of each water body affected.

3. Coordination of monitoring. The commissioner shall coordinate the monitoring program established under this section with other dioxin monitoring programs conducted by the department, the United States Environmental Protection Agency or dischargers of wastewater. The commissioner shall seek to integrate the results of these other programs, as relevant, into the reports required by this section.

4. Report. The department shall report by December 1, 1990 on the results of the monitoring program to the joint standing committee of the Legislature having jurisdiction over natural resources. The final report shall contain the department's conclusions as to the levels of dioxin contamination in the sample subjects and the likely scope of dioxin contamination in the State's waters.

5. Fees assessed. The commissioner shall assess the selected facilities for the costs of sample collection and analysis. Fees received under this section shall be credited to the Maine Environmental Protection Fund. Payment of these fees is a condition of the discharge license issued under this Title for continued operation of the selected facilities.

Sec. 2. Allocation. The following funds are allocated from the Maine Environmental Protection Fund to carry out the purposes of this Act.

1987-88

ENVIRONMENTAL PROTECTION, DEPARTMENT OF

Water Quality Control

APPENDIX 2

2378-TCDD and 2378-TCDF IN FISH FROM SELECTED MAINE RIVERS

ABBREVIATIONS

Fish species

BBH	brown bullhead
CCP	common carp
BNT	brown trout
CHP	chain pickerel
FLF	fallfish
LMB	largemouth bass
SMB	smallmouth bass
WHP	white perch
YLP	yellow perch

Other

C(n)	composite of n fish
D	duplicate
F	fillet
M	matrix spike
S	skinless
TCDD	2378-tetrachlorodibenzo-p-dioxin
TCDF	2378-tetrachlorodibenzofuran
TEQ	toxic equivalents= TCDD + 0.1 x TCDF
W	whole fish

APPENDIX 2. 2378-TCDD AND 2378-TCDF IN FISH FROM SELECTED MAINE RIVERS

A83 ANDROSCOGGIN RIVER AT WORUMBO DAM, LISBON FALLS

DATE	SPECIES ID	LENGTH (mm)	WEIGHT (gm)	TYPE	LIPID %	MOIST %	TCDD (pg/g)	TCDF (pg/g)	TEQ (pg/g)
900601	BNT01	305		SF	0.8		3.0	7.3	3.7
	BNT02	356		SF	2.2		7.6	8.9	8.5
	BNT03	432		SF	0.63		5.4	2.2	5.6
						MEAN	5.3	6.1	5.9
	SMB01	279		SF	0.15		4.4	4.9	4.9
	SMB02	330		SF	0.27		4.8	6.4	5.4
	SMB03	406		SF	0.16		3.9	4.0	4.3
	SMB03D						(4.5)	(4.4)	(4.9)
						MEAN	4.5	4.9	5.0
	SMB03M				RECOVERY		107%	73%	
				MEAN OF ALL FISH			4.9	5.5	5.4

APPENDIX 2. 2378-TCDD AND 2378-TCDF IN FISH FROM SELECTED MAINE RIVERS

A586 ANDROSCOGGIN RIVER ABOVE RILEY DAM, JAY

DATE	SPECIES ID	LENGTH (mm)	WEIGHT (gm)	TYPE	LIPID %	MOIST %	TCDD (pg/g)	TCDF (pg/g)	TEQ (pg/g)
890715	SMB01	394		SF	4.38	74.3	9.6	21.8	11.8
	SMB02	562		SF	5.62	72.8	14.7	35.1	18.2
	SMB03	368		SF	2.94	75.5	24.9	30.1	27.9
	SMB04	381		SF	3.34	73.9	15.2	22.0	17.4
	SMB05	381		SF	4.39	70.8	18.9	23.7	21.3
	SMB06	381		SF	2.72	78.7	14.3	19.9	16.3
	SMB07	356		SF	5.40	71.4	15.1	26.9	17.8
	SMB08	356		SF	5.41	71.0	10.1	16.6	11.8
	SMB09	394		SF	5.67	68.4	28.1	56.2	33.7
	SMB10	330		SF	2.35	80.8	24.7	52.9	30.0
	SMB10D						(25.6)	(53.2)	(30.9)
						MEAN	17.6	30.5	20.7
	SMB10M				RECOVERY		106%	122%	

