MONS 065304

TRANSCRIPT OF PROCEEDINGS

UNITED STATES OF AMERICA

ENVIRONMENTAL PROTECTION AGENCY

In the matter of:	)	
	)	
TOXIC POLLUTANT EFFLUENT STANDARDS	)	Docket No. 1

Arlington, Virginia

8 May 1974

MONS 065305

Transcript of Proceedings

Arlington, Virginia

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UNITED STATES OF AMERICA

ENVIRONMENTAL PROTECTION AGENCY

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TOXIC POLLUTANT EFFULENT STANDARDS: Docket No. 1
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EPA Conference Room
Room 1112
Building #2, Crystal Mall
Arlington, Virginia

Wednesday, 8 May 1974

The hearing in the above-entitled matter was reconvened, pursuant to adjournment, at 9:00 a.m.

BEFORE:

WILLIAM J. SWEENEY,
Administrative Law Judge.

APPEARANCES:

(As heretofore noted.)

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C O N T E N T S

WITNESSES:	DIRECT	CROSS	REDIRECT	RECROSS
James H. Wright		2625		
Thomas O. Munson	2678			
James H. Wright (Resumed)			2681	2683
Edward L. Simons		2686	2743	2745
W. B. Papageorge		2749		

EXHIBITS:	FOR IDENTIFICATION	IN EVIDENCE
80	2614	2614
81	2625	2684
82	2685	
83-1 through 43	2748	

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P R O C E E D I N G S

JUDGE SWEENEY: Come to order, gentlemen.

There will be no smoking during the course of the hearing.

Before we proceed, the affidavit of Marshall T. White on behalf of Federal Paperboard Company, Inc. will be identified as Exhibit 80, and since you want no cross-examination, Mr. Eckert, that will be received in evidence.

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(The document referred to was marked Exhibit No. 80 for identification, and was received in evidence.)

MR. ECKERT: Your Honor, before we commence with examination of the witnesses, I'd like briefly to address scheduling problems.

It now appears that it would be very difficult to get ready to go with EPA endrin witnesses by Friday and I believe Mr. Rogers is not going to take more than half a day to a day on cross-examination of industry endrin witnesses.

I will attempt to reach Mr. Miller today to see if we can start on EPA cadmium witnesses this Friday and perhaps get the EPA cadmium witnesses on and off the stand, but we'll have to see how that goes.

MR. LORANT: Mr. Eckert, I talked with Mr. Rogers

several days ago and pursuant to that conversation I've arranged for one witness to come today to be available possibly for tomorrow afternoon in the event you are finished with PCBs at that time. The other witness is scheduled to come on Thursday to be available on Friday.

Now, if I understood what you're saying, it's that you don't intend to get to any endrin witnesses this week?

MR. ECKERT: No, all I said was there was some difficulty with EPA endrin witnesses, not the industry witnesses.

MR. LORANT: Oh, I'm sorry. I misunderstood.

Yes, again, that was also a subject of conversation, and I agreed there would be some difficulty there, particularly since the entire affidavit has not been received for Dr. Parish. I thought there was another affidavit due from someone from Columbia. Would that be it?

MR. ECKERT: I'm not familiar with the subject matter area.

MR. LORANT: If your position is you're not getting to the endrin witnesses this week, I agree. I thought they were scheduled for June 3.

JUDGE SWEENEY: Well, if we can't get to them before, they will be heard on May 27.

MR. LORANT: That's a holiday of some kind, isn't it?

JUDGE SWEENEY: Not unless we have taken care of the

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endrin witnesses before then.

MR. LORANT: All right.

MR. WILLS: My name is Wills, for Westinghouse.

Before we get any further involved in PCBs, on behalf of Westinghouse I would like to move that EPA sometime before the end of the week formally advise us of the witnesses that they are planning to call in rebuttal, since on the 8th of April we were told one witness; last May 1, we were told one witness, Dr. Duke. Two days later we received some statements from people and weren't identified as to the references; and yesterday I understand from Mr. Eckert possibly there are four.

With respect to those statements, the one of Dr. Veith, it contains references to 41 exhibits, none of which are identified, or identified to us as to where we find them.

So I would request that you order EPA to identify the witnesses, to provide the data bases for the summaries that were -- the data from which they were extracted, to be furnished to us, plus all the unpublished articles or those in-press articles that EPA has within its control, since most of these documents are referring to EPA research laboratories.

MR. ECKERT: Let me say in response to that that EPA recognizes the problem here.

The witnesses are four: Dr. Duke, Mr. Wilson, Dr. Daneker, and Dr. Veith.

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Those affidavits which are unpublished or otherwise unavailable are now being reproduced and will be distributed about noontime today.

MR. WILLS: Well, I ask you, what about the individual who called a Westinghouse individual, and said he was a consultant hired by EPA to determine -- yesterday I received information from one of our clients who was contacted by a consulting firm hired by EPA, apparently to find out the dollar amount and how our capacitors were used.

I assume that that is information that will be testimony. I want to know if this is correct.

MR. ECKERT: I don't know why you make that assumption. We've hired consultants to assist us with cross-examination on several witnesses.

MR. WILLS: He called us Monday to assist with cross-examination today? Okay.

The other motion I have, your Honor, deals with the Freedom of Information Act, the spirit of the publication of the rules of this procedure that were published in the Federal Register. With respect to other documentation or laboratory studies conducted by EPA people concerning PCBs, prior to this hearing we saw some unpublished data in the National Academy of Science Report.

The data in there more or less did not conform to other published data. From what information we have received in

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rebuttal testimony, we have seen a direction toward a particular point of view with EPA research data. Since we do not know what other reports or what other studies, what other literature that has been developed with respect to toxicity, degradability, or even treatment of effluent standards -- there apparently was some work done by a Dr. Price in this area -- we would request that EPA be required to produce this.

And also, since the review process under the statute requires other agency comments, any copies of written comments of other agencies prior to the promulgation of these rules.

MR. ECKERT: All I can say is, if you have a Freedom of Information request, there are regulations dealing with Freedom of Information Act requests. You're perfectly free to make one and we'll be glad to respond to it in time.

However, I think that's outside the scope of this hearing and we intend to put into the hearing record all the information on which we propose to rely.

MR. WILLS: In other words, you're going to preclude us from obtaining other scientific information within your control that deals with PCBs?

MR. ECKERT: Absolutely not. I said if you had a Freedom of Information Act request, then simply follow the procedures under the Freedom of Information Act. You're certainly free to get any data which we might have.

As for data on which we intend to rely, we are producing it in the form of testimony and we are going to make the men available for cross-examination who prepared it.

MR. WILLS: Are you going to make Mr. Stallings available, who published some unpublished data that we tried to get out of Columbia for the last three months and we can't?

MR. ECKERT: Well, if there have been some problems with unpublished data cited in EPA affidavits, as I say, we're going to bring that by today, and if there's something missing, please let me know and I'll see that it's taken care of.

MR. WILLS: Well, take one example, Dr. Duke's statement that refers to some summaries of data. Are we going to get the data base or any explanation of the procedures by which that data was originally compiled so we can see the numbers that went into the data summary?

MR. ECKERT: Well, so far as I know, the only data that were ever published were the data summaries.

If you have questions on that, Dr. Duke will be able to answer those questions as far as the raw data is concerned. If you want us to produce the scientists' scratch papers, then I think you are really in the Freedom of Information Act area and not what we're talking about in this hearing.

JUDGE SWEENEY: Who's the first witness, Mr. Eckert?

MR. ECKERT: The first witness is Mr. Carlson,

Rudolph F. Carlson.

JUDGE SWEENEY: Who's he with?

MR. ECKERT: With Electric Utilities Company.

MR. RICHEL: I'm with General Electric. I have one brief point that I would like to discuss.

Industrial witnesses, including those at General Electric, addressed themselves to material provided by, and apparently relied on by EPA. Since that time, EPA has introduced the testimony of, I understand, four other witnesses who introduce -- who themselves introduce much new material.

Our witnesses have no opportunity to address themselves to what has become a moving target, and I'm asking for your assistance in determining how we may best respond to that new information in the form of testimony as opposed to cross-examination.

JUDGE SWEENEY: I don't know of any way under the Administrative Procedure Act for you to do that the way I look at the Administrative Procedure Act.

Now, if we follow EPA's theory of the procedure, you should all be given an opportunity to put in rebuttal testimony. However, as I understand it, the parties do not agree with EPA as to the proper procedure. In other words, the parties say the burden of proof is on EPA, so that would mean that you have no chance for rebuttal if your theory is

correct that EPA has the burden of proof.

MR. RICHEL: I think they are consistent. We addressed subject matter A; then given the introduction of testimony by four EPA witnesses, we are now in the area of some other subject matter, B.

Very specifically, no data was introduced, as you know, concerning 1016 in your original material, in large part because there just wasn't much.

EPA has now taken it upon itself to respond to that possible problem area and come up with data in the last few months and put that into their testimony.

I think it would be unfair and perhaps arbitrary to refuse to allow us the opportunity to directly address that question among others.

I'm willing to discuss this with EPA counsel off the record. I did want to raise the matter on the record because we've been placed in a bind.

JUDGE SWEENEY: All right. You talk to him off the record, but you know what the time factors are in this case. I don't know just when you would have time to do so.

MR. RICHEL: Well, the time factors as I understood them initially -- well, I understood initially that you intended to conclude hearings by at the very latest the first week in May.

JUDGE SWEENEY: Right.

MR. RICHEL: That, I guess, was a fantasy. So I don't know what the time factors are now.

JUDGE SWEENEY: It wasn't a fantasy until the Deputy Administrator said that he could get something out even though we ran through May.

MR. RICHEL: Did he intend to consider the testimony adduced at this hearing?

JUDGE SWEENEY: I don't know. I am sure he did.

MR. RICHEL: I could get something out, too.

Well, I will --

JUDGE SWEENEY: Well, in answer to your question, you talk with Mr. Eckert off the record.

MR. RICHEL: Yes, sir.

MR. ECKERT: Has Mr. Carlson been sworn?

JUDGE SWEENEY: No.

Now, Electric Utilities Company, as far as I know, is not a party to this proceeding. Why are you calling him?

MR. ECKERT: Well, I'm a little taken aback. I thought he came in under the aegis of one of the objectors.

JUDGE SWEENEY: Which one?

MR. ECKERT: To tell you the truth, I can't answer that. I didn't realize that -- as you see we keep a separate book for objections and for testimony, but I had not cross-checked to make sure that Mr. Carlson was a witness -- was a representative of a party.

JUDGE SWEENEY: I don't have any objection myself. But if you want to allow someone who is not a party and hasn't met your rules of evidence to submit testimony and be cross-examined --

MR. ECKERT: We are willing to waive that in this case because we think Mr. Carlson may have some useful information to contribute.

MR. RICHEL: Your Honor, I'm not Mr. Carlson's attorney, but the question really is does he want to testify? Not whether EPA wants to waive any rules.

JUDGE SWEENEY: Well, the question is does he want to get his affidavit on the record, is the first question.

MR. RICHEL: Apparently, it has been submitted to EPA, though not in a way which would lead him to the status of a party. Is that correct?

MR. ECKERT: Well, what happened was, apparently, and I don't have the books in front of me, he submitted an affidavit by March 15, but he did not submit it, submit an objection by January 18. So, all I'm saying is in this case we think he may have information to contribute.

Are you objecting to this?

MR. RICHEL: No, I'm saying the witness should be given the privilege of deciding whether or not he wants to testify or just have his material submitted.

MR. ECKERT: Well, let's ask Mr. Carlson right now.

Do you wish to testify at this hearing, Mr. Carlson?

MR. CARLSON: Well, I'm not represented by counsel, I should point out. I think I would prefer to check with counsel on that, which I could do later in the day.

MR. ECKERT: Well, we could start out with another witness.

JUDGE SWEENEY: Why don't we do that.

MR. ECKERT: How quickly could you get back to us, Mr. Carlson?

MR. CARLSON: If I could reach my attorney, within an hour.

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MR. ECKERT: All right. Will you please do that?

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I would like to call Dr. James H. Wright.

JUDGE SWEENEY: What company is that, Mr. Eckert?

MR. ECKERT: Westinghouse.

Whereupon,

JAMES H. WRIGHT

was called as a witness by the Environmental Protection Agency and, having been first duly sworn, was examined and testified as follows:

JUDGE SWEENEY: Dr. Wright's statement will be identified as Exhibit 81.

(The document referred to was marked Exhibit 81 for identification.)

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CROSS-EXAMINATION

BY MR. ECKERT:

Q Good morning, Dr. Wright.

A Good morning.

Q In your testimony you attach a statement, "Qualifications of James H. Wright."

I understand that you're a chemical engineer with a doctor of philosophy degree; is that correct?

A Yes, sir.

Q Have you any training in the biological sciences?

A I've had considerable experience training in the last -- I would say five or six years. Reporting to me is a

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group of biologists, public health people, and a variety of other technologists dealing with terrestrial and aquatic biological problems.

Q When you say "practical experience," could you be more specific as to what types of experience you personally have had?

A Well, yes. I participated in the planning, for example, of field data-gathering programs. I participated in those and at present, on a continuing basis, I am on the analysis of data, the validity of results, the statistical confidence that can be developed from the data that the staff has provided in that area; in other words, in the review, audit and evaluation function.

And I have published summary articles on certain biological effects in national and international journals.

Q Have you ever conducted bioassays on marine organisms?

A I personally have not conducted bioassays on marine organisms.

Q Have you supervised studies in which bioassays were conducted?

A Yes, I have.

Q Were those long-term or short-term bioassays?

A In general they tend to be-- I would say the greatest frequency was very short-term; that is to say

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within a year.

Q But longer than 96 hours?

A Oh, yes.

Q Would these be statis or flow-through, or intermittant flow?

A Now when you call for bioassays, I would say that -- Well, for example, some of the tests that were-- I'm thinking now of one particular one that was conducted for a period of actually a week. I'm thinking of where we created test conditions similar to an intake and ran for a period of time.

Q How many facilities does Westinghouse operate in which PCB's are used?

A Used in what fashion, sir?

Q Well, let me rephrase the question:

From how many Westinghouse operations are PCB's discharged?

A I don't know the answer to that. I would take your first question, modify it somewhat, and say we have about half a dozen facilities involved in the manufacture where PCB is an input material to the manufacture.

We have some other facilities involved in the repair of equipment which may contain PCB's.

Q I want to get back to that in a minute but would like to skip over to some other matter.

JUDGE SWEENEY: I thought it was Dr. Tucker.

MR. ECKERT: I mean Dr. Tucker.

MR. PARK: Judge, I would just point out: There is no difficulty, Mr. Eckert, whatsoever in who swore. I think the document shows that Mr. Papageorge swore to the whole thing. The other two gentlemen are prepared right now to swear to it.

You see, we prepared this on the assumption that the object during the hearings was not to attack the personal credibility of a given witness, but to try to obtain information, and we have looked on this as a presentation by the company by a group, if you will, and not by one person.

I used the analogy yesterday of Dr. Thompson's testimony in the early part of the hearings.

I think, if I may say so, the EPA has been educated in the passage of weeks here in some procedures that have come forward now after about a month with some affidavits from others who participated with Dr. Thompson in preparation of the EPA's initial direct testimony. We've had one day now. We've had Dr. Paul Wright come in last night. Since he was the third member of the group who put this together, I feel it would be very much amiss if the talents of all three of these people were not employed in this hearing and whatever knowledge they have on the subject of PCBs was not made use of.

JUDGE SWEENEY: Will you proceed, Mr. Eckert, and gain as much education as you think you need.

MR. ECKERT: Mr. Papageorge.

XXXXXX Whereupon,

W. B. PAPAGEORGE

resumed the stand and, having been previously duly sworn, was examined and testified further as follows:

XXXXX CROSS-EXAMINATION (Continued)

BY MR. ECKERT:

Q I'm going to be referring to page 11 of your statement.

A I have it.

Q In the second paragraph you state, "Not enough is known about the fate and effect of PCBs in the natural and diverse aquatic and marine environments to properly design laboratory studies."

I'd like to know how much more and what additional data would need to be known in order to design laboratory studies.

A The laboratory studies that I personally observed in both commercial laboratories, industrial laboratories, and EPA laboratories, appear to me to involve crystal clear water flowing either through troughs or contained in aquaria in static conditions.

I have been exposed enough to polychlorinated biphenyls to understand that they are the most complex group of chemicals that serve as industrial fluids, and by complex I'm

talking now of physical and chemical properties. I have yet to see any information that totally describes how these materials behave in the environment.

The environment, as I understand it, is a most complex set of conditions. It includes the sediments we've talked of and even within the sediments there are many different physical and chemical properties. Who can answer how these sediments affect PCBs? And vice versa?

In the natural environment we have many types of, I believe the term used is biota, plants and animal life that effectively contribute to the total situation.

The water itself has different chemical constituents. I don't know that anyone has totally described the impact of these chemicals on the effects or actions of PCBs. We don't know the effect of sunlight, for example, or darkness. I could go on and on. But the point I wish to make is that natural systems to me represent most complex types of conditions, and the chemicals we're concerned with are themselves very complex, so how can you take these materials in a laboratory, look upon them as complex mixtures under ideal conditions, if you will, or synthetic conditions that don't resemble the natural condition that arrive at responsible conclusions?

Q Well, let me ask you this: Are you suggesting that every possible variable be investigated and that every possible

experiment be run before we take any action to control these chemicals.

A I am submitting you, sir, that a responsible scientist will conduct enough studies under enough conditions that satisfy him that any extrapolation he makes is a valid one. He should not take what I would call giant leaps forward and jumping into conclusions.

Q Well, let's take the problem of extrapolation from lab data to environmental areas.

Have you seen any correlations with respect to differences which have been observed between effects of PCBs in the environment and effects in the laboratory?

A I don't remember if I've seen actual correlations where data is compared to data in a single report. But I do know that laboratory data has reported mortalities in the species studied. I don't recall any report that reports mortalities of these same species in natural situations.

Q Well, that may be, but then have concentrations of the same levels been reported in the environment as causative of mortalities in the laboratory?

A That's a good point. That's the very point.

This again emphasizes how synthetic the laboratory situation is where the levels studied are not typical of the natural situations.

Q Well, but that doesn't quite answer the question.

I mean, have the levels recorded in the laboratory been observed in the environment or not. When you say extrapolate, can't you extrapolate from levels which have been observed to be harmful at levels which have not been observed to be harmful in the laboratory? Or levels which would probably be harmful and which might not be harmful in the environment?

A No. I would be most hesitant to extrapolate because the information that I observed in the laboratory may be meaningless, say, in the muddy Mississippi River.

Q Well, once again, you made a statement here that results from such studies are not extrapolatable. And in fact, as I understand it, you don't have any correlations, so this is an opinion unsupported by data or studies. Is that correct?

A No, that is not correct.

MR. RICHEL: Your Honor, I'd object to that question.

JUDGE SWEENEY: Your objection is overruled.

MR. RICHEL: May I give the grounds?

JUDGE SWEENEY: No.

MR. RICHEL: I love it.

JUDGE SWEENEY: Go ahead and answer the question.

THE WITNESS: If I recall the question correctly, it went something like this: I have no basis for claiming that the laboratory information cannot be extrapolated to

the real natural situation.

I believe if you read enough of the literature that is abundantly available, you will find in many instances the presence of PCBs recorded in the environment that exceed presences recorded in experimental studies, and yet the species observed seem to be thriving, multiplying, reproducing.

BY MR. ECKERT:

Q Could you be specific? Could you name,in fact, one such study?

A I can't recall the study, sir, but I think it is well known among those who studied coho salmon PCBs in Lake Michigan. There is no evidence that the coho salmon are being affected adversely in that environment. In fact, they are thriving. The problem is what to do with them since they contain PCBs in their tissues that exceed the tolerance level that FDA is permitting.

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Q Are you saying that there are lab data that indicate that the coho salmon would be dead at the concentrations that exist in Lake Michigan?

A There is data that was used by EPA in arriving at the proposed standard that refers to salmon eggs being affected by the presence of PCB's. This would imply that salmon cannot reproduce under certain conditions.

There is no evidence that in Lake Michigan coho salmon -- and I recognize these are possibly different species of salmon, but Dr. Hugh Thompson refers to trophic levels and similarities in trophic levels, so I think it is a fair conclusion to jump into, to say that there is no evidence that the coho salmon in Lake Michigan are not reproducing.

Q Now isn't that factor used by EPA a concentration of 0.5 parts per million in the eggs of the salmon?

A Yes. And it was related, as I recall, to .5 parts per million in the tissue of the adult salmon.

Q Have levels of 0.5 parts per million in the eggs of coho salmon be observed in Lake Michigan?

A I have seen no studies, no reports of studies, in which coho salmon eggs were analyzed.

Q Do you know what the concentration of PCB's is in Lake Michigan?

A I have seen reports. I don't recall exact numbers, but they are in the range of parts per billion, less than a

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part per billion, as I recall.

Q Isn't it in fact around 10 parts per trillion?

A I don't know. I don't recall it that specifically.

Q Now you have stated here that:

"Fundamental, scientifically-based data is lacking."

Yet you have cited in your affidavit some 43 exhibits. Wouldn't you call many of these scientifically-based data?

A Some of the references cited can be classified as scientific data of a fundamental nature, but you'll note it's of a varied type. Some of it refers to just presence of PCB's; some of it refers to the biodegradability of PCB's, or to disappearance of PCB's. Some of it refers to its effect on certain species, so it's a varied nature and I personally do not believe that there is enough data to give any scientist the confidence to impose a realistic standard.

Q Have you reviewed the affidavit distributed by EPA in this proceeding?

A I'm confused by your question because I received a mountain of paper.

Q On PCB's?

A On PCB's.

Q Yes.

MR. PARK: What are you referring to, Mr. Eckert?

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MR. ECKERT: I'm referring to the testimony--

MR. PARK: That came out yesterday?

MR. ECKERT: The material distributed yesterday was merely supplementary, unpublished material. The affidavits have been distributed for some time. I'm referring to affidavits of Dr. Duke, Dr. Nebakker, Dr. Veith, and Mr. Wilson.

MR. PARK: Well, I would like to point out that of course I'm the one who received those. I received them about a week ago, I guess; no earlier than that.

MR. ECKERT: So your staff hasn't had an opportunity to review them?

MR. PARK: They're reviewing those for their testimony which takes place in about a week or two in the future. They were not reviewed for this proceeding, as I understand.

MR. RICHEL: I think we should note part of that material was received, at least by the General Electric Company, on Friday.

MR. PARK: Judge, may I speak with Mr. Papageorge for a half minute?

JUDGE SWEENEY: Yes.

(Brief recess.)

MR. PARK: All right. Thank you, your Honor.

BY MR. ECKERT:

Q Now in the last paragraph on page 11, you refer

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to studies on bioaccumulation and you state:

"These data would support the selection of a factor considerably lower than the factors which were applied."

That's the last sentence in the paragraph.

To your knowledge, are any of the studies which you cite there bioaccumulation studies on a long-term basis, say over a several-month period of time?

A Well, as indicated earlier, this is an area in which Dr. Wright is much more capable of responding than I am, but I have to pass on to you that I personally received from Dr. WRight, to help me in my understanding of the general PCB situation.

Q Now on page 12, the next to the last sentence in the paragraph on the top of the page reads:

"These safety factors. . ."

and I assume you're referring to the .5 and .6 safety factors in the proposed standards --

". . .resulting in approximately twofold reductions are so small as to be of no beneficial toxicological consequence."

In your opinion, should an additional safety factor be utilized to account for the possible formation of furans through uncontrolled oxidation in the environment?

A Again, this is an area that Dr. Wright could

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respond to, but as I heard your question you want my opinion. Did I hear that correctly?

Q Well, yes; that's right.

A I know of no information available to anyone about the formation of these materials you referred to as furans in natural situations of the type we are discussing here, so I don't see how I can have any opinion on what kind of safety factor would be required, if any.

Q Well, let's take a look at Exhibit 8 which is attached to your testimony.

On page 374 at the very bottom of the page you will note a statement:

> "Irradiation of chlorinated biphenyls dispersed in water, followed by GC/MS, revealed identifiable traces of 2-chlorodibenzofuran as a photolysis product. . ."

and so on.

Wouldn't that seem to indicate that some furans might be produced under irradiation, for example by sunlight?

A I'm not qualified to comment on that. Dr. Tucker might be able to.

MR. PARK: Judge Sweeney, one last thing on this point I made earlier. Can I ask Mr. Eckert:

Do you plan to examine these two people that we have present here on these subjects or not?

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MR. ECKERT: I'm going to examine Dr. Tucker. I don't know if I'm going to have time to get to Dr. Wright. It's a matter of timing.

MR. PARK: I would like the record to indicate that as these questions are asked we have two people we consider experts present here in this room. They are ready and willing to answer these questions.

JUDGE SWEENEY: We understand that. I think the record is clear.

BY MR. ECKERT:

Q In the third paragraph on page 12 you state that:

"Appropriate control is achieved. . ."

The last sentence:

"In our opinion, appropriate control is achieved using average stream flow rates."

If the average stream flow rate were used, what percentage of the time would the concentration in the stream exceed the desired target concentration?

A I have not made those calculations.

Q Well, wouldn't it be 50 percent of the time?

A Mathematically, yes.

Q Now if we used seven-day, ten-year low flow, what would that percentage be, do you know?

A No, I do not know.

I don't understand the point you're trying to make

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here.

Q I'm just asking whether or not you made this evaluation, and apparently you haven't, so I'll proceed.

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On the bottom of that page you state:

"Because of their chemical and physical properties, PCB's can be found in soils and waters at point sources long after a discharge has occurred."

Is this based on samples which the Monsanto Company has made?

A Yes.

Q Can you tell me where, for example, the soils and waters at point sources have been measured?

A At what locations?

Q Yes, at what locations.

A I can only speak for Monsanto's plant at which the polychlorinated biphenyls are produced.

Q That's at Annistan?

A No, sir. It's the plant that is located in Sauget, Illinois, which we referred to yesterday as the William G. Crumridge plant.

Q Now at the Sauget plant, could you tell me in general summary how the sampling program was carried out, how the measurements were made?

A In order to describe this sampling program, I will

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take a while to describe the physical situation and what we've done at that plant.

To give you the proper perspective, the plant dates from the early 1900's, prior to World War I, as best I can remember. It's an industrial complex in which we make over a hundred different chemical products. It has over a thousand employees. This gives you an idea of the size of the unit.

Within this complex we have a situation where sewer systems and water runoff and process runoff systems have been evolving through the years. They are of varying degrees of age, varying degrees of effectiveness, and some of course are in good repair and some are in constant need of attention.

Also, within this plant we have two facilities that are directly involved with polychlorinated biphenyls. One is the unit in which the polychlorinated biphenyls are produced. The other is the unit at which we destroy the scrap polychlorinated biphenyl when it can no longer be recovered and reused.

These two units since -- oh, for the past several years have been undergoing a program whereby we have installed facilities to contain the loss of PCB's into the environment, let's call it, or into the rest of that location.

To describe it -- and I found this expression

eb9

useful in getting the proper understanding -- we use the concept the "bathtub" approach, which really involves paving, curbing, isolating the drains from these curved pavements into a separate sewer system, into a sump in which any accidental spills would be trapped before these drainage points enter the rest of the sewer system of the plant which, in turn, goes to the Sauget Village municipal treatment plant.

Now when we completed all of this work we of course monitored to see how effective our program of control was. You can see what we did; you can see that we could now analyze water samples that directly relate to the current PCB activities and also analyze water samples that are not related to the current PCB activities.

With the difference in that data we must conclude that PCB's are coming from sources other than the two I mentioned, the two active sources.

The question then is: Where could these be coming from?

The only conclusion we could reach is that these must be coming from locations throughout this large industrial complex which, at one time, involved either the use or the handling or the storage of polychlorinated biphenyls, and we find this presence of polychlorinated biphenyls to vary, for example, with sewer breaks, with heavy rainfalls and the like, so it's a changing number that we see.

eb10

Q Let me ask you this:

Are you able to isolate which measurements are taken of PCB's from current activities from ones that are not associated with current activities?

A Yes, we can. We can determine the PCB's resulting from the current activities. We can determine the PCB's resulting from total activities and by subtraction, we arrive at the PCB's whose source we cannot identify.

Q What I mean is this:

Are there discharges which are so physically isolated from the current activities that you can sample them, you can sample that stream and say that stream contains PCB's; however, none of the PCB's in that stream can be from the current operations, it must all be from the soil or residues?

A We have not done that program, and I'm not familiar with the sewer system to be able to respond to the sampling at all of these points.

Q Are all the Aroclors currently sold by Monsanto manufactured at this location?

A Yes, sir. There are only three types manufactured today.

Q Which three are those?

A Aroclor 1221-- I apologize, there are four: Aroclor 1016, Aroclor 1242, Aroclor 1254.

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Q Have the discharges from the Crumridge plant been analyzed to determine if any of the Aroclors which are no longer being manufactured are present in the discharge?

A That is rather difficult to do. The PCB's identified in the discharge have been generally described as Aroclor 1254. Since we still make Aroclor 1254, it is rather difficult to determine whether that's current production, except for this very important feature in that these two sewer systems are separate and distinct and we can analyze the water coming from the current activities.

Q Well, let's take the sewer system which contains water not coming from current activities. Has that been analyzed to see which Aroclors are present?

A That water has been analyzed at the point where it enters the village treatment plant, the Sauget treatment plant, waste treatment plant.

Q But doesn't that stream include both current activity --

A Yes. To make it fairly simple, and I know I'm oversimplifying, imagine a Y. One leg of the Y represents the simplistic picture of the total plant sewer system, the other leg of the Y representing the composite from the incinerator area where we destroy PCB's, and the production area where we manufacture and handle PCB's.

These two streams come together. Eventually

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they end up in the village treatment plant and that's the point where we analyze, at the village treatment plant.

Q So that at the point at which you take the samples the two streams are mixed together?

A That is correct. And also this system picks up not only process waters, if you wish to define them as-- In other words water related to chemical production, but they include the typical kinds of waters that exist in any insulation of this type: the sanitary waters, rainfall, runoff; every water source imaginable ends up in this system.

Q Now you stated here that PCB's can be found in soils and waters. Have you measured the soils at the Crumridge plant?

A Not to my knowledge.

Q Is this statement based on other measurements of soils?

A We have measured soil samples and I'll have to defer to Dr. Tucker as to what his laboratory has looked at.

Q On page 13, under "Economic Considerations," in the first paragraph you state:

"Yet, inspite of all our efforts, we cannot today meet the proposed effluent standard."

But in fact isn't it your testimony that you are not affected by the proposed effluent standard?

A This presupposes there that if we were in a

ebl3

position where our plant outfall had to enter a navigable water in spite of all the efforts in both the technical and the money and all the resources we put into controlling PCB's, -- then I might add here because I feel it is important, we believe that the best control for PCB's is preventing it from every coming in contact with the water, as much as is humanly possible.

In spite of all these efforts -- and we believe this is unique for an industrial chemical of this type -- we just don't see how the standard that is proposed can be achieved.

Q What levels of PCB's enter the Sauget treatment plant in terms of concentrations in pounds per day?

A This number will vary -- has varied and I think, as has been pointed out already in previous testimony, we do have the problems mentioned of sampling and what-have-you. But the number as best I recall varies from 10 to 15 pounds per day.

Q Now you discussed the sump in the PCB manufacturing facility-- I'm sorry, the sump is the terminal point before going into the treatment plant for wastes from the incinerator and the manufacturing facility; is that correct?

A Yes, sir.

MR. PARK: Mr. Eckert, one of the people here said the earlier answer sounded like-- I wonder if we could

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ask the clerk, did he say 10 to 15 or 10 to 50, just for clarification?

MR. ECKERT: Well, what was the witness' answer?

THE WITNESS: Ten to 15 pounds per day.

BY MR. ECKERT:

Q Getting back to my original question, I have correctly described it?

A Yes, sir, that's it.

Q Is any treatment given to the material in the sump before it enters into the treatment water?

A The treatment is one of physical separation of the two phases. In the event that the PCB's are present, being heavier than water, they accumulate at the bottom of the sump. Periodically they are pumped out, put into proper containers, and removed to the incinerator for destruction.

Q The figure that you gave of 10 to 15 pounds per day, I assume that is based, as Dr. Simon's figures were based, on a concentration, average concentration times an average flow. Is that correct?

A Yes, sir.

Q And can you give me the figure for that average concentration and the average flow?

A I have figures for the average flow. I do not have handy the concentration but one could work back.

The total complex from which this water comes has

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a flow that runs from about 15 to 18 cubic feet per second, which is about eight to ten million gallons a day.

Q What do you consider to be the major sources of the 10 to 15 pounds per day?

A I believe the major sources of these are locations throughout the plant, --

Q What about the sump itself?

MR. PARK: He's not finished with his answer.

MR. ECKERT: I'm sorry.

BY MR. ECKERT:

Q Will you proceed, please?

A (Continuing) -- throughout the plant, in which at one time we used PCB's, whether as a heat transfer unit or as a hydraulic fluid or even -- may even have stored material in particular areas.

At the time the PCB's were treated as most other chemicals there were some leakages; some did get into the soils; some did get into the sewer systems. Through the years, through the 40 years or so it has been manufactured there there has been this accumulation -- manufactured and used.

I cannot specifically point to a source because it is not highly visible and not easily locatable. We have some suspicions that underneath our plant there are -- you might even call them caverns where erosion from broken sewer lines has resulted in a removal of the soil. It's conceivable

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that some PCB's are back in there.

The sewer lines themselves conceivably could have some PCB's adhering to the matter that adheres to the walls of the system.

The soil of course is probably the most important contributor and by "soil" I'm also referring to crushed rock surfaces and so on throughout the plant.

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Q Has any measurement been made of the effluent from the sump following the active PCB work?

A Yes.

This is where we get our -- where we get an idea of the PCB's that result from the current activity.

Q And how many pounds per day come from the sump?

A That, too, sir, varies with the sampling conditions. As best I recall it runs from, oh, a pound and a half, two pounds, sometimes it will reach five pounds as a peak per day.

These seem at times to be affected by rainfall, by activity throughout the unit.

Q Now, in the other parts of the plant, are PCB's stored or piped through or otherwise present? And when I say "other parts," I'm referring to other than the incinerator and the manufacturing area.

A No, sir, not knowingly.

And I'd like to comment: we've been talking PCB's, using the three letters to designate mixtures of chemicals, really, so when I'm referring to these numbers in pounds per day, what I'm saying is that this is the material the analytical chemist sees with his instruments, that contains a chlorinated biphenyl, irrespective of the amount of chlorine involved, all isomers.

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Q Are PCB's discharged from any facilities operated

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by Monsanto into receiving waters?

A No, sir. No that I'm aware of; they shouldn't be. They can't be.

Q Are they present or used in any facility other than the Krummrich plant?

A No, sir.

Mr. Eckert, I don't know if this is in order or not, but some thoughts come to me as I read some scratch notes that might give some perspective.

You've talked about the eight to ten million gallons per day water from the plant as a total. It might help to look at the amount of water coming out of those parts of the plant which today are actively involved with PCB's. This is the producing unit and the incinerating unit.

In those two areas, we have these kinds of quantities involved: the production area averages about 250,000 gallons a day. The incinerator area, when running full out, about 190,000 gallons a day.

Now, the production area goes from a low of about 100 to a high of about 500; the incinerator area, a very low number of 14,000 gallons a day up to a quarter of a million, 250,000.

I mention that because it might be interesting when we look at this Mississippi River in which these streams eventually end up to note that the average flow represents

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0.0002 percent of the mass of water in that river compared to the average flow of that river.

Q Have you made any measurements of PCB's in the Mississippi River?

A Yes, sir.

We tried some measurements, and found them, frankly, to be information that we didn't know quite how to use. In fact, it was baffling.

This occurred, as best I recall, after we had some discussions with EPA representatives following the issuance of the Interdepartmental Task Force Report, in which, as I best recall, the recommendation was made that 0.01 parts per billion should be the tolerable amount of PCB's in the main bodies of water; I believe I'm correct there.

We went to the Mississippi River, took some samples above stream and down stream, and I'll agree with any professional scientist that will say that one sample doesnt' tell the whole story; but the results are baffling.

Upstream measured higher than downstream from our plant. This further emphasizes how complex it is to get a sample --

Q What were those measurements?

A As best I recall, it was about 0.2 part per billion upstream, 0.1 part per billion downstream. And this is based on an analysis of the total water sample, which contains a

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considerable amount of sediment.

So with that kind of information we decided we would be in a better position to make some better use of our resource -- laboratory, technical, manpower, and what have you -- in concentrating our efforts back at the plant, preventing the material from ever reaching the water, rather than try to monitor the large Mississippi River.

Q Who made those measurements?

A I don't know the individuals by name, but they were personnel at Monsanto's plant at which the material is manufactured.

Q Did they use gas liquid chromatography?

A Yes, sir.

Q Do you know what the variation of that technique is at these levels?

A I'm not qualified to answer that. Again, I would suggest that Dr. Tucker, who serves as our advisor, could best answer.

Q How far down the stream from Sauget is the confluence with the Mississippi?

A I'm confused, sir: it is on the Mississippi.

Q It is on the Mississippi River?

A Yes, sir.

MR. PARK: Did you understand the question? What is on the Mississippi River?

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THE WITNESS: I understood the question: how far down --

MR. ECKERT: I didn't understand. I didn't know that Sauget was on the Mississippi River.

That answers my question.

MR. PARK: Would you repeat your question? I'm not wure I understood it.

MR. ECKERT: Well, I understood he said that the waste eventually wound up in the Mississippi River, and I inferred, incorrectly, that that meant they were discharged into a tributary that went into the Mississippi River.

THE WITNESS: No, sir.

This discharge is to the sewage treatment plant, which in turn discharges into the Mississippi River.

BY MR. ECKERT:

Q Now, on page 13 you give some cost figures. You suggest a:

"Design using adsorption, settling and filtration of aqueous waste, followed by incineration of the adsorbent."

Have you estimated or made any attempts to determine what levels of PCB's would be present in the discharge from such a facility?

A No, sir.

And I'd like to emphasize the important word in that

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paragraph is "conceptual". This is just a figment of my imagination, if you will, that this approach might have some merit.

But I'd like to point out -- and I don't know quite how to express this, but let me attempt -- doing nothing about controlling PCB's, in my opinion, is irresponsible.

Spending scarce resources -- and no matter how big the organization, whether it be the U.S. government or Monsanto or what have you -- resources pursuing technology to reach some unwarranted level or objective can, again, be considered irresponsible.

At this point in time there has been no reason whatever for anyone working with PCB's to expend any kind of resources looking for the levels that your proposed standard now seeks.

The emphasis has been made in controlling PCB's to a level that, as best as I can determine, is unprecedented for industrial chemicals worldwide.

And I say this with all seriousness. I could be accused of being subjective, but I have to complement the people involved in our plant. I mentioned this bathtub approach, I mentioned the incinerator; I didn't mention, but I should have, perhaps, this activity devoted to the production of a PCB that our studies show is respectively less persistent in the environment than the old mixture.

brb 7

All of these took us twenty main years of effort, technical effort, and the expenditure of two to three million dollars, all aimed to getting to this point of a few pounds per day from a unit that produces -- I forget the number -- 50 million pounds per year, approximately.

Q Well, we'll get to that persistence in a minute.

MR. ECKERT: I don't have any further questions for Mr. Papageorge. Unless you have some redirect, I would like to get to Dr. Tucker.

MR. PARK: Okay. I do have some redirect.

JUDGE SWEENEY: Go ahead.

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REDIRECT EXAMINATION

BY MR. PARK:

Q I guess, starting with the most recent first, Mr. Papageorge:

You were asked a few minutes ago about PCB use in other Monsanto plants. I suspect you were thinking in terms of manufacture.

Is PCB used in electrical apparatus and so forth in those plants?

A That's a good point.

Our plants do not use PCB's for anything other than in the uses to which we now market, mainly in capacitors and electrical transformers. We do not use PCB's for any other purpose.

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Q All right.

Is the Krummrich plant the only plant discharging into the Sauget sewage treatment facility?

A Oh, no.

We are one of many industries located in that area that discharge into the treatment plant, and as I -- I have some notes:

I believe we represent about half of the gallonage. The total gallonage to this treatment plant runs 16 to 20 million gallons per day, which is double what we introduce.

Q So if the effluent from the Sauget waste treatment facilities were monitored where it enters the Mississippi River, there would be no way of telling where a specific substance or substances came from?

A That is correct, yes.

Q Yesterday, during your examination, there was a reference made to, and several questions asked about something referred to as "the Yusho disease."

This was in connection, I believe, with a reference in Monsanto's testimony relating to the fact that -- at the bottom of page 10 of the testimony, I believe, the sentence at the bottom of the page, which was summarizing the paragraph pointing out the considerable amount of production of PCB that has taken place worldwide for a number of years -- and the paragraph concludes with the statement

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"With this amount of material discharged into the environment, it is of considerable importance to note that extensive harm predicted by some theories has not been found and documented."

As I recall, it was in this context that the Yusho disease was raised.

Is that an example, the Yusho disease, an example of PCB's in the environment causing harm?

A Not in my opinion.

Again, I perhaps assumed something. The Yusho incident,which we discussed yesterday, was a tragic industrial accident which resulted int he contamination of an edible oil at extremely high levels -- and I am told this by toxicologists within the Food and Drug Administration -- and to get some perspective, this would amount to going to an eating establishment and ordering a beverage or food containing high levels of PCB's: it's not surprising that the human beings that did eat this oil or ingest this oil exhibited the symptoms we talked about yesterday.

But this in no way fits the environmental concept that we have been discussing here.

Q Do you recall the levels of PCB that were in the rice oil that the people actually consumed?

A I believe it was 2000 arts per million, of that order of magnitude.

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Q You're saying that that was in no way related to any environmental situation?