APPENDIX 2. 2378-TCDD AND 2378-TCDF IN FISH FROM SELECTED MAINE RIVERS

K247 KENNEBEC RIVER AT SHAWMUT DAM, FAIRFIELD

DATE	SPECIES ID	LENGTH (mm)	WEIGHT (gm)	TYPE	LIPID %	MOIST %	TCDD (pg/g)	TCDF (pg/g)	TEQ (pg/g)
880519	BNT01	343	454	SF	0.55	70.5	4.2	4.4	4.6
880513	BNT02	444	1000	SF	0.56	72.0	4.4	2.5	4.6
880519	BNT03	432	900	SF	3.84	72.0	10.3	7.4	11.0
880514	BNT04	330	340	SF	0.99	7108	8.1	4.1	8.5
880519	BNT05	340	450	SF	2.50	74.3	5.2	9.7	6.2
	BNT05D						(6.6)	(10.9)	(7.7)
880519	BNT06	381	680	SF	0.08	72.0	1.3	0.53	1.3
880513	BNT07	432	900	SF	2.23	74.8	4.2	5.0	4.7
890707	BNT08	432	1130	SF	2.28	69.9	6.8	4.5	7.2
890710	BNT09	406	900	SF	0.81	69.1	8.5	7.6	9.3
890714	BNT10	387		SF	2.76	66.0	8.8	9.4	9.7
						MEAN	6.2	5.6	6.8
880830	BNT10M				RECOVERY		98%	92%	
880830	WSU1-5	359	528	WC5	1.63	72.5	11.2	34.7	14.7
	WSU6-10	374	558	WC5	5.81	73.3	9.4	30.8	12.5
						MEAN	10.3	32.8	13.6

APPENDIX 2. 2378-TCDD AND 2378-TCDF IN FISH FROM SELECTED MAINE RIVERS

K-1.0 KENNEBEC RIVER BELOW EDWARDS DAM, AUGUSTA

DATE	SPECIES ID	LENGTH (mm)	WEIGHT (gm)	TYPE	LIPID %	MOIST %	TCDD (pg/g)	TCDF (pg/g)	TEQ (pg/g)
880402	BNT01	330		SF	2.45	78.1	2.1	2.8	2.4
	BNT02	432		SF	2.07	75.5	5.5	2.9	5.8
	BNT03	491	1300	SF	2.05	80.4	<0.6	1.3	<0.7
	BNT04	419	620	SF	0.66	83.6	<0.8	1.3	<0.9
	BNT04D						(<0.4)	(1.8)	(<0.6)
						MEAN	2.2	2.1	2.4
	BNT04M				RECOVERY		80%	78%	
880830	WSU1-5	373	581	WC5	5.29	79.8	4.6	13.2	5.9
	WSU6-10	372	547	WC5	3.66	74.7	5.4	13.5	6.7
						MEAN	5.0	13.4	6.3

APPENDIX 2. 2378-TCDD AND 2378-TCDF IN FISH FROM SELECTED MAINE RIVERS

P32 PENOBSCOT RIVER AT VEAZIE DAM, VEAZIE

DATE	SPECIES ID	LENGTH (mm)	WEIGHT (gm)	TYPE	LIPID %	MOIST %	TCDD (pg/g)	TCDF (pg/g)	TEQ (pg/g)
900615	SMB01	310		SF	0.26		2.2	5.5	2.8
	SMB02	335		SF	0.06		1.1	1.2	1.2
	SMB03	330		SF	0.06		2.1	3.7	2.5
	SMB04	318		SF	0.08		1.8	1.3	1.9
	SMB05	330		SF	0.04		2.1	E2.3	2.3
	SMB06	330		SF	0.02		1.6	1.7	1.8
	SMB07	343		SF	0.08		2.1	2.5	2.4
	SMB08	333		SF	0.02		1.4	2.0	1.6
	SMB09	330		SF	0.05		1.5	1.3	1.6
	SMB10	318		SF	0.08		2.8	3.5	3.2
						MEAN	1.9	2.5	2.1
	WSU1-5	352		WC5	1.03		5.4	21.4	7.5
	WSU6-10	339		WC5	1.53		5.8	26.7	8.4
	WSU6-10D						(7.0)	(30.5)	(10.0)
						MEAN	5.9	25.0	7.4
	WSU6-10M				RECOVERY		118%	100%	

APPENDIX 2. 2378-TCDD AND 2378-TCDF IN FISH FROM SELECTED MAINE RIVERS

P166 PENOBSCOT RIVER NEAR FREESE ISLAND, MILFORD

DATE	SPECIES ID	LENGTH (mm)	WEIGHT (gm)	TYPE	LIPID %	MOIST %	TCDD (pg/g)	TCDF (pg/g)	TEQ (pg/g)
880824	SMBCS1	338	545	SFC5			<0.7	3.8	<1.1
	SMBCS2	340	545	SFC5			1.1	3.7	1.5
						MEAN	0.9	3.8	1.3
880901	WSUCS1	386	681	WC4			7.3	63.1	13.6
	WSUCS2	394	726	WC4			12.1	85.2	20.6
						MEAN	9.7	74.1	17.1

APPENDIX 2. 2378-TCDD AND 2378-TCDF IN FISH FROM SELECTED MAINE RIVERS

P338 PENOBSCOT RIVER NEAR PASSADUMKEAG RIVER, PASSADUMKEAG

DATE	SPECIES ID	LENGTH (mm)	WEIGHT (gm)	TYPE	LIPID %	MOIST %	TCDD (pg/g)	TCDF (pg/g)	TEQ (pg/g)
880615	SMBPS1	338	545	SFC5			2.3	8.2	3.1
	SMBPS2	338	545	SFC5			<1.2	5.2	<1.7
						MEAN	1.8	6.7	2.4
880831	WSUPS1	384	681	WC5			<0.6	50.1	5.7
	WSUPS2	384	681	WC5			5.0	24.8	7.5
						MEAN	2.8	37.4	6.6

APPENDIX 2. 2378-TCDD AND 2378-TCDF IN FISH FROM SELECTED MAINE RIVERS

P445 PENOBSCOT RIVER BELOW SOUTH LINCOLN BOAT RAMP, LINCOLN

DATE	SPECIES ID	LENGTH (mm)	WEIGHT (gm)	TYPE	LIPID %	MOIST %	TCDD (pg/g)	TCDF (pg/g)	TEQ (pg/g)
880609	SMBSL1	320	454	SFC5			<1.2	3.1	<1.5
	SMBSL2	325	499	SFC5			<1.3	3.8	<1.7
						MEAN	<1.2	3.4	<1.6
891003	SMBSL1	337	506	SFC5	0.64		3.0	4.1	3.4
	SMBSL2	337	506	SFC5	0.29		2.0	2.9	2.3
						MEAN	2.5	3.5	2.8
900823	SMB01	328	450	SF	0.40		0.96	2.1	1.17
	SMB02	354	560	SF	0.22		E0.53	1.0	E0.63
	SMB03	345	500	SF	0.28		2.1	2.6	2.4
	SMB04	362	640	SF	0.52		E1.1	2.6	E1.4
	SMB05	403	830	SF	0.78		3.4	8.9	4.3
	SMB06	440	1010	SF	0.19		1.4	1.6	1.6
	SMB06D						(1.4)	(1.6)	(1.6)
						MEAN	1.6	3.1	1.9
	SMB06M				RECOVERY		107%	89%	
				MEAN FOR ALL BASS			1.7	3.3	2.0
880831	WSUSL1	444	999	WC5			28.2	188.3	47.0
	WSUSL2	447	1044	WC5			45.7	214.2	67.0
						MEAN	37.0	201.2	57.0

APPENDIX 2. 2378-TCDD AND 2378-TCDF IN FISH FROM SELECTED MAINE RIVERS

P538 PENOBSCOT RIVER AT NORTH LINCOLN

DATE	SPECIES ID	LENGTH (mm)	WEIGHT (gm)	TYPE	LIPID %	MOIST %	TCDD (pg/g)	TCDF (pg/g)	TEQ (pg/g)
880603	SMBNL1	330	499	SFC5			<0.4	2.2	<0.6
	SMBNL2	333	499	SFC5			<0.3	1.4	<0.4
						MEAN	<0.4	1.8	<0.5
891003	SMBNL1	320	451	SFC4	0.56		<0.2	0.7	0.3
	SMBNL2	320	451	SFC4	1.2		E0.36	2.0	E0.56
						MEAN	0.3	1.4	0.4
				MEAN FOR ALL BASS			0.3	1.6	0.4
880603	WSUNL1	434	953	WC5			<0.5	17.6	2.3
	WSUNL2	424	908	WC5			20.8	104.0	31.2
						MEAN	10.6	60.8	16.7