A No.

That rice oil was not contaminated as a result of PCB's entering the natural environment, and by some transport methods found themselves in this oil, no.

Q All right.

The paragraph to which I referred a moment ago is concluded at the top of page 11 of our testimony, and the first sentence at the top of page 11 reads:

"This lack of evidence --," that is, of harm caused to the environment by PCB,

"-- indicates that all of the PCB's do not persist in the environment as a result of factors such as the biodegradation that we discussed previously."

I think a question was raised in this context yesterday about drawing an inference of the lack of persistence from a lack of harm.

Would you want to clarify or elaborate on that point, sir?

A I'll try. I don't know if I understand that question, or understood it even yesterday, but let me try to describe the intent of the words that we've been talking about.

We are aware of the amount of polychlorinated biphenyls and the types of mixtures that were marketed, and we

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know from the applications into which half of these materials entered, at least half were the type that, in a very short period of time, the PCB's would end up in the environment as we all understand it.

Coupling that thought with another concept, or with another supposition which I didn't believe was appropriate to discuss in this particular paragraph -- but let's make an assumption at this point that PCB's, at some level -- and for our purposes it is not necessary to say how high, but at some level -- should create some effect which could be interpreted as a harm.

You'd expect then that with all of this million tons of material that is mentioned here introduced into commerce, you'd expect, if in truth it accumulates in the environment, does not persist, keeps building up, some day that clock is going to run out and an effect will be noted. I have not seen any evidence that documents this effect.

The question, then, is raised: what happened? Are we wrong in some manner, or is it because we really don't know enough about PCB's? Is there something that makes these PCB's inactive or unavailable or destroys them?

So the point I wanted to make there is that something has happened to PCB's introduced freely into the environment under the old ideas we had about PCB's, to such a degree that this harm which I know many of us have read -- what's

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going to happen to us and to all of the creatures in the world hasn't happened.

Now, in addition to that: in spite of all of this material introduced very freely into the environment and none of this harm or evidence of harm being recorded, surely it can't get any worse, because under today's conditions those applications have been discontinued in this country and in most of the rest of the world, and I personally don't see how it can get any worse than it has been, and I can only see improvement.

Q Thank you, Mr. Papageorge. I have just a couple of others here.

I'd like to call your attention to Monsanto's Exhibit 33, I believe. Yes. Reference 33.

Again, a question was asked yesterday concerning the levels that show on a graph, a chart, on about --

A It should be numbered page 5, because between 4 and 6 there is this graph.

Q Page 5 of reference 33.

(Continuing) -- showing levels of production of PCB at the Crumridge plant for the last several years, and the chart, after showing a drop in production of 1254 from 69 to 70, then it does appear that the amount of 1254 produced is relatively constant during the years after 1970.

Is it a fact that that's relatively constant?

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Would that have been a surprise in 1970, or what were the reasons for its remaining constant?

A. The reasons could be many. I will mention, but only as a point of information, the amounts of these materials produced and marketed will, of course, vary with economic conditions. It's not a great factor here but it could lead to some increases in the future, even though the applications are limited.

Going back: when we withdrew the polychlorinated biphenyls from the general marketplace and restricted the applications to which they were put, one would have expected that the amount of 1254 produced would then have dropped. This was a natural consequence because 1254 was used in paints, inks, adhesive, hydraulic fluids, heat transfer fluids, just about all the uses that other PCB's have been put to.

However, working against that reduction was another factor. This is the one where, in order to remove from commerce the more persistent higher chlorinated isomers as much as possible, we made another decision, and this was, "Let's remove Aroclor 1260 from the marketplace and its use in transformers, and replace it with the 1254 which, relatively speaking, has more of the biodegradable isomers in it."

So the reason we see 1254 quantities staying fairly constant is that one decrease was offset by another increase. But to get a true, total picture, one should look at the sum

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of 1260 plus 1254 if you're trying to get some impression of what effect, what types of products are now being introduced into the marketplace.

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Q Lastly, I would like to call your attention to our Reference No. 2; this is an article by Dr. Ricebraugh.

A Yes, sir.

Q And, specifically to page 353, the last paragraph.

I thought there was a little confusion concerning a question or two related to this paragraph, and I wasn't sure you understood the question that was asked.

Would you look at the last paragraph on page 353 where Dr. Ricebraugh points out that Aroclor 1242 production in 1970 was four times that of Aroclor 1254 production, and yet, in all of the zooplankton that was analyzed, he seemed to find 1254 and no 1242.

What conclusions or conclusion did Dr. Ricebraugh draw from this?

A Well, an obvious conclusion could be that Aroclor 1242 is being degraded such that the residual material that is being observed looks like Aroclor 1254.

Q If the environment immediately after manufacture and use contained some Aroclor 1254 and a greater amount of 1242, but if the 1242 biodegraded much more rapidly is it unreasonable to expect that zooplankton or any other organism that might retain in its system some PCB's would find only 1254?

A It's a reasonable conclusion, but, again, I would suggest Dr. Tucker would be a better source of information

jrb 2

in that area.

MR. PARK: That's all I have.

MR. LORANT: I have one question of the witness in case you have something further, I will interject my one question, if you please.

MR. PARK: What is your name, sir?

MR. LORANT: Bernie Lorant.

MR. PARK: Are you with EPA?

MR. LORANT: No. I am one of the -- I represent one of the Objectors.

MR. PARK: Fair enough.

RECROSS-EXAMINATION

BY MR. LORANT:

Q I wanted clarification on one answer you gave, Mr. Papageorge. Yesterday you were asked, "Can you state metabolism has occurred if you don't identify a metabolite?" and your answer to that question was, No.

I am not sure exactly what you mean by that, but I take it you do not mean that one must structure structurally or chemically identify a metabolite before you know metabolism has occurred; is that correct?

A That's my understanding.

Q So that by identifying the metabolite you weren't thinking of chemical identification, necessarily?

A I'm not really qualified to talk about the

jrb 3

metabolitic processes, but in my, say, layman's understanding when they talk about metabolite, as I understand it, it's a chemical entity identifiable by the chemist, that could conceivably have resulted from some process involving another chemical in a creature, let's say, that has ingested or breathed, absorbed the material.

Q That may come close to the definition of what a metabolite is. The thrust of th question is when does metabolism occur, and my only point is: I wanted to make sure what you meant by your answer in that I inferred a chemical identify being required by your answer, and I think you fall short of that; do you not?

A Yes.

In my understanding of these matters it is possible for something to be metabolized resulting in chemical entities that cannot be directly traced back to the original material. For example, the resulting metabolite might be carbon dioxide and water, finding carbon dioxide and water I cannot jump to the conclusion that material was metabolized or that it wasn't metabolized. It doesn't tell me anything.

Q Well, you may see a potential metabolite as a spot on a paper chromatogram and not know what it is, but know that it is not your original product -- chemical; isn't that true?

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A Right.

Q Or as a peak on a gas chromatograph?

A Yes.

Q Or any other manifestation that tells you a change has occurred without necessarily being able to elucidate a change?

A That is correct.

Q Okay.

MR. LORANT: Thank you.

BY MR. ECKERT:

Q Just a few questions.

On the Sauget plant, does any other facility, to your knowledge, any facility other than the Crumbridge plant, contribute PCB's to the Sauget plant?

A I do not know.

Q Now, in response to questioning from Mr. Park with respect to your statement on the lack of evidence of harm in the environment, you stated that a lot of the PCB's have gone up, but, as I understood your testimony, you stated that something has happened to them, so that we don't find them.

Couldn't that something simply be dilution?

A It is possible.

I am trying to recall Dr. Serafin's analysis. I really don't remember the details.

jrb 5

Q Now, on your response to Mr. Lorant's question with respect to metabolism I wasn't trying to force you yesterday to say that you had to be able to elucide the chain between the metabolism, between the material metabolized and the metabolite; but you would agree, wouldn't you, that in order to show metabolism you should be able to find something which you could call a metabolite, even though you may not be able to trace it back to the material metabolized?

A I agree.

MR. ECKERT: No further questions.

JUDGE SWEENEY: You are excused.

(Witness excused.)

MR. PARK: Could we have a short recess, sir?

MR. ECKERT: It's up to Judge Sweeney. I would just as soon move it to Dr. Tucker. We're short of time.

Whereupon,

tucker

E. SCOTT TUCKER

took the stand as a witness and, having been first duly sworn, was examined and testified as follows:

CROSS-EXAMINATION

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BY MR. ECKERT:

Q Dr. Tucker, as I understood your background, you are an analytical chemist, is that correct?

A Yes.

Q Which analytical technique is used for the

jrb 6

measurement of PCB's, the quantitative measurement of PCB's?

A The dominant technique that is employed is electron capture gas chromatography. There are, however, other techniques.

Q Now, is that technique more sensitive in the measurement of higher chlorinated homologs?

A There is a dependence in the sensitivity on the degree of chlorination as well as the substitution or the position of the chlorine in the biphenyl molecule.

Q So that the more chlorines in the molecule, the lower the level at which you would expect you would be able to detect residues; is that correct?

A That's correct.

May I add something to that? With the sensitivity of the electron capture detector there's hardly any problem in detecting monochloro biphenyls through deccachloro. There's adequate sensitivity to detect, with this technique, to detect any isomers including the monochloro biphenyl.

Q Right. But wouldn't the limit of detection for each isomer change with respect to the number of chlorine atoms?

A Yes, I believe we've established that in your first question.

Q Do you have a rough idea for comparative purposes of what the limit of detection would be for a homolog with

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six chlorine atoms or five chlorine atoms as opposed to one with two?

A When you talk homolog, are you talking an isomer or a homolog? I think we should define it.

Q Well, let me ask you what's a homolog?

A A homolog, well, if you're talking about six chlorines you could have -- well, let's talk about three because I forget how many homologs there are in the six; but if you have, say, two chlorines in a molecule, I think you can have upwards of 12 isomers.

Now, all of those 12 isomers constitute a homolog or dichloro biphenyl. So, now, if you're talking about the sensitivity of a homolog, then you may talk about 1 to 12 isomers which would, of course, improve your sensitivity in a sense.

If you are talking about the detection of a specific isomer then you're into the area where we really don't have any information that indicates specific sensitivities of this sort. So, I think very honestly the question should be clarified if you're going to pursue this.

Q I am glad you did clarify that, and I was asking about homologs rather than isomers.

As I understand it, it's much more difficult to identify individual isomers than it is to identify homologs?

A Yes, but isomers are available and you can

jrb 8

measure them and you can run them through an electron capture gas chromatograph.

Q Well, could you give me, just for comparative purposes the limit of detection for 5 chlorine atoms in the homolog as opposed to three?

A Okay.

I believe -- and with your permission, of course -- that it might be better to talk about detections in terms of, say, 54 chlorinated biphenyl, which people say is a pentachloro biphenyl, or, say, a 42 percent chlorinated.

If you take something like a 42 percent chlorinated biphenyl and assume unity at the detection limit, and you go to something like a 1248, which is 48 percent chlorinated biphenyl, you get, I think, a factor of about 1.542 increase in sensitivity.

If you go to a pentachloro biphenyl, or a 54 percent chlorinated biphenyl you may get upwards of a factor of 5, and so on. But it is one order of magnitude difference between monochloro in homolog sense, and a deccachloro or, in terms of sensitivity.

Q So let me pose you a hypothetical:

Assume that we have measured in the environment a level of very close to the detection limit of 1254; wouldn't it be quite possible that there might be 1242 there in a concentration of roughly one-fifth that which would not

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be picked up by the detection method?

A Since your question is hypothetical I would have to answer yes. However, under actual laboratory conditions when you're operating near your limit of detection there are ways of getting more of the material into the instrument, and I believe that you would sincerely have some indication that there was chlorinated -- lower chlorinated materials there.

So in the real sense, no; hypothetically, yes.

Q Well, what is this technique for getting more of the material into the instrument?

A Concentrated sample by evaporation, injecting a larger amount, increasing the sensitivity of the detector.

Q Well, when you speak of concentrating by evaporation, do the vapor pressures of the various homologs vary?

A You have two questions here.

Q Well, let's speak of the formulation of 1254, 1242, 1216, do the vapor pressures in the formulations vary?

A Yes, obviously.

Q And is it true, as a general rule, that the lower chlorinated formulations have a higher vapor pressure than the higher chlorinated formulations?

A Yes.

Q So that if you were to evaporate a sample concentrate you would expect, would you not, to lose more of

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the lower chlorinated formulations?

A If you were not an analytical chemist and did not perform these analyses, you might; that is not the case.

Q Well, I don't understand your answer.

A The answer is that, no, under the conditions of evaporation that are applied by most analytical chemists you do not lose the monochloro biphenyls.

Q How is it done?

A You generally blow a stream of nitrogen or air across a hexane containing solution. Now, hexanes' boiling point is so low relative to a monochloro biphenyl that you don't lose it, the monochloro biphenyl.

Q Now, in the process is salicic acid used as a clean up?

A There are some procedures, and I believe it was initiated by the EPA where salicic acid is used as a solid absorbant for clean up.

Q Is this a procedure that you use?

A No.

Q Is it a procedure that might widely be used?

A It is a procedure that has been used. There are some problems with it, if that's what you're alluding to.

Q Well, could you describe the problems?

A The problems are that if you are not quite careful in terms of the type of solvents and things of that sort

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that you use, you lose the PCB's from the solvent absorbant. The potential exists to lose some of the monochloro biphenyls or the lower chlorinated biphenyls.

However, as you go to more polar solvents, when you load a salicic acid column, you do get these materials, and most analysts who have been in the business for a while are aware of this fact, and are very careful to avoid the loss of the lower chlorinated materials in their work-up of samples.

Q Now, I would like to turn to your paper on bioaccumulation -- on bacterial degradation, rather.

A What number is that, please?

Q I'm just trying to find it myself.

It's number --

A No. 21, I believe.

Q Right. That's correct.

Now, a general question first: In conducting this test did you make a budget of precisely what happened to the PCB's that were used in the test?

A Yes. There is a budget here in a sense. In other words you're putting in so much, you're measuring what's left, and the other disappears; so, therefore, you can account for 100 percent. And that's a budget in a sense.

Q That is a budget in a sense; but do we know exactly what happens to that which disappears?

jrb12

A These particular experiments deal with primary biodegradation. I think that's fairly well spelled out in this particular article. In studying the biodegradation of materials this is probably one of the things that you look at initially, because, after all, if it does not undergo primary biodegradation, I mean, a minute change, then there isn't much sense in looking at it in any further extensive tests.

However, if I will be allowed, I will say that as time has become more available, and in our laboratory we have conducted other tests which do show that a number of polychlorinated biphenyls undergo ultimate biodegradation.

By "ultimate biodegradation," I mean complete mineralization to CO_2, water, and mineral salts; and they do so at a rate that is equivalent to glucose.

Q Which formulations?

A These primarily are the lower chlorinated ones. We've been dealing with monochloro biphenyl mixtures. We worked with Aroclor 1221, and we're working our way up the scale.

Now, I will tell you very honestly that as we get into the more higher chlorinated materials, I do not anticipate complete, ultimate degradation, nor would any microbiologist.

Q How have you -- well, you've stated that it undergoes complete degradation to CO_2; how have you identified

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the CO_2 as being resulting from the degradation?

A Well, there are two techniques that are generally employed to do this type of thing. One is, of course, the radio-label techniques; the other -- well, actually, there are three.

One is stable isotope techniques, Carbon-13; one is radio-label techniques, Carbon-14; and another is just sikmply to use a nutrient pour system which has a low endogenous respiration rate and produces little CO_2. And then you add your carbon source, so, therefore, most of the CO_2 comes from your carbon source. And you can do a budget analysis.

The particular test that was employed is the test Thompson and Gunthie. It is a test that is used by the Soap and Detergent Association; it's well-established, and it's been around for, I would say, perhaps, maybe 10, 15 years.

Q These recent tests thatshow the complete, the ultimate biodegradation, they are not included in the exhibits you have?

A I am sorry, they are not; but I felt they were worthy of mentioning and I did ask your permission.

Q Yes.

Well, unfortunately, we can't examine you on those because we haven't read them. Are they written up so they can be supplied?

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A I can provide you with handwritten or maybe even notebook pages. I will have to check to make sure that this information can be released; but at this point in time I see no reason why it cannot be provided to you.

Q Now, in the tests that you did here you vigorously aerated the sample for a period of 48 hours; isn't that correct?

A That's correct.

Q Now, isn't it possible during that aeration that some of the PCB's simply evaporated?

A This is a rather obvious possibility, yes.

Q Did you use glass containers?

A Excuse me. If you are not going to pursue that, I would like to make a comment with your permission?

Q You may clarify your answer.

A Each time this test is run we take the total effluent, gas effluent, from this unit and scrub them through scrubbers. The scrubbers are then analyzed to determine what the volatility losses are. And I believe if you look into the paper in detail the volatility losses are spelled out.

Q What did you use to scrub the gases?

A The scrubbers were three hexane scrubbers in series, and what was done was they were analyzed, each one was analyzed; in other words, No. 1 was analyzed, No. 2 was

analyzed, No. 3 was analyzed. These scrubbers are put in series to insure that you are not blowing them through, completely through; and in all cases the last scrubber contain a very insificant amount, which means we were trapping any volatilized PCB's.

So volatility losses are not contributing to the primary biodegradation rates states.

Q Were glass vessels used for this experiment?

A Yes.

Q Do PCB's adsorb onto glass?

A Yes.

Q Was this accounted for in any way in your results?

A Yes.

There's a little trick in this kind of game, that when you're dealing with water and soluble materials you obviously run into this problem, and I'm glad you brought it out.

We operate these units until we achieve what is called a steady state, by which I mean that the surfaces in the system, for example, the glass and things of this sort, have actually -- there has been actually enough material introduced into the system that you read a steady state, i.e., your active adsorption sites on the glass are not -- are fully covered. And so your losses are not due to mechanical reasons.

jrb 16

Q In this experiment, in this particular experiment, you di not identify the metabolite; did you?

A To answer your question, no; there is a reason that we didn't.

Q You can explain.

A Okay.

We manufacture well over -- you see, the scope of my group is a little bit broader than PCB's, although we do have direct responsibility for the analytical portion of PCB's and the biodegradation and things of this sort. The company itself manufactures in the thousands of products and we are attempting to develop tests which will tell us about the environmental compatibility of our products.

And so time is of essence. So the first thing to do is obviously establish that we do get primary biodegradation. The second thing was to see if we get ultimate degradation.

I currently have one new Ph.D. who is in the process of attempting to elucidate what some of the metabolites are, and what the mechanism is for the breakdown of PCB's.

Q Now, after this 48 hours continuous aeration, what percentage of the PCB's that were used in the experiment were degraded?

A Well, I would refer you to the paper. Unfortunately they are not numbered because the journal to which it was

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submitted said "put it lightly in blue" and that does not Xerox.

But there is a graph in here, and it's about halfway through, and in it we plotted average degradation rate per 48 hour cycle versus the percent chlorine, which, of course, is on a weight-weight basis.

Did you find the graph?

Q Yes, I have the chart before me.

Could you describe each of these formulations in terms of the number of chlorine atoms?

A Yes, I can.

The initial one, biphenyl, obviously has zero chlorine atoms.

Aroclor 1221 I believe has approximately -- in between, say a mono and a dichloro biphenyl. I think it leans a little bit toward the dichloro biphenyl.

MCS 1043 is a research compound that was utilized becausse it fit in between and will give us a point so we can get a trend. It is sort of a di-tri compound.

Aroclor 1242 is a trichloro biphenyl. It's considered that on a percent chlorine weight basis

Aroclor 1016 is of course the version that has the higher molecular rate, more persistent PCB isomers removed, and it would correspond to, say, something less than a trichloro biphenyl, since you obviously remove some of the

jrb 18

heavier chlorinated materials.

And Aroclor 1254 is a material that has, it's a pentachloro biphenyl, and which has for sometime now most closely represented what researchers are finding in the environment. However, I hesitate to say that with Aroclor 1254 even some of the earlier peaks which are tetrachloro biphenyls, and even maybe some pentas, are not found in the environmental samples.

Is that an adequate description of the compounds studied?

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Q Yes.

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2A ebl

JUDGE SWEENEY: We'll take a 15-minute recess at this time.

(Recess.)

JUDGE SWEENEY: Back on the record.

BY MR. ECKERT:

Q Dr. Tucker, I have a couple of questions on bioaccumulation but before we get into that, I have a couple more questions on your experimental data.

Have you made any attempt to sample environmental conditions to substantiate or correlate your findings in the laboratory?

A Yes, in a sense. I think because, again, of the lack of manpower and the scope of the problem we are dependent a great deal upon the government and the academic people to provide this kind of information.

And I think yesterday when you were referring to references 2 through 13 in our testimony, there is adequate information that supports the kind of biodegradation data and the tissue accumulation data that we've been able to generate with our resources.

Q I'd like to turn to Exhibit 12.

A What page of our testimony is that referred to, please?

Q Well, you've referred to Exhibits 2 through 13 at page 6.

A Right, page 6.

I'd like to refer to it in context to our testimony, so I'd like to have it handy.

Exhibit 12?

Q That's right.

Now the statement in the text of the testimony is that:

"Environmental monitoring programs have clearly demonstrated that, with the exception of direct high-level controllable release near points of manufacture or use, the PCB's found in our environment are the more highly chlorinated ones, i.e., those containing predominantly five or more chlorine atoms per biphenyl molecule."

A Excuse me. I've been attempting to put those references back in order so that I can find them in a rapid fashion, so if you would be kind enough, can I have the question repeated, or the statement or whatever it was? I'm sorry, I wasn't listening.

Were you reading a statement out of the text here?

Q I was reading the third paragraph on page 6, the last sentence of the paragraph, beginning "Environmental monitoring programs."

A Okay.

Q Now with reference specifically to Exhibit 12,

cb3

to your knowledge are those eagles which were sampled eagles which were found near points of manufacture or use?

A I have no knowledge of that, no. I do not believe it is stated in the article. However, I could be wrong. I'd have to take time to read the article to answer that question. I do not have knowledge of there being near the point source discharge.

Q I'd like to have you look at page 254 of that article. Now this is a chart representing the mass spectrum of analysis of tissues of the eagle, is it not?

A Yes. This is I think a GC mass spectrum.

Q Now on Figure 2, can you identify what the peak is that is labelled M-256?

A That's the M/E I believe, as indicated in the figure for the empirical formula $C_{12}H_7Cl_3$, and by the isotopic abundance pattern, a fragmentation pattern, I would probably say it's a trichloro biphenyl.

Q So here's an instance where a biphenyl containing less than five chlorine atoms was found in the environment; isn't that correct?

A I would like to clarify-- Okay.

Yes, to your question. But can I digress for a second and sort of describe what Aroclors are, just very briefly?

Q If you think it will help explain.

eb4

A I really do, and after all, we are all here to try and clear this up.

In each of any chlorinated biphenyl product which is produced by direct chlorination you'll find a little bit of Aroclor 1221, a little bit of Aroclor 1242, a little bit of Aroclor 1254, a little bit of Aroclor 1260. The point is that they are dominantly one or the other.

In other words, when you chlorinate a biphenyl directly you get a distribution so the potential exists to have any one of 210 isomers in any of the products.

I think that's an important point; at least it is to me.

Q That is an important point. Doesn't that seem to indicate that no matter which PCB you are discharging, it will be probably contain some of all the PCB's?

A I think this is an obvious point that has been established, yes.

Excuse me. Are you going to move on from this article?

Q If you have some additional explanation of this article, please go ahead.

A Okay.

I believe this article was included here in support of the statement and I think there is actually a better demonstration of the fact that this article does support the

mb5

conclusion which has been our objection. It can be seen if you look at the graphs on page 253.

There are of course-- I believe these are electron-capture chromatograms of Arocore 1254 products or what I prefer to call 54 percent chlorinated biphenyl, and then that which was isolated from the eagle carcasses.

And I think you'll see that there is a definite difference in the pattern of peaks between the standard and those which were isolated from the eagle. So that if you would look at it going from left to right, in Chromatogram A you will see the early eluding peaks, which of course would be the lower chlorinated materials in that particular product, and if you go to the Chart B and starting from the left-hand side again, you'll see that they are highly attenuated, which indicates that they have been -- they may have been metabolized and/or excreted, which is a point which is being made in that particular paragraph.

Q Well, now, you stated that these are attenuated. Could the attenuation be accounted for by the lower rate at which the lower chlorinated biphenyls accumulate in tissue?

A I think-- I heard that mentioned yesterday and I think while there's a difference in, say, the hydrophobic character of these, I think they are close enough together that they pretty well accumulate to the point where you would see them; so, No.

eb6

Q Well, you are seeing them here, aren't you, even though they are attenuated?

A The authors of this paper did see a trichloro biphenyl; yes, sir, but the fact that the material was not the same as the standard indicates that something has occurred that has altered the pattern.

Q Now on Exhibit 37 I believe, the paper by Baxter et al., --

A I have the exhibit.

Q In general is it a fair summary to say that this paper shows that very little, if any, degradation of hexachloro biphenyls occurs?

A Yes, that is a fair statement; in the time frame that they used, I might add.

Q Now with respect to time frames, these experiments were all done under what might be described as ideal conditions for bacterial degradation. Isn't that correct?

A I think in these particular experiments -- and I would have to review it -- that they used a basal medium, and I'm not so sure that you consider it "ideal" conditions.

You might consider it a nutrient pour system, but I would have to review the paper again, however.

Q Well, I suppose I should ask the question differently.

Are you likely to encounter in the environment

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circumstances as conducive to bacterial degradation as the circumstances induced in these experiments?

A I would say that you would find in the environment a spectrum of these types of things. In other words, for example, in river water you have a nutrient pour system. In activated sludge you have a nutrient -- a highly active system. So I'd say you can find these conditions in the environment.

Q Now you described the gas recapture or cleanup phase of your old experiments.

A You mean where we checked to make sure we did have volatility losses?

Q Yes.

A Okay.

Q Was the same procedure followed in this experiment?

A I would have to check.

As I recall, Jean Mainprize was the one, the microbiologist involved, and Ron Lidgett. They did check for volatility losses. I think they found they weren't significant. I don't know whether it is in this specific article, but through personal communication with these people, since they are part of our company, of course I have discussed their work extensively with them.

Q On page 7-- And hold the Baxter paper, if you will, to one side.

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A Page 7, not of--

Q Page 7 of your affidavit.

A All right.

Q A definition is proposed of polychlorinated biphenyls, and it identifies them as those having gas chromatographic retention times greater than 60, relative to -- and I don't know how to read that.

What does this define? Can you describe in lay terms what this means?

A Okay.

First of all it is defined in terms of what I would say is the recommended EPA methodology which I believe has come out of the Cincinnati Laboratory that Jim Lichtenberg has worked on and that they are in the process of validating.

So the "60" refers to a retention time relative to a standard compound para para prime DDE.

The cut point which is defined by 60 gets down into-- It starts-- There are some tetrachloro biphenyls and then of course the ones that are further up, the persistent ones, the ones that are long lived in the environment.

Is that adequate?

Q I think I understand.

In other words, this is generally those having four or more chlorine atoms, or is it more than four?

eb9

A What you said was correct. These are the polychlorinated biphenyls that have generally -- start with tetrachloro biphenyls and then go up.

However, just below 60 there might be a minor amount of a tetrachloro biphenyl or something of that sort, but it is sort of a point where you are cutting at the tetrachloro biphenyl and up.

Q Now it's not your contention, is it, that the lower chlorinated biphenyls are not toxic?

A You know, it is not my contention that anything is not toxic. You have to be real careful when you talk about toxicity. I'm not a toxicologist and I don't want to be trapped into acting like I am one.

Let me explain-- Do you want to know why we proposed this definition?

Q Yes.

A Okay. All right.

The definition is proposed because we sincerely believe that the predominant problem with polychlorinated biphenyls is the persistence of some of the higher chlorinated ones in the sense that if they persist for exceedingly long periods of time and can bioaccumulate, then there is the potential possibility that they could achieve, if they continue to be released, that they could achieve a level in higher organisms that could have a toxic impact. And this is

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true of anything that accumulates.

So we are focusing on this.

Now unfortunately in this testimony, it is not stated clearly that we are not recommending that we shovel the lower chlorinated biphenyls out into the environment. We are only saying "Let's restrict ourselves to the problem at hand," and we believe persistence to be the dominant problem.

And you have to look at this document in combination of all things that are suggested and not just isolated points. In other words, clean up, restrict and release, restricted use, and things of this sort.

Q Well, if we had to cut off somewhere, wouldn't we want to cut off at a point which included those which have been found in the environment? For example, the ecodata showed that some of the free chlorine--

A Well, first of all, let me back up.

You asked me if I could establish that those eagles were collected near a point source discharge. I said No. Can you establish that they were not?

Q Well, I think that the burden of proof here, if I can be so bold, ought to be on those who are putting this stuff out.

A All right. I may be overstepping my bounds. If I am, I apologize.

ebll

I don't know that those eagles -- how close those eagles were to a point source discharge so therefore, I can't have any idea whether or not they could have gotten the trichloro biphenyls because they were directly exposed to it or because it came up through the food chain.

Q Well, what about Jensen's papers?

A You've only cited one reference to me that shows one example of finding one trichloro biphenyl in an environmental sample.

Q Well, I'll cite another one. How about Jensen's paper? I believe that's Exhibit 4.

A Yes, Exhibit 4.

MR. LORANT: Are you referring to Reference 4?

MR. ECKERT: Reference 4 to his exhibit.

BY MR. ECKERT:

Q Now on page 248 of that paper it states:

"We found that the principal PCB components were PCB numbers 7 to 14 but the mussels also contained the lower numbers."

Do you know what lower numbers he's talking about?

A Well, as I understand it -- and I've have to go back and look, of course, but Gunther Widmark, who works with Soren Jensen -- He does not work with him now, but they were at the University of Stockholm. They developed a numbering system for the polychlorinated biphenyls so the numbers 7

eb12

through 14 don't necessarily designate 7 -- a biphenyl that contains seven chlorines.

And I think if you really read this statement and think about it a little bit, I don't think the implication is necessarily there that they are finding the lower chlorinated materials, i.e., monochloros, dichloros, trichloros. It's just saying that they are finding the lower numbered peaks as witnesses by their numbering system.

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If you will go further, and if I may read this:

"The results suggest that the low PCB numbers are metabolized or excreted faster than the higher numbers, so there is an increase of the latter as it passes through a food chain."

This is also so in Jensen's statement.

Q Turning to page 9 of your affidavit, you describe a procedure that was done to evaluate the accuracy of these analytical techniques.

Do you know what the solubility of Aroclor 1242 is?

A Yes, I do.

In pristine distilled water, you know, solubility with these types of compounds is kind of a shaky thing, but in pristine distilled water, I believe, the solubility of Aroclor 1242 is on the order of 200 parts per billion.

Q How about 1254?

A 1254, I think, drops -- there is a linear relationship, incidentally, which is very nice and interesting -- I think 1254 is on the order of about 50, but I am coming from memory now.

Q And 1260?

A At 25.

Q In other words, the distilled water used in these experiments was spiked with between two times and twenty times

brb2

the amount which it could solubilize.

Isn't that about right?

A. That is correct.

Q. Could the insolubility of the PCB's account in part for the differences between the results obtained by the labs?

A. No, it could not, and I will explain why.

In the instructions, as I said, the actual whole experimental design which we set up -- the details are available -- in the instructions to the other laboratory that participated in the test, since they were instructed to extract the bottles with hexane each time and then combine the hexane extracts, then this would effectively take all the insoluble PCB's out of the bottle.

As you point out, the problem in preparing analytical standards of this sort with the water-insoluble materials is really a real difficult one. Even if you would put it in below the solubility limit of the Aroclor in question in the water, in distilled water, some of it would still go out on the glass, be preferentially adsorbed on the glass.

So to answer your question, no, that could not account for the variability that was seen.

Q. Well, would the hexane extraction take the adsorbed PCB's off the glass?

A. I am laboratory B, incidentally. I think we did

brb3

a pretty good job. We got 93.7 percent, and that's a fair amount in this kind of game.

Q Was the variability different for 1254 or 1260 or 1242 alone, as opposed to the mixtures of all three components, sir?

A Let me refresh my memory here.

(Pause.)

These limits which are stated, the 95 percent confidence limits and the repeatability limits that were obtained through analysis of variance refer to the whole works.

These data are all the data. In other words, they include the mixtures, too. We did do an additional experiment which is not mentioned here, in terms of could you or could you not identify whether you had a 1254, a 1242, and a 1260? There was some variability there.

However, the manner in which these were quantitated is the exact manner which the FDA recommends, and it's probably one of the better ways in terms of doing it when you're dealing with rough mixtures, so that when we had a sample that had all three of the Aroclors in it it was simply broken down into three regions, and three different standards were employed.

So I would not think it would contribute -- in other words, I do not think it would skew the variability.

Q Now, there is a report that was published by Holden

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which involved a collaborative study of PCB's.

Did Monsanto participate in that study?

A. Was this the ideal baseline study or the OECD work?

Q. The OECD work, I believe.

A. I do not know whether Monsanto participated in it. My laboratory did not. We may have in Europe, but I don't know.

Q. Are you familiar with the findings of thes study, Doctor?

A. I'm familiar with it in a cursory sense, but I am not familiar with the actual samples or how they were prepared or how they were distributed or the instructions that were given and how they should be handled, and things of this sort, so I'm not prepared to address myself to that at all.

Q. Well, just addressing yourself to your own results, your recovery of 93.7 plus or minus 19.2 percent: would you say that that is a pretty reasonable degree of accuracy of analysis?

A. It represents accuracy and precision, and I would say quite honestly in a laboratory like ours where we've been doing it for seven years and where the same person did the analysis on the same day on the same instrument, that yes, these are pretty good results, and these are the kind of results that a laboratory can achieve if they do it carefully

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enough in their own laboratory with well-trained analysts and good equipment, good, well-tuned equipment -- and also with pristine clear distilled water samples.

Q Now, are you familiar with any processes by which furans can be formed through oxidation of polychlorinated biphenyls?

A As an organic analytic chemist, yes, I am very familiar with organic chemistry and with the fact that you can make furans.

Q Now, Exhibit 8 to the Monsanto testimony is the paper by Crosby.

A I have it.

Q I will put to you the same question that I put to Mr. Papageorge.

On page 374 and 375, the statement is made that:

"Irradiation of chlorinated biphenyls dispersed in water, followed by GC/MS, revealed identifiable traces of 2-chlorodibenzofuran as a photolysis product --"

I won't read the rest of the sentence.

Do you have the sentence in front of you?

A Yes.

Q Does this indicate to you that under irradiation from the sun in the environment, furans could be formed from PCB's after discharge?

brb6

A I will say yes, the possibility exists, if I am allowed to qualify that statement.

In the experiment that Crosby performed, he could have easily produced what they call phenyl phenols, ortho-phenyl-phenols; and when you put an ortho-phenyl phenol in a gas chromatograph in an injection port that's hot -- and I don't care whether it's glass or metal or what -- and you have another chlorine that is ortho to that, you stand a good chance of producing in the instrument a furan; and I've discussed this problem with many people.

I'd also like to go on in this particular article and read some more of his quotations, because I want to make sure that the relevance of this to an environmental situation is established.

First of all, on page 373, to indicate that you can form phenyl phenols through hydroxylation, and that all these things are subject to photodegradation -- even the furans if they are indeed produced in the environment, and there have been people who have looked for them and not found them -- it says:

> "Previous work in this laboratory demonstrated that chlorinated aromatic compounds are reductively dechlorinated readily in organic solvents when irradiated with UV light at sunlight wavelengths. Under similar conditions, irradiation

brb7

in aqueous media results in replacement of the chlorine by hydroxyl as well as by hydrogen."

This points out the fact that there is a possibility of forming phenyl phenols which, as I indicated, if you treat them -- if you heat them you can condense them and produce furans in the instrument. So you have to be damn careful on this type of thing.

I would like to also turn to page 375 -- and let me just review this very, very shortly.

(Pause.)

Okay. The bottom paragraph starting out, as I said, on page 375, it starts out, and I would like to read it:

"The photodecomposition of the lower chlorinated PCB isomers in both polar and nonpolar solvents reveals the operation of environmental mechanisms which could effectively degrade these widespread decontaminants."

The point is, we can have other than biological degradation that accounts for peaks not appearing in residues and in water; and I would say, as he goes on he says:

"Indeed, the notable absence of the lower chlorinated biphenyls from most environmental samples --"

And he is referencing our reference 9 which is this

brb 8

huge, magnificent study that was carried out by some real competent people.

"-- is suggestive of an important role of decomposition in the environmental fate of PCB's, the interpretation of their source and movement, and prediction of toxic effects on aquatic life," i.e., he is again saying there is a mechanism other than biodegradation for degradation of these materials.

And, incidentally enough, the higher chlorinated biphenyls absorb the kind of light that passes through our atmosphere to a greater extent than the lower chlorinated ones, because you get a shift toward higher wavelengths, absorption wavelengths, as you increase the chlorination of the biphenyl molecule.

Q Doctor, your testimony has been very helpful, and I want to thank you.

MR. ECKERT: I have no further questions.

MR. PARK: Could I have one half minute?

JUDGE SWEENEY: Yes.

(Pause.)

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I do have one question.

REDIRECT EXAMINATION

BY MR. PARK:

Q Dr. Tucker, yesterday you may recall there were a few questions concerning sampling and the problems that might be created by improper sampling, or, perhaps, improper handling of samples.

Could you clarify this subject of sampling and analysis of samples, please?

A Yes. I think it is an important thing that we're all approaching, and something we ought to address ourselves to is, we ought to resolve sampling problems and, of course, analytical differences in our laboratories, if we're going to get into the enforcement area which -- we aren't there, obviously.

But it was touched on yesterday, and it was asked, you know, sort of, why was sampling such a problem? And we've done a lot of sampling in our plants. And we have found that -- and to make the statement in here, and I would like to just add to it a little bit.

We found that the type of sampling that one applies can affect drastically the results that you get in terms of what's coming out of the plant. So obviously, if it doesn't represent what's there, it can be the high or low, so you can have real problems. So you have to design the system for

dr-2

each plant; in other words, you have to go in and look at it and make sure you're doing it right.

Also, I note that there's a frequency designated in the Federal Register for sampling. And I think that this should be looked at very closely, as to wether or not it is the correct frequency for sampling.

We have also found that, in sampling our discharges, that the depth at which you sample -- I mean vertically, also horzontally -- can make the results vary by orders of magnitude. We've found that if we sample where turbulence versus where we have quiescenct conditions, you can get just total differences.

Also, the particulates are extremely important in terms of how you sample -- the size of the particulates in the stream, and things of this sort.

Also, I think that in industrial effluents, especially industrial effluents like Monsanto's, that the effluent is extremely more complex than you find out in Lake Michigan or in other areas. So that you have to be exceedingly careful in the identification and the quantification of what you see; because in the world there are a lot of other things that are electron-capture active.

I also think that we're really going to have to look at whether grab sampling, which is recommended, is really right and whether or not we shouldn't really get into isokine-

dr-3

tic continuous sampling, which is probably the ultimate in this kind of thing.

At the same time, in terms of frequency, we mentioned the rainwater problem that brings up backgrounds and things of this sort that can give erroneous results. All I can say is that as we go down the road, that we've got an awful lot of work to do, and I hope we can all cooperate.

MR. PARK: That would conclude our examination here, your Honor, but I would like to just make sure the record does contain my objection to the failure by the EPA to question Dr. Wright on toxicology, since he is here present, and ask him the questions he had asked of Mr. Papageorge. I object if they fail to do so now, since he is available.

JUDGE SWEENEY: You're excused, Dr. Tucker.

(Witness excused.)

MR. ECKERT: Do you recall specifically the questions?

I have my questions all laid out.

MR. PARK: There were a few related to page 11, Mr. Eckert. I think the bottom two thirds, perhaps.

MR. ECEKRT: Oh, yes. Right.

MR. PARK: I think if Dr. Wright could testify for just a few minutes, it would be appropriate.

MR. ECKERT: All right. I think a couple of questions for Dr. Wright would put this in place.

dr-4

MR PARK: We'd appreciate it.

Whereupon,

PAUL WRIGHT

was called as a witness by the Environmental Protection Agency and, having been first duly sworn, was examined and testified as follows:

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CROSS EXAMINATION

BY MR. ECKERT:

Q Dr. Wright, I would refer you to the second paragraph on page 11 where it is stated that "not enough is known about the fate and effects of PCB's in the natural and diverse aquatic and marine environments to properly design laboratory studies."

I would like to know what more you would need to know in order to properly design a laboratory study.

A Some of the prime considerations in designing laboratory studies is to imply parts of the design that are directed to the populations in the environment which you wish to simulate, and in this particular case this would include the species, their location, the period of time they would exist in a particular environment.

Q Well, is your point then that everything has got to be done on a case by case basis, depending upon the organisms in the receiving water?

A It is not necessary to do everything on a specific

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point by point basis, as long as the studies which are designed and conducted are done in such a manner to be applicable to each of the particular point sources.

Q Now, hasn't a great deal of work been done, in fact, on PCB's and a wide variety of organisms, and occurred in a wide variety of environments?

A That's precisely what has been done. Many grab samples have been taken under many different environmental conditions, in which many different organisms have been sampled.

Q I'm referring to bioassays. Now, haven't a number of bioassays been run on a number of different organisms?

A Yes.

Q And don't these organisms occur in all parts of the country?

A Not all organisms occur in all parts of the country.

Q No, but aren't there representative-- Haven't representatives been tested of organisms which occur in all parts of the country where you find PCB's manufactured?

A My opinion is they have not been conducted in a manner that can be used to matrix or blanket each of these situations.

Q Well, specifically, what's missing?

A An indication of the areas to which any specific assay applies, and the expected differences you might wish to look for in those specific areas.