APPENDIX 2. 2378-TCDD AND 2378-TCDF IN FISH FROM SELECTED MAINE RIVERS

P735 W BR PENOBSCOT RIVER IN ROCABEMA IMPOUNDMENT, E MILLINOCKET

DATE	SPECIES ID	LENGTH (mm)	WEIGHT (gm)	TYPE	LIPID %	MOIST %	TCDD (pg/g)	TCDF (pg/g)	TEQ (pg/g)
880706	SMBEM1	323	454	SFC5			<0.1	3.9	<0.5
	SMBEM2	328	499	SFC5			<0.4	3.4	<0.7
						MEAN	<0.2	3.6	<0.6
880830	WSUEM1	353	545	WC5			<0.5	20.3	2.5
	WSUEM2	356	590	WC5			0.9	28.3	3.7
						MEAN	0.7	24.3	3.1

APPENDIX 2. 2378-TCDD AND 2378-TCDF IN FISH FROM SELECTED MAINE RIVERS

PEB E BR PENOBSCOT RIVER

DATE	SPECIES ID	LENGTH (mm)	WEIGHT (gm)	TYPE	LIPID %	MOIST %	TCDD (pg/g)	TCDF (pg/g)	TEQ (pg/g)
880830	SMBGS1	343	590	SFC5			<0.5	<0.2	<0.5
	SMBGS2	348	545	SFC5			<0.3	<0.2	<0.3
						MEAN	<0.4	<0.2	<0.4
	WSUGS1	437	863	WC3			<0.1	1.0	<0.2
881021	WSUGS2	425	817	WC4			<0.1	0.6	<0.2
						MEAN	<0.1	0.8	<0.2

APPENDIX 2. 2378-TCDD AND 2378-TCDF IN FISH FROM SELECTED MAINE RIVERS

PPQ10 PISCATAQUIS RIVER IN HOWLAND IMPOUNDMENT, HOWLAND

DATE	SPECIES ID	LENGTH (mm)	WEIGHT (gm)	TYPE	LIPID %	MOIST %	TCDD (pg/g)	TCDF (pg/g)	TEQ (pg/g)
891013	SMBPQ1	342	564	SFC4	0.22		<0.2	0.3	<0.2
	SMBPQ2	342	564	SFC4	0.48		<0.1	0.1	<0.1
						MEAN	<0.2	0.2	<0.2

APPENDIX 2. 2378-TCDD AND 2378-TCDF IN FISH FROM SELECTED MAINE RIVERS

R48 PRESUMPSCOT RIVER AT RT 302, WESTBROOK

DATE	SPECIES ID	LENGTH (mm)	WEIGHT (gm)	TYPE	LIPID %	MOIST %	TCDD (pg/g)	TCDF (pg/g)	TEQ (pg/g)
891005	SMB01	460	1400	SF	0.18	76.1	4.0	4.0	4.4
	SMB01D						(3.6)	(4.5)	(4.0)
	SMB02	335	450	SF	0.31	76.7	0.70	1.3	0.83
	SMB03	223	125	SF	0.42	88.4	E0.88	E0.94	E0.97
						MEAN	1.8	2.2	2.0
	CHP01	480	660	SF	3.25	74.4	<2.6	0.51	<2.6
	WHP01	235	175	SF	0.04	82.2	E1.1	3.9	E1.5
	WHP02	215	125	SF	0.86	76.1	0.94	3.1	0.97
	WHP03	222	150	SF	0.60	70.2	1.4	5.1	1.9
	WHP04	230	170	SF	0.24	78.1	E1.2	4.2	E1.6
	WHP05	230	175	SF	0.84	73.0	1.7	4.9	2.2
	WHP06	220	110	SF	1.52	76.3	1.2	3.8	1.6
						MEAN	1.2	4.2	1.6
			MEAN FOR ALL PREDATORS				1.6	3.2	1.9
	WSU1-5	436	954	WC5	0.19	74.8	3.6	10.4	4.6
	WSU6-10	409	832	WC5	0.43	74.4	6.6	12.6	7.9
						MEAN	5.1	11.5	6.2