Q Well, now, we're talking about things that degrade

dr-6

extremely slowly, here.

Isn't it possible for PCB's discharged in the one location to migrate to some rather considerably different locations?

A. Yes, it certainly is.

Q. On the bottom of the page, you refer to a series of studies showing bioaccumulation.

What was the duration, in general terms, of the bioassays which showed magnification ranging between 1,000 and 75,000?

A. I think these were in terms of the laboratory studies, in terms of four to six weeks, at which time the general consensus was a plateau had been reached.

Q. Were studies done on the entire life cycles of any organisms?

A. I believe not in these references. But I do not recall life cycle studies of bioaccumulations.

Reproduction studies have been done.

Q. Have you reviewed the affidavit of Dr. Veith which we distributed?

A. Not in detail. I only recieved it two days ago.

Q. Now, I refer you to Exhibit 23.

On page 175 of Exhibit 23, and this is a paper, by the way, by Duke, Lowe, and Wilson, you see the paragraph beginning, Residues of Aroclor 1254?

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A Yes.

Q Now, starting seven lines from the bottom of that paragraph, the sentence beginning "Less than 0.1 ppb" --

A Yes.

Q Would you read that sentence, please?

A It indicates that less than a tenth ppb -- in other words, a tenth microgram per liter -- of Aroclor occurred in the water at Station 2, and it was not detected in the lower bay water.

Q All right.

Now, I'd like you to refer to Table I, which is on the facing page.

A Yes.

Q Now, if you will look down to the values for the residues in the organisms sampled, would you read the value for residues of Aroclor 1254 in croaker?

A It's a value of 12.

Q 12 parts per million, isn't it?

A Yes, it is.

Q And for Menhaden?

A Eleven.

Q And it's ten for pinfish, is it not?

A Yes, it is.

Q And then there's another value of eleven for menhaden -- I'm sorry, twelve for menhaden; correct?

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A. Yes, twelve.

Q. Now, taking the value of twelve, could you determine roughly what the apparent degree of accumulation is in this environmental situation, based on the ambient level of 0.1 micrograms per liter?

A. I could make this calculation you suggest. I would not imply to you that that calculation would represent the apparent bioaccumulation in the environment any more than I would imply to you that the data presented by Crump and Weisner, where they have similar point source measurements in the water and similar assays of fish tissue in the same water, where you could make calculations with a wide range.

Q. Well, let's just see what we do agree upon.

Our croaker, for example, the level of the croaker is 120,000 times the level that was detected as the maximum level in the ambient waters; is that correct?

A. When the measurements were taken, that's correct.

Q. When the measurements were taken.

And the statement is made that -- not that the level was 0.1 ppb but that it was less than 0.1 ppb; isn't that also correct? This is on page 175.

A. Yes, it is.

Q. So that it might well have been more than 120,000, mightn't it?

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MR. PARK: Could I ask, where does 120,000 come from?

MR. ECKERT: That's 12 parts per million, divided by 0.1 parts per billion.

I have no further questions. Thank you, Dr. Wright.

MR. PARK: May I have one, sir?

JUDGE SWEENEY: Go ahead.

XXXXXXX

REDIRECT EXAMINATION

BY MR. PARK:

Q Dr. Wright, in your opinion as a toxicologist, is it appropriate, or would it be appropriate, to base standards for an entire country or any given very broad area, on the basis of an effect found on an organism or a species such as salmon eggs or pink shrimp, which are found in only a small or an isolated part of this country or area?

A It's my understanding that the purpose of the PCB effluent standard is to protect the aquatic organisms and to protect the organisms, the higher trophic levels, that may feed upon the aquatic organisms. And to base this total degree of potential toxicity to all these organisms on a specific piece of data, a specific species, would not be applicable.

Q In other words, if salmon eggs, as an example, are unusually sensitive to PCB; but if they are found only inside the northwestern part of the country in waters that drain into

the Pacific, it would not be appropriate or, say, make good sense, to establish standards in the eastern part of the country for rivers that drain into the Atlantic or the Gulf of Mexico on the basis of sensitivity of salmon eggs?

A That is a correct interpretation of what I've said.

Q One last question, Dr. Wright.

Could you quickly turn to our reference number 28. This is the Woods Hole article.

MR. ECKERT: Which exhibit is this?

MR. PARK: Our reference 28.

I have a copy here for you, Mr. Eckert, if you need one.

MR. ECKERT: I have it here. I'm just turning to it.

BY MR. PARK:

Q On page nine there is a little table back of the page that I believe was referred to by someone, and frankly I can't remember whether it was Mr. Eckert or ourselves, in connection with the reference that we have on our page six of our testimony.

The third paragraph up from the bottom on page six of our testimony.

My question is, Dr. Wright, how does the article on the Woods Hole oceanography support the statement that's there on page six?

A. The paragraph on page six, in essence, says that during the period of time the polychlorinated biphenyls have been manufactured, that the primary amounts of material have been the lower chlorinated homologs; and if the lower chlorinated homologs were accumulated in the biological organisms to the same extent the higher chlorinated homologs were, we would expect to find them presently in approximately equal concentrations or approximately higher concentrations than the higher chlorinated homologs.

The data available from the environmental samples indicates that that is not so. And the data presented from Woods Hole, in studies in the laboratory where the accumulation from water directly into the organism, indicates that the bioaccumulation of the lower chlorinated homologs is much less than that of the higher chlorinated homologs, and would support the statement that has been made.

Q. And that statement is?

A. I will read: "It further demonstrates that even under conditions of unlimited use, and without special precautions to avoid release into the environment, which is not now the case, that the lower polychlorinated biphenyls degrade rapidly enough to prevent bioaccumulation."

MR PARK: That's all that we have.

MR. ECKERT: I have very little bit of recross on that same paper.

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RECROSS EXAMINATION

BY MR. ECKERT:

Q Would you turn to page nine?

A Yes.

Q Do you see the table of concentration factors for various isomers?

A Yes, they range from 1,000 to 48,000.

Q A 48 to 1 differential, in some cases.

Couldn't the difference in concentration factors account for the lack of finding of lower chlorinated homologs in the organisms, rather than bacterial degradation or environmental degradation?

A Either of those factors could account for the lack of accumulation, and in order to know which factor is responsible, you would have to have an integration of the total exposure period, and the isomers exposed.

Q You'd have to have more data than they have here, isn't that correct?

A We sufficient data of the experiment reported by Woods Hole to evaluate his experiment and to define what the accumulations were in that particular system.

Q That's right. But, as I understand it, we don't have the data to say whether these differences in accumulation result from merely the degree to which, shall I say, the partition coefficient or the degree to which these homologs degrade,

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we don't know which of those factors is responsible, isn't that correct?

A. No, even in this instance we don't.

MR. ECKERT: No further questions.

JUDGE SWEENEY: You're excused.

(Witness excused.)

MR. ECKERT: Now, before we start with Dr. Lauer, perhaps we can break for lunch.

JUDGE SWEENEY: Yes. We'll recess to 1:00.

Before we leave, are we finished with Exhibit 83 now?

MR. ECKERT: Yes, I am.

JUDGE SWEENEY: Exhibit 83 and the referenced attachments thereto are recieved into evidence.

(The documents referred to as Exhibit 83 were received in evidence.)

MR. ROGERS: Your Honor, I guess there have been some more requests for documents, basically on PCB's.

Dr. Blanchard is here, and perhaps we could straiten it out with the parties right now.

JUDGE SWEENEY: All right. We'll recess for lunch.

(Whereupon, at 12:00 noon, the hearing in the above-related matter was recessed, to reconvene at 1:00 on Thursday, May 9, 1974.)

AFTERNOON SESSION

(1:05 p.m.)

JUDGE SWEENEY: We'll be back on the record.

Who is the next witness, please?

MR. ECKERT: Dr. Gerald J. Lauer.

Whereupon,

GERALD J. LAUER

took the stand as a witness and, having been first duly sworn, was examined and testified as follows:

CROSS-EXAMINATION

XXXXX BY MR. ECKERT:

Q Dr. Lauer, on the second page of your affidavit you state that "The acute toxicity of PCB's is too variable to justify across-the-board standards."

Can the same statement be made about the chronic toxicity of PCB's?

A There is lesser data and information on the chronic toxicity of PCB's available in the literature; but I think the same statement would be true for those, the chronic toxicities as well.

Q I would like to refer to your Table 1 where you do present some of the acute data. Are these concentrations nominal or measured concentrations?

A Well, that would vary from one piece of data to the other, and to identify specifically what that was, we

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would have to go back to the original reference and look. I suspect as far as the older data is concerned for a good part of the data most of those concentrations would be nominal rather than final, especially relative to the static tests.

Q Would you expect if those had been measured concentrations instead of nominal concentrations that the values would be lower?

A As a general proposition -- you mean the values for the LC-50 or the values for the concentration of PCB present?

Q Either one?

A Well, the values -- the effect on the values for the LC-50 probably would be to lower them if by using the nominal information compared to using the measured concentrations throughout the term of the experiment.

Q Let's take a look at the first data point given. It's Aroclor 1221 for cut-throat trout.

Now, Aroclor 1221 is a relatively low chlorinated mixture, is it not?

A Yes, it is.

Q And what is the LC-50 for Aroclor 1221?

A In that particular experiment it's listed as 1,170 parts per billion.

Q Now, Aroclor 1242 has somewhat more chlorine than

jrb 3

1221, isn't that correct?

A That's correct.

Q Do you see the figure for cut-throat trout on the bottom of that page, and Aroclor 1242?

A Yes, I do.

Q And what is that figure?

A That figure is 5,430 parts per billion.

Q Now, on page 3 of Table 1 a figure is given for cut-throat trout and Aroclor 1248. Now, there is more chlorine in 1248 than 1242; is there not?

A That's correct.

Q And what is the figure for cut-throat trout there?

A 5,750.

Q Moving on to page 4 we come to Aroclor 1254 which has still more chlorine than 1248, isn't that right?

A That's correct.

Q What is the figure for cut-throat trout and 1254?

A 42,500 parts per billion.

Q And finally on page 6 of Table 1 we have Aroclor 1260 which, as I understand, is no longer being made; isn't that correct?

A I could not verify as to that from my own knowledge.

Q Nevertheless it contains more chlorine than any

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of the other mixtures listed here, isn't that right?

A That's correct.

Q And the LC-50 is what value for cut-throat trout?

A 60,900.

Q Now, from these data points would you conclude that at least for cut-throat trout the acute toxicity is inversely proportional to the chlorination?

A That would appear to be the case for cut-throat trout under the particular bioassay conditions that were used to determine those data.

However, I would point out in looking at other species you can find, you know, mixed patterns and reverse sorts of patterns. It doesn't seem to be a clear-cut kind of generic pattern relative to -- or at least among species as compared to within a particular species.

Q Well, I'm wondering about some of these data points myself.

Now, let's take Aroclor 1242 on page 1 of Table 1.

Now, earlier testimony by Dr. Tucker was to the effect that the solubility of Aroclor 1242 is on the order of 200 parts per billion; is that correct?

A If that's what he said I presume it is correct. I don't know that of my own knowledge.

Q Well, in any event it is no higher than 200; I believe that was the highest number he used. And here we

jrb 5

have an LC-50 of 5,430 parts per billion.

How could you have LC-50 based on a figure well beyond the solubility of the compound under test?

A The usual way that that happens is that in bicassay operations or tests -- and I could not swear to that being the case in this instance, but I suspect it's the case -- the toxicant being tested is delivered into the test container and to the organisms being exposed by way of dilution apparatus, using solvents to deliver the toxicants into the system, in concentrations higher than would otherwise be able to exist in solution, in water alone.

Q Now, getting back to page 2 of your affidavit, you state "This complexity" -- and I'm reading from just below the middle of the page -- "This complexity of influences requires that effects of pollutants be evaluated on a case-by-case basis and not be the across-the-board approach used by EPA."

How would you go about evaluating the effects of pollutants on a case-by-case basis?

A Well, there's a great deal involved, and I don't think I could give a complete description for that here.

However, in some respects I think generic studies could be employed if they were done in such a way as to be applicable to the conditions that exist at each of the discharge sites; but, for the most part, these need to be

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complimented by studies that would take into account the unique conditions that would exist t each discharge point. And these unique conditions would apply both to the type and nature of the discharge as well as the nature of the receiving body of water and the biota in it.

So I would think there would be a two-pronged sort of approach to look at this with both being required, the first being hopefully possible in order to save a lot of reinventing the wheel from site-to-site. The second to look at the specific discharge sites being used to take into account those conditions which are unique to each discharge point, and to the biota that exists there.

Having said that, then I think the evaluation would have to take into account the quantities of discharge, the patterns of the discharge that do exist at that site, the volumes of flow, the amount of suspended sediment, the composition of the species and their particular roles involved in the basic functioning of the ecosystem at those sites; the longevity or life expectancy of the organisms involved; the length of their residence time within the vicinity of the discharge as opposed to being -- as opposed to further distances from the point of discharge; whether or not they would choose to prefer or avoid the discharge plume; all of those kinds of factors would need to be looked at, I think carefully in a way that's relevant to the evaluation of the

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environmental effects of the discharge at each of those particular sites.

I could not prescribe the precise research agenda for that because I think it would be inappropriate to attempt to do so from the seat of one's pants, to do so in a way that would be applicable to all of the individual sites; that would require a close analysis of the characteristics of the individual sites in order to come up with an agenda of data collection that would be addressed to this kind of an effort.

Q Well, have you any idea how much it would cost to carry out the kinds of studies that you're talking about for each pollution source?

A No, that would very much depend upon the characteristics of each site. In general it would be a substantial amount, but it would depend upon the characteristics at each site, how complex they were, and how much of the conditions at each site might be treated on a generic basis as opposed to a unique basis.

Q When you refer to generic studies are you talking about bioassays, for example?

A That would be one form of generic studies. If properly done and interpreted it would be useful.

Q How long would it take for any given discharge to complete carrying out the kinds of studies that you believe would be required?

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A Again, I could not answer that as an across-the-board thing. It would depend upon the conditions at each of the discharges. However, I think that the approach could be structured in such a way that you would identify the prime criteria that you wanted to get information on first and use those as the first cut factors for analysis, and then go on to lesser -- the lesser important factors as would be determined both by a general understanding of what's in the literature and what information came out of the first-cut analysis at those individual sites.

And I would think this would properly be done in the format of cooperative kind of a review of the conditions that exist at the site, hopefully, by the people who have the responsibility to come up with regulatory mechanisms and limits as well as those people who have to meet those regulatory limits. And the agenda would be established on that kind of a basis, and then undertaken.

I could not, as I indicated, give a timeframe in which this could be accomplished that would be applicable at any given site; that would have to be determined upon, based upon, that kind of a process.

Q At the bottom of page 2, you refer to the difference between acute values for various PCB formulations.

Isn't this variation typical of chlorinated hydrocarbons? For example, wouldn't you expect to find

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this same variation for DDT?

A Yes, you very much would, and it's dependent upon so many factors that this is exactly the reason why I would propose that it's not really a realistic procedure to look at the thing as an across-the-board effort. You really have to take into consideration the factors that do affect the toxicant potential of these kind of discharges relative to the conditions that exist where they are being discharged.

Q What factors are you referring to there?

A Many of them I just referred when you asked about what kinds of data, what kinds of research would need to be undertaken at these individual sites in a case-by-case evaluation attempt. And I think that my answer would apply here that I gave to that question.

Q On page 3 you refer to the bioconcentration data, and you state toward the bottom of the page, that "Most of the existing bioconcentration data are based on exposures of confined organisms in laboratories to concentrations in water formulated by use of solvents."

Are you familar with any data which are based upon environmental exposures rather than exposures in the laboratories?

A Yes.

There are some data in the literature that I had reviewed by the time I wrote this, and since then I have

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read the testimony of Dr. Veith and Nebeker and Wilson, et cetera, and Duke; and they also have some additional information part of which was not in the available scientific literature but is about to be in some cases, and in other cases it involves internal reports.

So I am familiar with information that exists wherein concentration factors or concentration factors have been computed based upon the concentrations found in water and in organisms from the same body of water.

Those do present some kind of a problem, though, because the main problem with those -- there are problems with the laboratory concentration factor information that I alluded to; there are also problems with the concentration factor estimates from field data, a large part of which have to do with the inability to really know what past exposure was that caused that concentration to exist in the organism.

It's not necessarily true that the fish that you catch in the vicinity of where the water sample was taken live within that particular concentration during the relevant exposure time that caused it to accumulate the amount that it has. It could have lived closer to the discharge point in higher concentration for part or all the time or it could have lived in locations further away from the discharge point than are represented by the chemical sample in the water.

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So those concentration factors are subject to that kind of uncertainty.

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We have improved our housekeeping capability and qualifications requirements to prevent Endrin being exposed to the possibility of getting into the sewer systems.

Q Are you through?

A And we have diverted some streams of water to better utilization, let's say.

Q And have you done everything that you can think of along those lines to minimize the loss of Endrin in your effluent?

A Yes, I would say so.

Q When some spills on the ground, how do you get it up?

A We have to shovel it up and place it in drums, and this is then disposed of.

Q Now, you have three streams leaving the plant. Isn't that correct?

A Yes.

Q Two of them go to Cypress Creek, which is what you have characterized as the open sewer, or the open storm sewer?

A Yes.

Q And one of them goes into the city interceptor and ultimately winds up in the Mississippi River?

A Yes.

Q And what is the total volume of effluent from the

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plant, all three streams?

A The total volume runs approximately 3300 gallons a minute.

Q And how much flows into each of the two streams going to Cypress Creek?

A The northwest stream averages approximately 250 gallons a minute. The southwest stream averages approximately 600 gallons a minute.

Q And, combined, you've characterized these two streams as containing about 10 parts per billion?

A Yes.

Q And totalling how much per day?

A Well, I take that back.

Combined, no. This would have to be a calculated figure. The southwest stream has about 10 parts per billion; the northwest stream usually has none, never more than one or maybe two, as a possible analytical artifact.

Q One or two --

A Parts per billion.

Q You say "an analytical artifact." What do you mean by that?

A Well, an inaccurate analysis, not definitely identified as Endrin.

Q Well, perhaps you mean something triggering your gas chromatograph that may not be Endrin?

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A That's right.

Q Can you explain the gas chromatographic analysis that you employ for Endrin?

A Yes.

We use an electron capture gas chromatograph, injecting extracts, solvent extracts of the aqueous sample, into the chromatograph to develop the chromatogram, in which the peaks are quantitated.

Q Well, could you be a little more specific, Mr. Marks? Would you go through it sequentially?

A All right.

The sample is taken in a glass bottle.

Q A sample of water?

A Of water from the effluent, either a grab sample or a composite, depending upon the purpose of the analysis. It's taken in a glass bottle to the laboratory.

A suitable portion, usually in the neighborhood of 800 milliliters of this sample, is shaken on a shaking maching for a specified period of time, like 15 minutes, with ten milliliters of a spectrally pure solvent, one which gives no response to the electron capture detector, either hexane or -- generally hexane, sometimes heptane.

This extract is then injected -- dried to remove any occluded water, and then injected in roughly one to two microliter quantities into the electron capture gas chromatograph,

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either preceded or followed by injections of standard solutions of the component to be analyzed, or a mixure of the components, and the peak heighth, and area of the desired peak from the sample of effluent is compared quantitatively with those of the reference materials of know concentration.

Q By peak height you are now talking about a chart on your instrument?

A Yes.

Q And a needle which is recording something?

A It is recording the output of the electron capture detector, the detector current flow.

Q And how do you know when it is Endrin, or how do you surmise when it's Endrin?

A By the retention time, the time from the injection of the sample to the appearance of the particular peak. It's a characteristic of gas chromatography that this is a constant value.

Q So if there is a peak at the right spot on your chart, it's presumptive that it is Endrin?

A Yes.

Q Why are you characterizing these as "possible artifacts"? What leads you to that conclusion?

A They occur on a stream which flows a short distance in a ditch in an area where, to my knowledge, there has never been any exposure to Endrin.

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I'm not analytically sure that is is Endrin, just because there's a peak there, and not something else that sometimes shows up, or possibly even use of contaminated glassware or something. At this low level of analysis it's extremely difficult to get an analytically pure set of glassware to work with.

Q What is the limit of sensitivity for this method of analysis?

A I would say in our experience it's between a half and one part per billion.

Q Where is your laboratory located?

A It's located inthe plant area.

Q The same plant area where you manufacture Endrin?

A Yes.

Q How many pounds of Endrin do you make per year?

A We make approximately 4.5 million pounds.

Q Don't you have a problem in your laboratory ensuring no contamination in dealing with levels this small?

A Yes, we do.

Q Would you attribute any of your feeling that this is an artifact to that situation?

A Yes, I would.

Q Now, the one that we've been talking about -- the stream we've been talking about, as I recall, is a 600-gallon permanent stream.

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Is that right?

A. Yes.

Q. Going to Cypress Creek?

A. Yes.

Q. And the 250-gallon per minute stream also going to Cypress Creek, that one would be about ten parts per billion, sir?

A. No.

That's the one that occasionally shows -- most of the time shows nothing, and occasionally shows a peak. It's a stream that flows throught the caustic chlorine area.

Q. I'm sorry; I'm confused.

Of the two streams, one being 250 gallons per minute, and the other being 600 gallons per minute, both going to Cypress Creek, is the 250 gallon per minute one the higher or the lower concentration?

A. It is the lower.

Q. The lower.

And the 600 gallon per minute is the higher?

A. Yes.

Q. And it is the one that has 10 parts per billion, then?

A. Yes.

Q. And the 250 has what may be artifacts; is that what you were saying?

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A Yes, right.

Q But in any event, based on your analyses, and assuming that everything you look for and peaks in the right spot in your chromatogram: this is counted as Endrin, and what is reflected in your statement as about a tenth of a pound per day?

A Yes.

Q So that some of that tenth of a pound per day could be artifacts?

A Yes.

Q The origin of those two streams: could you generally characterize them?

A Yes.

The smaller stream to Cypress Creek, 250 gallons a minute, consists of steam condensate from the Bryant heaters in the caustic plant, and seal water from the Nash hydrogen compressors in the caustic chlorine plant.

The streams on the southwest, about probably 300 to 400 gallons, this represents blowdown from the cooling towers and the water recirculation system. The rest of it is either uncontaminated heat exchanger water that is diverted to the ditch or air conditioner cooling water on the air conditioning system for the laboratory, and things of this sort.

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Q So that none of the combined 850 gallons in the two

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streams is relevant to the Endrin operation per se.

Is that true?

A Yes, as far as I know.

Q I believe Mr. Rogers asked you what the source of the Endrin in these streams are, or what you think they are; and if he didn't, I would like to ask that.

A I think it is pickup from the soil content.

Q How long has Endrin been manufactured there?

A Since 1955 that I know of, commercially.

Q Now, in your affidavit, I take it -- I take it you made a literature review to accumulate those references that you could find relevant to the state of the art of removing material like Endrin from water?

A Yes.

Q And you concluded in reviewing this literature that there is no demonstrated method for attaining the standard as presently proposed for Endrin.

Is that correct?

A Yes.

Q You were shown a reference by Mr. Rogers --

MR. ROGERS: Actually, two references.

THE WITNESS: This is the only one I have.

MR. ROGERS: And I referred to the Calgon article.

THE WITNESS: Oh, yes. You referred to it, yes. That's right.

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BY MR. LORANT:

Q I'll take the first one you showed him first; I don't seem to have it written down what that reference was. Would you again allude to it so we can identify it?

A Yes.

It's titled "Effectiveness of Water Treatment Processes in Pesticide Removal" by Robeck, Dostall, Cohen and Kreissl, and it appears in the Journal of the Journal of American Waterworks Association, in February, 1965.

Q Have you had a sufficient opportunity to lookaat it to draw conclusions from it, or would it require more time?

A I haven't had a chance to read it.

Q Let's defer that for a moment, then, and go on to the so-called Calgon study.

MR. LORANT: Is that definitive, or must Mr. Rogers --

MR. ROGERS: Yes.

BY MR. LORANT:

Q Have you had a chance to review that?

A Yes.

Q And have you done so with sufficient detail to draw conclusions from it?

A Yes.

Q And does anything in that article alter your conclusic

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as represented and drawn in your testimony submitted in this hearing?

A No.

JUDGE SWEENEY: Would this be a good point to break and give him overnight, then, to look at this other article?

MR. ROGERS: Is there any objection to making these two articles exhibits, to clarify the record? They were both -- there really are only two parties involved in this Endrin question, and we have referred to it several times.

MR. LORANT: I have no objection. Are they both in the public literature?

MR. ROGERS: I don't think the Calgon article is, because it was so recent, but they both have seen it --

THE WITNESS: Yes, I've seen it.

MR. ROGERS: And you were at the meeting when it was presented.

THE WITNESS: Yes.

MR. ROGERS: And the other one is a traditional classic article that has been referred to many times.

MR. LORANT: I would have no objection to that.

JUDGE SWEENEY: Do you have copies of those you could bring in tomorrow, Mr. Rogers? You should have at least one.

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MR. ROGERS: On the Calgon we have copies, and I

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was just informed we'll get copies of the other one also, your Honor.

JUDGE SWEENEY: If you'll bring two copies or more --

MR. LORANT: I would like one of each.

MR. ROGERS: We'll give you a Calgon one right now.

(Handing document to Mr. Lorant)

MR. LORANT: Thank you.

MR. ROGERS: Why don't we do this, your Honor?

JUDGE SWEENEY: All right.

If you've got it there we can put it in right now.

The Calgon article, entitled "Removal of Toxic Organics from Waste Water by Adsorption with Granular Activated Carbon" will be identified as Exhibit 85, and received in evidence.

(The documents referred to was marked Exhibit No. 85, for identification, and was received in evidence.)

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JUDGE SWEENEY: We will recess until 9:00 o'clock tomorrow.

(Whereupon, at 4:30 p.m., the hearing in the above-entitled matter was recessed, to be reconvened at 9:00 a.m. the following morning, Friday, 10 May 1974.)

TRANSCRIPT OF PROCEEDINGS
ENVIRONMENTAL
PROTECTION AGENCY

May 20, 1974

MONS 065628

Transcript of Proceedings

[illegible] PROTECTION AGENCY

Arlington, Virginia

Monday, May 20, 1974

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UNITED STATES OF AMERICA

ENVIRONMENTAL PROTECTION AGENCY

- -

In the matter of: : FWPCA (307)

TOXIC POLLUTANT EFFLUENT STANDARDS : Docket No. 1

- -

EPA Conference Room,
Room 1112,
Building #2, Crystal Mall,
Arlington, Virginia.

Monday, May 20, 1974.

Hearing in the above-entitled matter was reconvened pursuant to adjournment, at 9:00 a.m.

BEFORE:

WILLIAM J. SWEENEY, Administrative Law Judge.

APPEARANCES:

(As heretofore noted.)

eb

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PROCEEDINGS

JUDGE SWEENEY: We'll be on the record.

Who will be your first witness?

MR. ECKERT: Dr. Thomas W. Duke.

MR. RICHEL: Your Honor, if I may, may we have the right to call another witness first? Do we have any choice in that matter?

JUDGE SWEENEY: They don't, unfortunately, have the affidavits of anyone else but Dr. Duke available at this moment.

MR. RICHEL: Nonetheless, I do recall at one point in the past that EPA had some discretion to call those witnesses which it wanted to talk to in the order they wished to have, and I think it might be appropriate if we were allowed similar discretion since all parties are present, to the extent that--

JUDGE SWEENEY: We'd have to take a recess to do that.

MR. RICHEL: Why is that?

JUDGE SWEENEY: I say they don't have the affidavit of anybody else available here. They are being xeroxed and it will be later today before they are available.

MR. RICHEL: The affidavit or the exhibits?

MR. ECKERT: Well, in order to put the witness on the stand we're going to need to give Judge Sweeney both

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the affidavit and the exhibits, unless you plan to cross-examine only on the affidavit and have no questions on the exhibits.

MR. RICHEL: I have certain cross-examination that I'd like to pursue now that can be done in the absence of exhibits.

MR. ECKERT: I'll leave that up to Judge Sweeney, if he wants to allow that.

JUDGE SWEENEY: Well, I think it is up to Mr. Eckert who he wants to call. He's the one who is calling the witnesses. If you want to call Dr. Duke, why--

MR. ECKERT: Your Honor, I think it would be far better to get the witness on the stand where we have the exhibits in hand.

JUDGE SWEENEY: All right.

MR. PARK: Your Honor, could we ask, when do we expect the exhibits?

MR. ECKERT: I hope later this morning, as quickly as we can get them.

MR. RICHEL: On what basis do you believe that we should be required to cross-examine on exhibits that you belatedly give to us on the day of the hearing?

MR. ECKERT: The question is not having given the affidavits to you--

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MR. RICHEL: That's one of the subjects that I

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wanted to discuss with Dr. Veith.

MR. ECKERT: Which exhibits haven't you received?

MR. RICHEL: I've received no documents from Dr. Veith. I received none in the mail. On May 8th I came and requested that I be given copies of those documents, and they were not provided to all, and I did not receive a copy of any of those documents.

On May 9th, I requested receipt of those documents and I was told by you that they would promptly be placed in the mail. To date I have received nothing, and it is on the basis of that failure to receive information, your Honor, that I have been unable to critically review Dr. Veith's testimony. My technical colleagues at General Electric have been unable to critically review, in the absence of these exhibits or even reference to the titles. And it is on the basis of our inability to go forward now that I move that his testimony be stricken in total.

I should not be asked to receive documents here today, review them in the absence of technical assistance, and provide cross-examination. We were required to provide our information by a certain date. I'm afraid that consistent treatment has not been required of EPA.

So even though the fact that the exhibits are not here now is very much the point, and it is on that basis that I move to strike Dr. Veith's testimony.

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MR. PARK: Your Honor, we would join in that motion on the basis of--

JUDGE SWEENEY: In order to strike something, it has to be in the record; right? Is that right? How can I strike something that isn't in the record.

MR. PARK: The motion should be modified to move that it should not be admitted into the record on the basis of not being timely--

MR. ECKERT: I'm sure this material was mailed out some time ago, certainly no later than the 9th. Has no one here from industry received the affidavit and the exhibits from Dr. Veith?

Monsanto has received them?

MR. PARK: We received some but we're lacking a number.

MR. ECKERT: Is the number of exhibits you never received published or unpublished data?

MR. PARK: Both.

MR. ECKERT: Well, now, we could move to strike specific exhibits and the testimony relating thereto where you didn't receive it. I think we could entertain a motion of that type, but we tried to send out all of the unpublished data and the exhibits to each of the Objectors.

Mr. Richel, I think you are unique in that you have never received anything. I can only attribute it to the

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mails because I am almost sure I checked with my secretary and--

MR. RICHEL: Well, I will say this, your Honor. Good faith is a nice virtue, but that's not good enough. We have been put to many damn inconveniences in this proceeding. We have had dates changed behind our backs. We've been forced to proceed with cross-examination when we were assured that it would be one week later.

And now I'm being asked to receive material some time today and be prepared to cross-examine in a day or two days on that material.

I say it's unfair. I say I shouldn't be put through that burden. And I say that good-faith effort is insufficient, and that this testimony is essentially unsupported and that it should be stricken.

JUDGE SWEENEY: I can't strike something that is not of record. Don't you understand?

MR. PARK: Your Honor, let me correct the record on what we received. We have received only the few exhibits that were passed out on -- I guess it was May 8th or 9th, and nothing since that.

In searching through the literature ourselves we did gather up a few more of the items referenced in his testimony or his affidavit, but we have not received anything other than that passed out at the last hearing.

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I would move that--

JUDGE SWEENEY: You are all talking to me in a void. I don't have any of this. I don't know what you're talking about. Now let's proceed with Dr. Duke. At least we have his affidavit here, and we'll take up your problems when we get to them.

MR. PARK: Could I just simply move that Dr. Veith's affidavit with exhibits not be admitted on the basis that it was at the EPA request that the schedule was moved up--

JUDGE SWEENEY: When we get to it, you can make any motion you want, when we get to Dr. Veith. Right now we're with Dr. Duke.

MR. PARK: Dr. Duke hasn't been called yet.

JUDGE SWEENEY: Dr. Duke, will you take the stand?

Whereupon,

THOMAS W. DUKE

was called as a witness and, having been first duly sworn, was examined and testified as follows:

MR. ECKERT: Your Honor, I think I should very briefly lay a foundation for the record.

JUDGE SWEENEY: The written statement of Dr. Duke will be identified as Exhibit 102.

(The document referred to was marked Exhibit 102 for identification.)

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DIRECT EXAMINATION

BY MR. ECKERT:

Q Dr. Duke, do you have any corrections to make to the exhibit entitled "Exhibit 102"?

A Yes, I do.

Q Will you please read those for the record?

A The first is on page 10, the last line of the first paragraph. "Where waters in Escambia Bay show only trace levels (.3)" should read "(.03)."

On page 11, the next to the last line in the first paragraph. "That these mollusks would reach the less than 0.03 micrograms per liter" should read "0.03 micrograms per gram."

On page 14, the second sentence of the first paragraph. "Over that of unexposed controls by 10 micrograms per liter of Aroclor 1254 (Exhibit 11)" should be "(Exhibit 1)."

Q Do you have any further corrections?

A Yes.

On the same page, the second paragraph, the first sentence reads "Exhibit 2." It should be "Exhibit 11."

Next is page 18. The next to the last line of the second paragraph where it says "(Exhibit 17)" it should read "(Exhibit 23)."

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The last is on page 19, the last paragraph. The

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first sentence should be "five micrograms per liter of Aroclor 1254."

MR. ECKERT: Your Honor, the record should show that the exhibits which are being offered in evidence are numbers 2, 4, 6, 7, 10, 12, 16, 17, 19, 20, 22, 24, 27, 28, 30, 31, and 32.

The others, although referred to in the testimony, will be treated as references only.

BY MR. ECKERT:

Q With the changes you have made, Dr. Duke, is your testimony true and correct?

A Yes, it is.

JUDGE SWEENEY: Off the record.

(Discussion off the record.)

JUDGE SWEENEY: On the record.

MR. PARK: Your Honor, I move that the following exhibits not be admitted into evidence because they have not been sent to us for review prior to this proceeding, so that we could examine Dr. Duke on them, and have not been made available to us:

Exhibits No. 2, 6, 19, 22, 24, 28, and 30.

MR. ECKERT: These weren't provided to you on the day that we cross-examined your witnesses?

MR. PARK: That's correct. In fact, Mr. Eckert, others were not provided to us and we went out and found

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some others that I am not asking be stricken. The ones that I mentioned are those that we have not been able to lay our hands on, even through our own efforts.

MR. ECKERT: I'm afraid what we have here is a breakdown in the mails but I'm quite certain these materials were mailed out.

JUDGE SWEENEY: Were they sent out certified mail?

MR. ECKERT: No, they weren't. That's the difficulty.

MR. PARK: We appreciate you've been working under a very heavy burden but still we feel that we simply do don't have the basis for any cross-examination since we don't have parts of the affidavit.

MR. ECKERT: Your Honor, I don't have a response to make. If they haven't gotten the exhibits I don't see how they can cross-examine on them.

JUDGE SWEENEY: Well, you seem to be confused as to whether they were mailed or whether they were handed out a week ago when the parties were here with their own witnesses.

MR. ECKERT: I know that some of them were handed out at that time. Now what I'm afraid happened is that some people who are not parties objecting to PCB's walked off with the affidavits for PCB's. I'll just have to get our sign-up sheets and find out who got what.

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JUDGE SWEENEY: Well, you agree then with the motion, that it should be granted as to the exhibits specified at this time?

MR. ECKERT: I don't have a response to make. As I say, I don't know just who got what. I can't question the veracity of Mr. Park here because I don't have anything to say that he did get the material.

JUDGE SWEENEY: All right, the exhibits will not be received. That's the attached exhibits to Exhibit 102 of Dr. Duke, namely No. 2, 6, 19, 22, 24, 28, and 30.

Dr. Duke is available for cross-examination; is that correct?

MR. ECKERT: That's correct.

CROSS-EXAMINATION

BY MR. RICHEL:

Q Dr. Duke, I have a few background questions, and that's pretty much it. And frankly, I'm trying to establish the relevance or lack of relevance of your testimony to this proceeding at this point in time. I can't prepare you any better than that.

The standards proposed for the discharge of PCB's into marine waters are different from those proposed for discharge into estuarine and fresh waters. Is that correct?

A Are you saying there's a difference between marine, estuarine, and fresh water?

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Q Well, let me start off this way.

Has one standard been proposed for the discharge of PCB's into all waters?

A Not to my knowledge, no.

Q Have you reviewed the proposed standards?

A Yes, I have.

Q And as I read them, I understand that there are certain standards proposed for discharges of PCB's into marine waters.

A As opposed to fresh waters?

Q As opposed to fresh waters.

A Yes.

Q I take it these differences reflect a difference in the impact that PCB's will have on each type of environment.

A I did not formulate the standards. I can only say that that's possible.

Q Okay. I understand that response. You didn't, as I take it, have anything to do with the formulation of the proposed standards. Is that correct?

A Except that data from our laboratory were used.

Q Can you point to the direct use of that data in the establishment of the standard? Can you point to any part of one of the proposed standards and show the particular use of data from your laboratory?

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A It is my understanding that the background information for the standards were taken from the National Academy of Science document, --

Q Right.

A -- which we contributed data to.

Q I see.

A So therefore I assumed that our data was used in such a standard.

Q I see. Okay.

So in that sense it would be reflected in the NAS document and therefore considered by EPA in proposing its standards?

A That is my understanding, yes.

Q And I guess your testimony here today summarizes much of the data that was heretofore presented to NAS?

A It may do that, sir. It is in response to questions and so forth that the Objectors raised. It may also do what you say.

Q I see. Well, we'll get to that in a moment.

You testified, I take it, as to the presence of PCB's in Escambia Bay and as to the impact of PCB's on marine organisms.

A That's correct.

Q That's taken from your testimony.

A That's correct.

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Q Escambia Bay is an estuarine environment?

A Yes, it is.

Q And most of the aquatic organisms-- Strike that.

Most of the organisms cited in your testimony I take it are marine organisms?

A I would classify them as estuarine, yes, sir.

Q And estuarine is to be distinguished from fresh water?

A Yes.

Q Can you give me the basic distinction in the nature of each?

A An estuary is a semi-inclosed body of water that receives fresh water runoff from a river or stream or basin and also receives water from the ocean, and the boundaries-- Certainly you have salt water on the one side and fresh water on the other, and the animals that inhabit this area and can in fact move a little bit in each direction are known as estuarine animals.

Q I take it there's a certain affinity to salinity on the part of these estuarine organisms?

A Will you tell me what you mean by "affinity"?

Q I started to like the phrase.

(Laughter.)

Is there a certain biological need for saline content in their environment?

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A Yes, for many of these animals, that's certainly true.

Q I take it you have reviewed the testimony of the Objectors. That's what you were trying to tell me before.

A Yes, I have.

Q And I take it it is your position that you're responding to these Objectors.

A That's the purpose of my testimony, yes.

Q I'm sure.

Have you read the cross-examination of these witnesses, of our industrial witnesses on PCB's?

A No, I haven't.

Q Well, from your reading of the testimony, did you realize that no manufacturing facility of General Electric, Westinghouse, or Monsanto that is subject to the proposed standard discharges into anything but fresh water?

A I realized that, and I wondered about that. You see, even though our company does not discharge directly into salt water, Escambia Bay is a good example of often what enters fresh water ends up in salt water.

Q Did any of the Objectors object to the proposed marine standard?

A Yes.

Q Who? Any of the industrial Objectors to the PCB's?

A Yes.

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Q Who?

A I remember in particular some objections to the standards in general which I take it includes the estuarine and marine standards by Mr. Papageorge in particular.

Q But recognizing that his plants would not be affected by any other than the proposed fresh water standard. I think you could agree with me that any concern he might have would be academic.

A In my view of it, sir, I disagree. I think that he would be concerned that the material from his plants could reach salt water so his comments would be directed to both fresh water and salt water.

lB

Q Let me understand one thing here. Are you taking the position that he who discharges to fresh water is subject to marine standards?

MR. ECKERT: Objection. You're asking the witness for a legal conclusion with respect to the application of these standards.

MR. RICHEL: It seems like an important point.

BY MR. RICHEL:

Q Is it your impression that all dischargers into fresh water should be subject to a marine standard because the particles of their discharge may eventually get into marine waters, quite apart from your understanding of the law?

A Apart from my understanding of the law, I see that

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materials such as those that came from the Monsanto plant in Pensacola that border on this area where, in fact, they're on a fresh water stream, their effluent enters a fresh water stream, but they're close enough to be influenced by the estuarine environment and this material gets into the salt water environment.

I don't know the legal aspects of the standards but this is my understanding.

Q Did any Objector question the levels of Aroclor 1254 in Escambia Bay?

A To my knowledge they did not directly question it but there were questions that were indirect in this way.

For example, there was the question about if PCB were on particulate matter would it be environmentally active. This to me questions the Aroclore 1254 in Escambia Bay which was environmentally active.

Q Did you consider the-- Did EPA consider the question of adsorption onto particles in preparation of the proposed standard?

A The study that we made on Escambia Bay was available and in the Academy document; as to the extent it was considered, I cannot answer that.

Q To what particular contentions do you feel your testimony responds? To what particular and specific contentions raised by the Objectors do you feel your testimony

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responds?

A I have several. Would you like for me to make some specific comments?

Q Let's go one at a time. I was sure you would, but let's go over them one at a time.

A Certainly.

The National Electrical Manufacturers Association letter of January 18 --

Q One second. Excuse me.

Are they a party to this proceeding?

MR. ECKERT: They are. They filed an objection, as I understand it. That makes them a party.

JUDGE SWEENEY: Yes, they're a party, but where is their statement?