APPENDIX 2. 2378-TCDD AND 2378-TCDF IN FISH FROM SELECTED MAINE RIVERS

C96 ST CROIX RIVER NEAR WAPSACONHAGAN BROOK, WOODLAND

DATE	SPECIES ID	LENGTH (mm)	WEIGHT (gm)	TYPE	LIPID %	MOIST %	TCDD (pg/g)	TCDF (pg/g)	TEQ (pg/g)
900628	SMB01	404	740	SF	0.05		<0.1	<0.07	<0.1
	SMB02	434	920	SF	0.06		<0.2	0.17	<0.2
	SMB03	383	630	SF	0.05		<0.2	0.16	<0.2
	SMB04	425	830	SF	0.03		E0.33	0.47	E0.38
	SMB05	315	350	SF	0.15		<0.1	0.39	<0.1
	SMB06	313	375	SF	0.40		<0.2	E0.41	<0.2
	SMB07	332	480	SF	0.22		<0.2	0.63	<0.2
	SMB08	379	640	SF	0.29		<0.5	0.54	<0.5
	SMB09	415	950	SF	0.27		E0.36	0.91	E0.45
	SMB10	319	420	SF	0.34		E0.44	0.82	E0.52
						MEAN	0.3	0.5	0.3
890601	WSU1-5	371		WC5	1.32		E0.44	1.5	E0.59
	WSU6-10	371		WC5	1.09		<0.6	3.2	<0.9
	WSU6-10D						(<0.9)	(3.1)	(1.2)
						MEAN	0.6	2.3	0.8
	WSU6-10M				RECOVERY		121%	91%	

APPENDIX 2. 2378-TCDD AND 2378-TCDF IN FISH FROM SELECTED MAINE RIVERS

J348 ST JOHN RIVER BELOW MADAWASKA RIVER, MADAWASKA

DATE	SPECIES ID	LENGTH (mm)	WEIGHT (gm)	TYPE	LIPID %	MOIST %	TCDD (pg/g)	TCDF (pg/g)	TEQ (pg/g)
900915	YLP01	305		SF	0.16		<0.2	0.37	<0.2
	YLP02	305		SF	0.61		<0.3	0.54	<0.4
	YLP03	280		SF	0.56		<0.2	0.61	<0.3
	YLP04	255		SF	0.29		<0.4	0.62	<0.5
	YLP05	255		SF	0.48		<0.4	0.99	<0.5
	YLP06	305		SF	0.92		1.5	1.5	1.6
	YLP07	280		SF	0.14		<0.4	0.45	<0.4
	YLP08	280		SF	0.30		<0.4	0.33	<0.4
	YLP09	267		SF	0.94		<0.6	1.2	<0.6
	YLP10	267		SF	0.07		<0.3	0.26	<0.3
	YLP10D						(<0.2)	(0.25)	(<0.2)
						MEAN	<0.5	0.7	<0.6
	YLP10M				RECOVERY		121%	95%	

APPENDIX 2. 2378-TCDD AND 2378-TCDF IN FISH FROM SELECTED MAINE RIVERS

ISF32 SALMON FALLS RIVER ABOVE SOUTH BERWICK

DATE	SPECIES ID	LENGTH (mm)	WEIGHT (gm)	TYPE	LIPID %	MOIST %	TCDD (pg/g)	TCDF (pg/g)	TEQ (pg/g)
900628	SMB01	391	790	SF	0.14	77.1	E0.39	E0.45	E0.44
	SMB02	254	190	SF	0.11	72.1	0.50	0.30	0.53
						MEAN	0.45	0.37	0.48
	LMB01	315	420	SF	0.04	78.0	<0.4	0.47	<0.4
	LMB02	322	480	SF	0.14	77.9	E0.29	0.37	E0.33
						MEAN	0.35	0.42	0.36
	CHP01	428	460	SF	0.01	79.9	E0.18	0.23	E0.20
	CHP02	275	80	SF	0.10	78.9	E0.30	0.38	E0.34
	CHP03	400	360	SF	0.11	79.4	0.27	0.41	0.31
						MEAN	0.25	0.34	0.28
			MEAN FOR ALL PREDATORS				0.34	0.37	0.36
	WSU1-5	419	798	WC5	1.14	75.2	1.2	1.2	1.3
	WSU6-10	401	670	WC5	1.84	75.9	1.8	1.9	2.0
	WSU6-10D						1.9	2.6	2.2
						MEAN	1.5	1.7	1.7
	WSU6-10M				RECOVERY		125%	104%	