MR. ECKERT: They made allegations in their objection of January 18th to which Dr. Duke is in part responding.

MR. RICHEL: Must the testimony to which EPA responds be submitted by he who is made available for cross-examination or he who publicly gave his testimony?

MR. ECKERT: It seems to me, your Honor, that this material is in the record, it stands alone, and that we're entitled to rebut it.

JUDGE SWEENEY: It's not in any record I've seen, Mr. Eckert. I don't know why you say it is in the record.

MR. ECKERT: Aren't the objections filed by the

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Objectors on January 18th part of the record?

JUDGE SWEENEY: They have not been received in evidence at this hearing. I don't see why EPA has to worry about an Objector who doesn't appear at the hearing to present evidence.

MR. ECKERT: Well, it seems to me that such a person is at least a party to the extent that he has preserved his rights by filing an objection, that he has served notice that he is going to challenge us on certain points.

And it seems to me that we're entitled to shore up our case on these points.

MR. WILLS: Your Honor, if I may interject a point, it has been the position of EPA that their testimony is merely rebuttal to what industry or what the Objectors have presented and according to your order, all testimony to which they were supposed to be rebutting was to be submitted by March 15th, and apparently this group did not submit any testimony by March 15th, so therefore, there is no evidence before the hearing to be rebutted.

JUDGE SWEENEY: I don't consider anything said in any of the objections as evidence in this hearing, Mr. Eckert.

MR. ECKERT: Very well.

JUDGE SWEENEY: None of it was sworn to.

BY MR. RICHEL:

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Q Number two?

A Yes. In Monsanto's objection on page 2, Item 5--

JUDGE SWEENEY: Again you're talking about an objection?

THE WITNESS: This is an affidavit.

JUDGE SWEENEY: Of Mr. Papageorge?

THE WITNESS: Yes.

JUDGE SWEENEY: I see.

THE WITNESS: On page 2, Item 5, it states:

"Fundamental scientifically-based data is lacking."

BY MR. RICHEL:

Q And I guess some of your testimony and your citations attempt to shore up what were alleged to be lacks?

A I hope that this scientific data that we are presenting would rebut this statement.

Q In most part, was not this material available six or eight months ago, or a year ago?

A What material are you speaking of, sir?

Q The material you're citing as shoring up the lack.

There has been an allegation, I take it, that fundamental scientifically-based data is lacking. Now you have told me you're attempting to respond to that with the information contained in your document, your affidavit.

A Yes.

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Q I'm asking you whether or not the information contained in your affidavit was not available six months ago, a year ago, two years ago?

A Certainly some of it was, yes.

Q Did you present that to EPA?

A Pardon me?

Q Was that information that was heretofore available presented to EPA for whatever use it might make in Washington?

A Yes.

Q Can you identify that data that was heretofore presented to EPA in Washington?

A I don't understand exactly what you mean, "presented." In our laboratory when we develop scientific data and we put it in quarterly reports and in scientific reports to journals and so forth, this becomes part of the scientific data base.

Q I see.

A We supply this information to the scientific community and it is therefore available to EPA also.

Q And has that been the case with all the information contained herein?

A Not all of the information. Some of this information was developed after the standards were set.

Q Identify that information which was created or

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amassed after the proposed standards were set, please.

A To the best of my knowledge, without taking quite a bit of time looking at it, I think it has really been identified already as being those documents that were in press.

Q And where is that identification made?

A It's made in my affidavit:

"The following exhibits are included in my testimony --"

and where we have "in press" or something of this order, then that information -- and I say "probably" -- was not available at the time the standards were written.

Q All right. I'd like to look at this just for a moment.

I take it that's-- Well, is that information that was in press represented by the information that was stricken by Judge Sweeney a while ago? Are they equivalent?

A I believe that that's the case, yes.

MR. RICHEL: Your Honor, I move to strike those exhibits presented by Dr. Duke which were not in press at the time the proposed standard was proposed on the following ground:

The material was available to EPA, according to Dr. Duke's admission, at the time of EPA's preparation of the proposed standard. It may have been used in EPA's

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decision-making process and to raise it now is to, in a sense, either duplicate material that was already used in EPA's decision-making process or raise new material, and to the extent it raises new material, we should be allowed the opportunity to present direct testimony in opposition thereto. And as I understand it, that time is not available.

Therefore, it is improper rebuttal and should be stricken.

MR. ECKERT: Your Honor, I would submit that the question of whether or not data was available before or after the standards were proposed is not relevant to the question of whether or not it's rebuttal.

Now I think if Mr. Richel wished to make a motion to strike on the grounds that it wasn't rebuttal, then that seems to be consistent with what has been going on here during the last week, but the availability of information before or after the proposal of the standards doesn't have any bearing on that question.

JUDGE SWEENEY: Well, I understood that was what he was basing his motion on, the fact that it is not rebuttal and that they would not have a chance, it being new material they would not have a chance on their part to rebut it.

MR. ECKERT: I thought he was alleging that the mere fact that the information was available prior to the publication of the proposed standards made it non-rebuttal,

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and it seems to me that this information is rebuttal, that we can show that the Objectors challenged us on toxicity; they said that toxicity is terribly variable. We have shown that it isn't.

They have said that our bioconcentration factor was way out of line. We've shown that it is not only not out of line but typical.

These things are genuine rebuttal.

Mr. Richel's motion is far too broad, it seems to me, to even deal with it unless we get down to specifics.

MR. RICHEL: Well, your Honor,--

JUDGE SWEENEY: Do you want to be more specific? I thought you were specific.

MR. RICHEL: Well, may I have a ruling therefore on the motion?

JUDGE SWEENEY: Yes. I believe Mr. Richel -- and he can correct me if I'm wrong -- is objecting to the exhibits on the grounds that they are not proper rebuttal to any affidavits or any testimony by industry witnesses.

Is that correct, Mr.Richel?

MR. RICHEL: Yes, sir, in part; yes.

JUDGE SWEENEY: In part. Right.

MR. ECKERT: Well, Dr. Duke had a question which he was in the process of answering, going through his affidavit and identifying which portions of it were-- Now

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he just happened to start out with rebuttal to an Objector, but that's not the only material that his testimony rebuts. There's a great deal of it and perhaps when Dr. Duke finishes his response to Mr. Richel's original question, this matter will be clarified.

JUDGE SWEENEY: So far he has not pointed to anything--

You may continue, Dr. Duke.

THE WITNESS: I would like to refer then to the General Electric affidavit, Mr. Lauer's testimony, Dr. Lauer.

My pages are not numbered but in his testimony under Section B:

"Most of the existing bicconcentration data are based on exposures of confined organisms in laboratories or concentrations in water formulated by the use of solvents. Neither the data base nor level of understanding of the combined influence of these variables under natural conditions are sufficient to permit accurate prediction of concentration factors."

BY MR. RICHEL:

Q Which specific portions of your testimony relate to that point?

A The testimony on bioaccumulations in the laboratory studies and those studies in the second part of my testimony

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on toxicity and bioaccumulation relate to this, as well as the Escambia Bay study, because concentration factors can be determined from the Escambia Bay study.

Q The impact-- I think we can agree the impact of Dr. Lauer's statement that you cited refers to the effect of the use of solvents. It is no broad ranging question about or statement about determination of bioaccumulation factors. It is restricted, it seems to me, to the impact of solvents on the determination of bioaccumulation factors.

Now if you can point specifically in your testimony to a response to that point I will concede that it is relevant.

MR. ECKERT: Isn't your question a bit argumentative, or your point a bit argumentative? It seems to me that Dr. Lauer's point does not refer solely to solvents. He's talking about two factors, the confinement of organisms in laboratories and the use of solvents.

It seems to me that Dr. Duke's environmental data have nothing to do with confined organisms in laboratories or water formulated by the use of solvents. They refute that the bioconcentration data are based on these types of studies.

MR. RICHEL: Okay.

BY MR. RICHEL:

Q Are these studies that you present to show

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bioconcentration data based on exposures of unconfined organisms? I take it you present certain data concerning bioconcentration rates in organisms not confined. Is that correct? Is that the point which you are rebutting?

A Yes.

Excuse me. Let me give my feeling.

The question has to be raised as to the veracity of the bioconcentration factors. In our Escambia Bay study, for example, we are able to figure out with the data we present in our affidavit -- to figure concentration factors that in fact are field concentration factors and do not involve solvents except those that might be found in the natural environment.

Therefore, I rebut that statement with this testimony.

MR. RICHEL: I would like to raise one final point with the Hearing Officer before I relinquish the podium.

Your Honor, I would move to strike Dr. Duke's testimony on two grounds. The first:

It relates, as I see it, to a discussion of marine and estuarine matters, not to a discussion of impact on fresh water environments.Since no manufacturing facility of General Electric, Westinghouse, or Monsanto which is subject to the proposed standard, discharges into anything but a fresh water environment, I suggest that the testimony

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is simply not responsive.

Second of all, even if you were to determine a certain relevance of Dr. Duke's testimony, I suggest that the relevance would be tied to the issue of the relationship of marine and estuarine data to a fresh water context, and I am saying that this relationship was not clearly addressed by the Objectors. This relationship need not have been. We saw no reason to, and we would need additional time to address this relationship in direct testimony of our own.

So what I'm saying is even if it is relevant and I submit that it is not, even if it is relevant then it raises an issue which would require additional time and therefore, I submit that it's improper rebuttal.

MR. ECKERT: Your Honor, if I might briefly respond?

First of all, as to the first point, the Objectors have discussed the entire PCB standard, not simply the PCB standard relating to fresh water. And the relationship of marine and estuarine to fresh water data is, as I understand it, not what is in question here but rather, whether EPA's data supported its proposed marine standard.

And it seems to me that Dr. Duke's testimony is properly responding to the material raised by the Objectors.

MR. RICHEL: Your Honor, we simply are not affected by the marine standard, and the question on the

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marine standard is academic to us.

JUDGE SWEENEY: You don't have any objection to the marine standard as proposed?

MR. RICHEL: No, sir, nor does any other objector here since we have no manufacturing facilities that are subject to the standard and discharge into marine waters.

MR. ECKERT: I might point out, Mr. Richel, that not a single Objector made that distinction in the affidavits. Every one of them addressed his objection to the entire PCB standard. I don't recall anyone saying that the proposed marine standard is just fine with us.

JUDGE SWEENEY: Well, do they now state that for the record, Mr. Richel? You have already stated it for General Electric.

MR. RICHEL: Yes, sir. We have not addressed ourselves to it because it is not germane to us at this time.

JUDGE SWEENEY: How about Monsanto?

MR. PARK: If this would result in the granting of the motion, we would on the record agree to state that we have no objection to the marine standard.

MR. ECKERT: Your Honor, Dr. Lauer from GE presented a great deal of data on marine species and if we are not entitled to rebut that, then I don't know what we're entitled to rebut.

Mr. Richel may say that GE has no objection to

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the marine standard--

JUDGE SWEENEY: Well, if there is no objection to the standard, Mr. Eckert, why do we spend time arguing about whether it is right or wrong?

MR. ECKERT: Because I'm not sure that Mr. Richel can speak for all possible Objectors.

JUDGE SWEENEY: No, he's speaking for General Electric Company.

And I'm asking the other Objectors-- Monsanto says they have no objection.

MR. WILLS: With respect to Westinghouse, I don't believe we really have a standing to object to a marine standard since we do not discharge into that area.

MR. ECKERT: But I point out there are two parties who aren't even represented here today who might well.

MR. RICHEL: That has never been a restriction on making rulings here before.

JUDGE SWEENEY: Who are the other parties?

MR. ECKERT: The Environmental Defense Fund and the Natural Resources Defense Council.

JUDGE SWEENEY: Well, that would be their problem. If they don't want to attend the hearing we can't be responsible for them, Mr. Eckert. It is their responsibility to be here. They have not asked to be excused from the

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hearing. They entered an appearance, and if they aren't here, they have no reason to object to anything that occurs.

I don't see any point in going into this to no purpose.

MR. ECKERT: Has everyone stipulated that the proposed marine standard is acceptable?

JUDGE SWEENEY: I don't think there is any other Objector here.

Is there any other Objector here who objects to PCB's that hasn't spoken?

(No response.)

MR. RICHEL: The point should be taken that I would hate to see you use this at some opportune moment in the consideration of final standards to judge some other issue. I make it clear that we have no interest in it nor have we seriously considered it because we would not be affected by it.

I do not thereby intend to place any imprimator of adequacy upon it.

MR. PARK: In other words, what Mr. Richel stated is there are no point sources discharging into marine waters so far as we're aware.

JUDGE SWEENEY: I think now that it has been clarified, Mr. Eckert, that there is no objection to the standard you can accept it as being an acceptable standard

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and republish it.

MR. ECKERT: I think that's right.

MR. RICHEL: My point, your Honor, was in the form of a request to strike Dr. Duke's testimony since it does relate to impact of PCB's on a marine environment and since we are not affected by it, I moved to strike it as irrelevant and improper rebuttal.

JUDGE SWEENEY: Well, it is not of record to be stricken. It just will not be received, along with the other attached exhibits.



(Exhibit 102, previously marked for identification, was rejected.)

JUDGE SWEENEY: We'll take a short recess now.

(Recess.)

JUDGE SWEENEY: Back on the record.

Dr. Duke, you are excused.

(Witness excused.)

JUDGE SWEENEY: Mr. Eckert, do you have the affidavits of any other witness?

MR. ECKERT: Not at this time. I am unable to provide them to you yet. They are being xeroxed right now.

The only solution I can suggest is that we recess until after lunch and pick up again.

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MR. RICHEL: Your Honor, if I might address myself

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to that?

I need for my initial cross-examination no reference to any exhibits. I need only a reference by Dr. Veith and myself to a copy of his testimony. I would be happy to supply him with a copy for his use on the stand. I cannot conceive that a copy of that testimony is not available here today at this time.

JUDGE SWEENEY: Is there one copy for the Reporter?

MR. ECKERT: Certainly.

JUDGE SWEENEY: It would be better if you have two so there can be one for me as well.

Whereupon,

GILMAN D. VEITH

was called as a witness and, having been first duly sworn, was examined and testified as follows:

JUDGE SWEENEY: Dr. Veith has been called to the stand and he has been sworn, and his written statement will be identified as Exhibit 103.

(The document referred to was marked Exhibit 103 for identification.)

CROSS-EXAMINATION

BY MR. RICHEL:

Q I take it at the outset, Dr. Veith, that you swear to the exhibit since there was no affidavit attached

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to it initially?

A Yes, I do.

Q Now I'll be very straightforward again. I am not going to talk about much of the substance of your material. I will simply attempt to talk with you on the relevance of your material to this proceeding at this point in time, and it will be straightforward.

Who ordered you to prepare testimony for this proceeding?

A I had a letter from Dr. Thompson's office dated March 25th, --

Q Of this year?

A Of this year.

(Continuing) -- addressed to me from Dr. C. Hugh Thompson, Chief, Hazardous and Toxic Substances Branch.

JUDGE SWEENEY: Okay.

THE WITNESS: It simply says:

"Please address the specific objections --" which were enclosed --

"-- and data in your affidavit or in oral testimony."

And I assumed from that that it was left up to my discretion as an environmental scientist as to what would be addressed.

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BY MR. RICHEL:

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Q The problem I'm addressing here, incidentally, Dr. Veith, is not academic. It's a question of whether or not new material has been presented, material which we have not had a chance to respond to in our own direct testimony, and that's really all that is at issue here.

So I'm not trying to restrict academic freedom; I'm simply attempting to give us an equal shot at the material.

Now when did you start the task? March 25th was the date of the request.

A That was the enclosure of the formal affidavits of the Objectors that I received. We knew somewhere at the end of February or the first part of March that our laboratory would be -- Our director, Dr. Mount, called us in and said our laboratory might be asked to prepare affidavits on the industry's objections. At that time we were provided with the letters of objection filed around January 18th. Most of the dates are around January 18th.

So we had a list of, I would guess, in excess of 15 to 20 letters of objection. We knew approximately what the objections were before we had the affidavits.

Q Okay.

About what time did you start your task then of preparing for your testimony here?

A We started preparing the testimony I would guess the first -- approximately the second week in March to the

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third week in March. It was revised and I think the first draft was submitted I think about April 1st.

Q And the conclusion of your activities, in other words, the finished product, about when was that?

A I'm not certain that there were major changes made after April 1st, but perhaps by April 15th or thereabouts.

Q Okay.

A I don't have a date on the last draft.

Q I'm not going to hang you on it if that is approximate.

Since you started your work in about the second week of March I presume that your work was not used in preparation of the proposed standard.

A I can't respond to that.

Q Was your work used in developing the proposed standard or was it not?

A Do you mean the data that was summarized in my affidavit, or my work at the National Water Quality Lab specifically?

Q Okay. Let me come back to it. I can see your confusion and it's an unfair question -- my confusion.

I assume then that you reviewed the Objectors' testimony and the exhibits attached thereto in preparation for your own testimony?

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A Certainly.

Q And you considered review of that material essential to come up with a fair analysis of the Objectors' testimony, I take it?

A Yes.

Q And you considered it an essential part of your task-- You considered the review of our testimony and exhibits an essential part of your task, I take it?

A Well, defining what the task is may make that question also unanswerable from my point of view, and that is there was no clear task spelled out and there are quite obviously differences, from a legal point of view or a procedural point of view, and from a scientific point of view, and my task, as I assumed it to be, was to present the data that would lead to a respectable establishment of a standard either in support or refuting.

So much of the data that I summarized in my affidavit could have been summarized with or without the industry objections, --

Q Okay.

A -- but many of the points were put in specifically because the objections I thought were not true or did not summarize or give a fair appraisal of what the literature and the on-going studies showed.

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Q Nevertheless you were instructed, at least in

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part by Dr. Thompson's letter, to respond to certain objections. Am I correct? Or so you read it a moment ago.

A He said please address the specific objections and data either in your affidavit or oral testimony.

So I guess that can be construed as responding.

Q Now let me come back just once again:

In preparing for your testimony which, in part, attempts to -- or in whole, attempts to address objections raised by industrial Objectors, you considered it essential to review the testimony of the Objectors and the exhibits attached thereto and referred to therein? Is that correct?

A I would not agree that it was essential. I would say it was an integral part of it.

Q And would you say that it was fair of you to do this to be able to respond intelligently to those objections?

A Well, I think the objections, particularly where I felt we had data to rebut their objections, gave a crystalizing or a focal point for the testimony.

Q Okay.

Now we're to the point where I came in a while ago where I said I have seen nothing of your exhibits. Now in order for us to fairly evaluate your testimony and to make your testimony an integral part of our cross-examination of you, should we not have had the opportunity to review your exhibits? Is there any doubt in your mind?

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A I would have to say Yes.

MR. RICHEL: Now, your Honor,--

THE WITNESS: I wonder if I could add something?

Many of these exhibits, for anyone working in the area of hazardous materials and particularly PCB's, should be well aware of these exhibits if they are to address the problem responsibly, so that I don't feel that the fact that some of these were not, -- for logistical reasons or whatever, you did not receive them, I don't --

BY MR. RICHEL:

Q If I, as an attorney, Dr. Veith, wanted to review those exhibits and simply saw a number referred to in your testimony and no reference to the title of the article or the whereabouts of the article or data, is that not a difficult situation?

A I agree it's difficult.

MR. ECKERT: I really must object to this whole line of questioning, Mr. Richel. We have cross-examined a great number of industry witnesses who came up and said that the toxicity is 'way overstated in the EPA document without citing any evidence whatsoever. And Dr. Veith and in fact all the affidavits that we've presented here were a great deal more specific than that, and you certainly have enough to cross-examine on.

Now if you want us to stipulate that it would be a

eb39

great deal easier for you to examine with some cited references in front of you, I think there is no question about that, but that does not take away from the expertise of our witness nor his qualification to make the statements set forth in the affidavit.

MR. RICHEL: For the moment, your Honor, I have no quarrel with the witness' expertise and that is not involved here. I have no quarrel with the fact that he may have worked long and hard to prepare the testimony. I have no quarrel with his integrity.

I do quarrel with what I consider to be a sham in an administrative proceeding when we are continually burdened by an inability to get relevant material in time to adequately prepare for the future and it is on that basis that I make the following request:--

Well, let me say this, your Honor. When I received Dr. Veith's testimony, no exhibits were appended nor were the exhibits appended, as I understand, at the time of receipt to anybody else's testimony.

When we arrived on May 8th, there were limited numbers of copies available, as I understand it. They were given to some people, not to me.

I addressed Mr. Eckert and ask for the material and said, "If you send it to me promptly, that will be fine." Of course at this point I was anticipating a May 29th hearing.

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I was later to learn that that was changed to May 20th.

Now, nothing was received in the mail and I am saying therefore that I have not had the opportunity to properly prepare for cross-examination and whether you present the testimony here today or 20 minutes from now will not allow me to prepare for cross.

I think we were abused. I think it is unfair, and I'm asking that his testimony not be taken into evidence for that reason.

MR. ECKERT: Mr. Richel, you've made the point about the exhibits to Dr. Veith's testimony and I must acknowledge on the record that your objection is well taken. However, as to the testimony itself, you've had that for some time and I don't see any reason why you can't examine on that specifically.