APPENDIX 2. 2378-TCDD AND 2378-TCDF IN FISH FROM SELECTED MAINE RIVERS

KSBEB120 E BR SEBASTICOOK RIVER AT COUNTY RD, NEWPORT

DATE	SPECIES ID	LENGTH (mm)	WEIGHT (gm)	TYPE	LIPID %	MOIST %	TCDD (pg/g)	TCDF (pg/g)	TEQ (pg/g)
900712	WHP01	225	165	SF	0.62	76.2	0.78	4.5	1.23
	WHP02	223	180	SF	1.17	77.4	E0.33	1.7	E0.50
	WHP03	229	185	SF	0.74	77.8	0.79	3.2	1.11
	WHP04	236	215	SF	3.31	74.5	1.0	2.3	1.2
	WHP05	225	180	SF	1.78	74.1	1.4	3.5	1.8
	WHP06	224	170	SF	1.97	74.9	1.2	4.5	1.6
	WHP07	220	155	SF	1.08	72.3	0.87	3.9	1.26
	WHP08	222	160	SF	1.44	72.3	0.91	4.3	1.34
	WHP09	215	155	SF	2.29	72.6	1.5	9.6	2.5
	WHP10	212	140	SF	1.9	71.0	1.2	6.7	1.9
	WHP10D						(1.3)	(6.7)	(2.0)
						MEAN	1.0	4.4	1.4
	WHP10M				RECOVERY		126%	101%	

APPENDIX 2. 2378-TCDD AND 2378-TCDF IN FISH FROM SELECTED MAINE RIVERS

KSR365 W BR SEBASTICOOK RIVER AT RT 2, PALMYRA

DATE	SPECIES ID	LENGTH (mm)	WEIGHT (gm)	TYPE	LIPID %	MOIST %	TCDD (pg/g)	TCDF (pg/g)	TEQ (pg/g)
880831	SMB01	278	275	SF	0.14	79.5	0.52	0.20	0.54
	SMB02	284	310	SF	1.00	79.5	1.2	E0.32	1.2
	SMB03	368	675	SF	1.01	79.0	2.8	0.77	2.9
	SMB04	261	240	SF	0.45	78.5	0.91	0.54	0.96
	SMB05	287	325	SF	0.39	79.4	E0.48	0.33	E0.51
	SMB06	293	280	SF	2.14	78.7	1.5	0.35	1.5
880928	SMB07	285	310	SF	0.85	80.9	0.8	0.016	0.8
	SMB08	268	275	SF	0.45	81.4	1.2	0.32	1.2
	SMB09	295	340	SF	0.14	81.8	0.92	0.20	0.94
	SMB10	269	245	SF	0.36	79.7	1.5	0.35	1.5
						MEAN	1.2	0.35	1.2
880831	WSU1-5	394	624	WC5	7.13	75.8	3.4	1.7	3.6
	WSU6-10	379	548	WC5	2.39	79.7	3.2	1.5	3.4
	WSU6-10D						(3.1)	(1.4)	(3.2)
						MEAN	3.3	1.6	3.5
	WSU6-10M				RECOVERY		104%	89%	

APPENDIX 3

DIOXIN AND FURAN IN WASTEWATER FROM MAINE BLEACHED KRAFT PULP AND PAPER MILLS

Appendix 3.

BOISE CASCADE, RUMFORD

TREATED PROCESS WASTEWATER DIOXIN DATA

SAMPLE DATE (week of)	TCDD (PPQ) CONC.	TCDD (PPQ) DET. LIMIT	TCDF (PPQ) CONC.	TCDF (PPQ) DET. LIMIT
104 mill data 5/18/88	120		570	
3/1/89	25		80	
8/7/89	ND	6	20	
8/10/89	ND	13	20	
8/14/89	ND	5	13	
8/17/89	ND	5	18	
8/21/89	ND	8	21	
8/24/89	ND	5	10	
8/29/89	ND	5	18	
8/31/89	ND	11	20	
9/5/89	ND	11	20	
9/7/89	ND	9	18	
10/23/89	ND	3	7	
10/26/89	ND	5	6	
12/22/89	ND	5	20	
2/16/90	ND	2	6	
2/16/90	ND	1	7	
5/15/90	ND	10	ND	8
5/15/90	ND	1	5	
6/27/90	ND	3	8	
6/27/90	ND	3	9	

GEORGIA PACIFIC, WOODLAND

TREATED PROCESS WASTEWATER DIOXIN DATA

SAMPLE DATE	TCDD (PPQ) CONC.	TCDD (PPQ) DET. LIMIT	TCDF (PPQ) CONC.	TCDF (PPQ) DET. LIMIT
104 mill data - 1988	6.8		25	
3/16/90	ND	5	4	
4/23/90	ND	3	ND	6
5/31/90	ND	8	ND	5
6/19/90	ND	3	ND	1
7/16/90	ND	1	ND	3
8/7/90	ND	2	ND	6

Appendix 3.

INTERNATIONAL PAPER, JAY				
TREATED PROCESS WASTEWATER DIOXIN DATA				
	TCDD (PPQ)		TCDF (PPQ)	
SAMPLE DATE	CONC.	DET. LIMIT	CONC.	DET. LIMIT
6 mill data 1/87	88		420	
7/15/88(C)	30		150	
3/7/89(G)	30		100	
3/7/89(G)	EMPC(6)		EMPC(20)	
3/7/89(G)	EMPC(20)		EMPC(20)	
3/10/89(C)	16		74	
6/18/89(C)	ND	8	980	
6/21/89(C)	17		140	
7/13/89(C)	ND	16	60	
8/18/89(C)	20		110	
4/13/90(G)	ND	10	90	
7/20/89	30		150	DEP

Appendix 3.

JAMES RIVER CORP., OLD TOWN
TREATED PROCESS WASTEWATER DIOXIN DATA

	TCDD (PPQ)		TCDF (PPQ)	
SAMPLE DATE	CONC.	DET. LIMIT	CONC.	DET. LIMIT
104 mill data 6/88	89		130	
1/31/89	27		120	
2/22/89	210		340	
2/23/89	92		290	
2/24/89	77		340	
3/20/89	ND		34	
3/21/89	52		170	
3/22/89	61		200	
3/23/89	47		120	
3/24/89	ND		24	
3/25/89	36		73	
4/5/89	30		110	
4/10/89	17		52	
4/11/89	32		89	
8/24/89	32		94	
8/31/89	13		150	
9/11/89	ND	4.1	14	
9/15/89	ND	3.3	ND	8.1
9/21/89	ND	5.7	13	
9/27/89	ND	5.3	9.7	
10/11/89	ND	3.0	11	
10/19/89	ND	5.2	14	
11/2/89	ND	6.0	18	
11/6/89	6.7		22	
11/14/89	ND	9.5	ND	7.1
11/27/89	ND	6.4	20	
12/6/89	ND	8.4	13	
12/13/89	ND	6.3	20	
12/21/89	ND	4.7	23	
1/5/90	ND	6.8	ND	8.3
1/11/90	ND	9.0	ND	8.5
1/18/90	ND	5.9	6.1	
1/25/90	ND	5.7	10	
2/7/90	ND	4.6	17	
2/14/90	ND	6.6	23	
2/22/90	ND	7.3	15	
3/1/90	ND	6.0	11	
3/8/90	ND	3.0	12	
3/15/90	ND	4.0	16	
3/29/90	ND	7.4	14	
4/7/90	ND	7.2	24	
5/2/90	ND	7.0	19	
7/29/90	ND	9.9	49	

Appendix 3.

LINCOLN PULP AND PAPER
TREATED PROCESS WASTEWATER DIOXIN DATA

	TCDD (PPQ)		TCDF (PPQ)	
SAMPLE DATE	CONC.	DET. LIMIT	CONC.	DET. LIMIT
104 mill data 11/88	32		130	

S.D. WARREN CO., SKOWHEGAN
TREATED PROCESS WASTEWATER DIOXIN DATA

	TCDD (PPQ)		TCDF (PPQ)	
SAMPLE DATE	CONC.	DET. LIMIT	CONC.	DET. LIMIT
104 mill data 6/88	16, 19		63, 100	
7/10/90	ND	7.1	8.4	
7/16/90	ND	6.1	5.9	
7/16/90 DUP	ND	5.5	ND	7.3
7/24/90	ND	3.6	ND	3.9

S.D. WAREN CO., - WESTBROOK
TREATED PROCESS WASTEWATER DIOXIN DATA

	TCDD (PPQ)		TCDF (PPQ)	
SAMPLE DATE	CONC.	DET. LIMIT	CONC.	DET. LIMIT
104 mill data 88	6.3			
summer 1989	1			