JUDGE SWEENEY: Dr. Veith has already answered a question that in order to evaluate his testimony, the person asking questions should have the exhibits available, unless I misunderstood his reply.

THE WITNESS: May I speak?

JUDGE SWEENEY: Yes.

THE WITNESS: I think in rebuting or reading or evaluating a number of the industry objections, they were just flat-out statements with no substantiation, and there is no way you can rebut data without the data.

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MR. ECKERT: My point is simply this, your Honor. If you were to go through Dr. Veith's exhibit and delete all the little parenthetical references to Exhibit 2 and Exhibit 3 you would have something that looks exactly like what many of the Objectors provided to us. And the fact that we did cite literature references, we did cite studies that we have done, doesn't vitiate this.

I think that the witness still has the qualification to make the statements herein even if they weren't supported by any data at all.

Now as a scientist, that's one thing. The scientist would want to have all the data before him in order to evaluate it, but I don't see that the Objectors can state that they can't cross-examine on this material if only to show what is missing.

JUDGE SWEENEY: Well, Dr. Veith doesn't seem to agree with you, if I understood his answer correctly. He seemed to agree that it was necessary to have the exhibits in order to properly cross-examine his testimony.

MR. PARK: Your Honor, if Dr. Veith had prepared his affidavit on the basis of his own experience only and had not referenced or used as exhibits any other parts of the literature, that would be one thing and this might be comparable then to some of the other exhibits that have been mentioned.

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But he didn't do that. The great portion of his affidavit is a repetition, a pulling together or parts of the literature, apparently parts that have not been available to us to cross-examine and I think that if these parts of the affidavit are pulled out or are not admitted into the record, there really is very little left.

I would move that the affidavit in its entirety not be admitted into the record for this reason. The large portion of it has not been made available to the parties to review.

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JUDGE SWEENEY: As I understand it, the exhibits were available as of April first. I just don't understand what happened, why they weren't distributed.

MR. ECKERT: I don't understand, either.

On the date on which I examined the PCB witnesses, Dr. Blanchard came in with a pile of exhibits and put them on the table and had a sign-up sheet.

Are you sure Dr. Simons didn't get a copy?

MR. RICHEL: Right.

What happened was -- as a matter of fact, you're going to find my name on that list. You requested that I ultimately sign it so that I might get a copy. I pointed out to you at the time that the list seemed to be for those who received a copy.

You said, "No. Put your name on that list," and I so did, and I asked you to promptly send the material; and I accepted that.

MR. ECKERT: I'm sorry Dr. Blanchard interpreted that as an indication that you had received a copy. That was the problem.

MR. RICHEL: No. I made that clear.

MR. ECKERT: I recall now our conversation.

JUDGE SWEENEY: Well, as I understand the questions of Mr. Richel and the answers of Dr. Veith, they seem to be in agreement that proper cross-examination of

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this written testimony in Exhibit 103 cannot take place, and therefore the exhibit will not be received.

(Whereupon, Exhibit No. 103, previously marked for identification, was rejected.)

JUDGE SWEENEY: You are excused.

(Witness excused.)

JUDGE SWEENEY: At this time are we able to go forward with another witness?

MR. ECKERT: The only one we have left, I think, is Dr. Nebeker, because I think we will just stipulate here and now that the statement of Alfred J. Wilson is wholly in support of Dr. Duke's statement, and if Dr. Duke's is inadmissible then this statement is inadmissible.

However, we make no agreement that either one is inadmissible. We continue to maintain the are not --

JUDGE SWEENEY: Well, in that case, Mr. Eckert, we should have one to be identified as an exhibit and a ruling made on it.

MR. ECKERT: Very well, sir.

As a matter of fact, I'll supply you two.

JUDGE SWEENEY: Is Mr. Wilson available?

MR. ECKERT: Mr. Wilson is here.

Will you take the stand, please, Dr. Wilson?

Whereupon,

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ALFRED J. WILSON, JR.

was called as a witness and, having been first duly sworn, was examined and testified as follows:

JUDGE SWEENEY: The written statement of Alfred J. Wilson, Jr., will be identified as Exhibit 104.

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(The document referred to was marked Exhibit No. 104, for identification.)

JUDGE SWEENEY: Mr. Wilson, are the statements made therein true and correct?

THE WITNESS: They are.

JUDGE SWEENEY: Now, as I understand it, Mr. Eckert, you're offering this in evidence at this time?

MR. ECKERT: That's correct, your Honor.

JUDGE SWEENEY: But at the same time, you have the statement that it would not be relevant in the absence of the statement by Dr. Duke?

MR. ECKERT: That's also correct.

JUDGE SWEENEY: All right.

In those circumstances, Exhibit 104 will not be received in evidence.

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(Exhibit No. 104, previously marked for identification, was rejected.)

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JUDGE SWEENEY: You're excused, Mr. Wilson.

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(Witness excused.)

MR. ECKERT: Our last witness is Dr. Nebeker, and we'll call him at this time.

Whereupon,

ALAN V. NEBEKER

was called as a witness and, having been first duly sworn, was examined and testified as follows:

JUDGE SWEENEY: The written statement of Mr. Nebeker will be identified as Exhibit 105.

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(The document referred to was marked Exhibit No. 105, for identification.)

Mr. Nebeker, are the statements made in your written testimony true and correct?

THE WITNESS: I have one correction. The statement stands correct --

JUDGE SWEENEY: With the exception of one exhibit?

THE WITNESS: There is a correction to the exhibit, sir.

JUDGE SWEENEY: Do you want to make that correction?

THE WITNESS: It's page 23 of Exhibit 1. There should be two columns inserted in that figure.

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MR. PARK: Are you in your affidavit?

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THE WITNESS: This is in exhibit No. 1, not the statement. Page 23 of exhibit 1.

This is in reference to the concentration factors calculated from this test.

Under Aroclor 1242, we should have a "Nominal" column as well as an "Emission" column; and that would be 3.5, 11.0, and 33.0.

MR. PARK: You're adding, now, to this table 7, sir?

THE WITNESS: Right.

MR. PARK: And you're adding a column on the right hand side?

THE WITNESS: This would be on the extreme left hand side, next to 2.8, 8.7, and 26. There would be "Nominal" 3.5, 11.0, and 33.

The same under Aroclor 1248: the four numbers under the "Nominal" heading would be 0.37, 1.10, 3.3, and 10.0.

Then on the far right side of the table, there should be a "Measured" column. Next to 22,000 should be 27,000; next to 29,000 it should be 36,000; next to 14,000 it should be 16,000.

Under Aroclor 1248, next to 24,000 it should be 50,000; 28,000, 58,000; and 108,000.

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MR. ECKERT: We have the personal copy of one

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of our people here, of the exhibits, but I think it would be better for the Reporter to have this copy.

JUDGE SWEENEY: There are 14 exhibits in total, Mr. Eckert?

MR. ECKERT: Yes.

However, we only plan to offer in evidence Exhibits one through four and 13 and 14.

JUDGE SWEENEY: Do you have any questions on direct, Mr. Eckert?

MR. ECKERT: No, I don't, your Honor.

JUDGE SWEENEY: The witness is available for cross-examination.

MR. PARK: Your Honor, we have not received any exhibits referenced in Dr. Nebeker's affidavit until this past Friday. I received a little package which says, "Enclosed are exhibits one, two, six, seven, eight, nine, and twel from Dr. Nebeker's statement. Exhibits 4, 11, 13 and 14 will be mailed directly to you by Dr. Nebeker. The remaining exhibits are available in the open literature."

We do have a couple of questions we would like to ask of Dr. Nebeker in connection with exhibit No. 2, which is the same as the one which was referenced by an earlier witness, but on the basis that the exhibits were simply not given to the parties on any sort of a timely basis so that they could be reviewed and cross-examination could be prepare

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I move that all exhibits to Dr. Nebeker's statement, other than exhibit 2, be not admitted to the record.

JUDGE SWEENEY: Well, did you try to go through his testimony since receiving the exhibits? Do you have any problem, really?

MR. PARK: We simply -- the package that came in Friday afternoon, your Honor, in view of the time pressure with four witnesses due to appear here today, and the time schedule moved up some 8 or 9 days over our objection, there simply was not enough time to review the materials that were first mailed to us and received by us on Friday.

JUDGE SWEENEY: But I'm asking you: are you really unprepared to cross-examine him today? Couldn't you go ahead on the knowledge you have?

MR. PARK: This one exhibit --

JUDGE SWEENEY: Is his testimony incomprehensible to you because you didn't have the exhibits until Friday?

MR. PARK: He recites items from the literature, your Honor, some of which is apparently just not available. He'll make a statement and then give a citation, "Exhibit 2," or some other exhibit, and there is no basis for us to review and satisfy ourselves as to whether the exhibit is accurate in our opinion or whether it is being misconstrued or is a statement taken out of context or what.

JUDGE SWEENEY: Well, you do have the exhibits,

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don't you?

MR. PARK: No, sir.

JUDGE SWEENEY: You still don't have them?

MR. PARK: Right now, we received last Friday, the preceding working day, some of the exhibits.

JUDGE SWEENEY: Well, I think you should make an attempt to cross-examine him, and if you come to an impasse where you can really point out that you have been prejudiced, why, that's a different thing.

But just to accept the fact that you are unable, I don't know; I think perhaps you are able to go ahead.

MR. PARK: Well, we do want to cross-examine on one point, your Honor.

JUDGE SWEENEY: Well, you should cross-examine him on his entire statement.

MR. PARK: We don't have the entire statement, your Honor.

Does the clerk have the entire statement?

JUDGE SWEENEY: You don't have his statement that has been identified as Exhibit 105?

MR. PARK: I have the statement, but I was including, I guess, the exhibits in the statement.

JUDGE SWEENEY: Well, see what you can do with his statement. And if you run into difficulty, then you can try to explain what the difficulty is.

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MR. PARK: All right.

Well, our difficulty is -- well, all right.

CROSS-EXAMINATION

BY MR. PARK:

Q Dr. Nebeker, do you consider your 14 exhibits to be part of your statement or not?

JUDGE SWEENEY: No.

Mr. Eckert -- maybe you didn't hear him. He specified the numbers that would be offered.

MR. ECKERT: One through four, 13 and 14. And I can only reiterate that even if we had not provided the exhibits, we make every effort to do so.

This is the equivalent of the great bulk of Objector affidavits in that the Objectors would simply say, "So-and-so is true," without citing any authority whatsoever.

MR. PARK: We're not arguing the point.

JUDGE SWEENEY: That goes to the weight of what I said, Mr. Eckert, and you didn't object to it at the time. I don't know why you keep referring to it. That doesn't have anything to do with what their right to object -- their right to object; if they prefer to object they have the right to do so, and the fact that you didn't doesn't --

MR. ECKERT: Yes, your Honor.

But what I'm pointing out is, I agree with you

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that the objections go only to the weight to be accorded to the evidence, and if some of the exhibits are missing, then that goes to the weight to be accorded to the statements in the record; but not as to whether or not --

JUDGE SWEENEY: The situation is completely different.

You're saying they did not provide exhibits; you are providing the exhibits, only you didn't mail them out. You have them, for the record, here. The reporter has them.

MR. ECKERT: Very well.

MR. PARK: I didn't understand that. Are those on the desk before the Reporter exhibits 1 through 4, 13 and 14?

JUDGE SWEENEY: Right.

MR. PARK: Your Honor, could the record show that the note that I received this last Friday, three days ago, states that exhibits 4 -- it says, "Enclosed are exhibits 1, 2, 6, 7, 8, 9, and 12. Exhibits 4, 13 and 14 will be mailed directly to you by Dr. Nebeker."

Now, I appreciate his gesture there, but I guess -- when do we expect to receive these, sometime next week?

MR. ECKERT: Have any of the Objectors received Dr. Nebeker's mailing?

JUDGE SWEENEY: Then you still don't have exhibits 13 and 14?

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MR. PARK: That's correct, sir. We do not have those. I have not seen them.

MR. WILLS: With respect to Westinghouse, I did receive exhibits 4, 13 and 14 on the 16th of May, addressed to me by name.

JUDGE SWEENEY: How about 1, 2, and 3. Do you have those?

MR. WILLS: Those are the ones that came in late Friday morning or the first part of the afternoon.

JUDGE SWEENEY: So you do have all the exhibits mentioned, one through 4 and 13 and 14?

MR. WILLS: As of the 16th or 17th, I finally got all the exhibits. It should be noted I made telephone calls prior to the hearing on the 8th of May, trying to get the exhibits.

MR. RICHEL: I've received, your Honor, several exhibits on the 16th of May from Dr. Nebeker. Those were numbered 4, 11, and 13. Perhaps a day or two or three earlier I received a number of other exhibits directly from EPA, I presume.

JUDGE SWEENEY: Do you have all the exhibits, though, that have been mentioned: one through four, and 13 and 14?

MR. RICHEL: I do not know. I'll look at the numbers.

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I see 4; that was received, as Mr. Park indicated, on the 16th. I received that, whenever that was; that's number 4.

One and two apparently were presented to me several days earlier. I don't have a date on them.

Number three has not -- is not here. Therefore I have not received it.

That's one, two, three, and four; and the other exhibits you were discussing?

JUDGE SWEENEY: 13 and 14.

MR. RICHEL: As Mr. Park indicated, those were two exhibits received very late in time. I did receive those on the 16th of May.

JUDGE SWEENEY: Mr. Park hasn't received them at all.

MR. PARK: We must be under a handicap, residing out in St. Louis. The mails don't seem to operate as rapidly as they do in New York and Pennsylvania.

But, your Honor, we had planned on the original schedule date of May 28 or 29, and I'm sure Dr. Nebeker would have gotten those things in the mail to us at least a few days prior to that date. It was not at our request that the hearing date was boosted up.

JUDGE SWEENEY: Mr. Nebeker, when did you prepare your statement?

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THE WITNESS: It was in progress most of the latter part of March.

JUDGE SWEENEY: And when was it completed?

THE WITNESS: About April 2.

MR. ECKERT: Your Honor, I have a suggestion which I know means delay, but it seems to me that it's the only alternative at this point, and that is this: I will personally stand at the xerox machine today, if necessary, to make sure that everyone here gets copies of everything that he needs. Then, at the conclusion of the hearing on all other substances, all other witnesses, if there is time left over before the 31st we can take another day, if necessary, and bring back Dr. Nebeker and Dr. Veith and have cross-examination at that time.

MR. PARK: Your Honor, I'd object to that.

At great inconvenience we have rejuggled schedules and cancelled dates in order to be here at this hearing on this date, having made our plans -- as the transcript shows -- for May 29 or May 28 as the date on which industry would cross-examine the EPA witnesses on PCB's.

It was not until, I believe, last Tuesday we heard -- by happenstance, by telephone -- that the date had been changed to May 20. So we rejuggled our schedule and we are here today to cross-examine.

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We are surprised and disappointed that we have not

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been given affidavits intact with all the exhibits and so forth. I feel a little bit like a party to any other trial who has shown up in timely fashion and the other party is not present.

I would think a dismissal would be proper, or in this instance, that the affidavit in question would not be admitted into the record.

MR. WILLS: Your Honor, with respect to Mr. Eckert's proposal: as he knows, I talked to him last Tuesday evening after I found out about the changes and informed him at that time that I was supposed to be present at a hearing on May 20th, 1974, in Columbus, Ohio, and asked him if it was possible to change the hearing back to the original date, the 28th and 29th; and he said no, due to the pressing of time we would be concluding the hearing on the 24th of May, so therefore there would be no way to move it back to the 28th and 29th.

Now, at this point, when it's obvious that they have not gotten their evidence out in a proper timely manner, now he's willing to go back to the 28th and 29th.

MR. ECKERT: I don't think I told you that it was not possible. I just told you it was not my discretion, that Judge Sweeney has the authority to control the conduct of the hearing, and it's up to him as to whether he was going to allow the hearing to continue on beyond any given

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date.

I was not able to make any representation on that. I wasn't in the hearing. Mr. Rogers had been conducting it, and I could not --

MR. RICHEL: Your Honor, if I may speak?

As I understand the rules in part 104, the rules for the conduct of these hearings, EPA would be free to reopen hearings if they wanted to consider the propriety of information that was excluded during the course of these sessions. That option would remain open to them if they saw fit.

I'm saying now that it makes no sense and is unfair to treat us differently than others in recent days, and reopen the hearing informally for us when that was not the case for other Objectors.

Testimony was deemed irrelevant or improper rebuttal for other Objectors, and it was not admitted into evidence. That testimony, as I understand it, will remain in the record, however.

I see no reason to treat us any differently.

MR. ECKERT: It seems to me, first of all, to distinguish your case, we are not talking about testimony that it improper rebuttal and therefore is inadmissible for all time, but rather the simple procedural point that you have not had the affidavit, the exhibits, far enough in

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advance to review and to cross-examine.

Now, at least, as to Dr. Nebeker, I would suggest that we back up ten minutes where we were before when Judge Sweeney said, "Well, proceed with the cross-examination of Dr. Nebeker, and if you can show that you were prejudiced, then we'll rule on that at the time," and I don't see any reason why we don't do that.

We can consider a later hearing later on, if necessary, for Dr. Veith, but I don't see any reason --

MR. RICHEL: You raised the issue through your suggestion now that a later hearing be held, and it is to that suggestion that we have been objecting.

MR. ECKERT: But I'm distinguishing this case. I think this is not the case where an affidavit is ruled inadmissible; this is a case where you simply haven't had time to prepare. In the other cases it could not have been cured by going back and preparing.

MR. RICHEL: As I understand the exclusion of Dr. Duke's testimony, it was not because of lack of time, but because --

MR. ECKERT: I'm not suggesting we bring back Dr. Duke or Mr. Wilson. I'm suggesting that we proceed with the cross-examination of Dr. Nebeker right now and that if necessary we open up the hearing, re-open the hearing, to cross-examine Dr. Veith when you have had all of his exhibits

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and a chance to review them.

JUDGE SWEENEY: There is no question that this is proper rebuttal, Mr. Nebeker's statement?

MR. PARK: We would like to cross-examine Dr. Nebeker on a portion of his testimony, but we would move that all portions of his statement, except that on page 5, referring to exhibit No. 2, be struck because it is incomplete and not given to us in timely fashion.

This hearing date having been set with the concurrence of the EPA, the burden being on them to get their affidavits to us in timely fashion, it would be very irregular and a real burden on everyone concerned to have another hearing date another week or ten days hence.

JUDGE SWEENEY: Mr. Eckert, I think first of all you should give Mr. Park the two exhibits he doesn't have, 13 and 14.

Can you do that now?

MR. ECKERT: We can do it. We cannot do it right now. That's what's being xeroxed back in Washington. We can do it shortly.

JUDGE SWEENEY: Well, can you loan him your set, or does someone have a set he can look at?

MR. ECKERT: You have the only other copy we have, your Honor.

MR. PARK: Your Honor, that really wouldn't do much

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for us to be given it right now.

JUDGE SWEENEY: Well, the others -- you can be looking at them and the other parties can go forward with the cross-examination. We'll see what the complications are. I just don't think it is impossible for cross-examination to take place of this witness.

MR. PARK: All right.

We would like to question Dr. Nebeker a little in connection with some statements made on page 5 of his statement.

BY MR. PARK:

Q Dr. Nebeker, if you will pull that out, please?

In the only full paragraph on the page, you make reference to exhibit No. 2; you might pull out that exhibit, please, also.

In this paragraph you describe an experiment with fathead minnows. Could you tell us, please, the purpose of the experiment?

A The purpose was to determine the toxicity of Aroclors 1242, 1248, and 1254 to the fathead minnow.

Q 1242 and 1248?

A And 1254.

Q Then, late in the experiment, you did analyze some fish tissues?

A Tissues were analyzed, yes.

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Q From which fish, now, were those tissues taken, sir?

A From which fish?

Q Well, let me ask: in your test how many fish were used?

A For the bulk of the test we used ten adults, and tissues were obtained from these ten adults.

Q From the ten adults?

A Yes. Or those that survived.

Q Are you saying all ten survived?

A In any given concentration there was quite a range of survival.

Q In, say, the Aroclor 1254, how many survived, sir?

A In the Aroclor 1254, we had -- this is on page 19 -- it's given: none survived at measured concentration of 15 micrograms per liter; nine survived at 4.6.

Q This is on page 19 of exhibit 2?

A Yes.

Q And this is Aroclor 1254?

A Right.

Q When you say nine survived after three weeks: at what level?

A This is after approximately eight months

Q Was this that table entitled "Spawning and Egg

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Production of the Fathead Minnow"?

A. Yes.

Q. This was after what? You say after eight or nine months?

A. Yes.

Q. Is that a normal period for a toxicity study, sir?

A. No.

This is full life cycle studies. These types of studies should be conducted, really, with any toxicant that we are concerned with. The economics prohibit it most of the time.

Q. But this is s toxicity study?

A. Yes.

Q. How often do you run a study of this duration, Mr. Nebeker?

A. It took two years to complete this one study.

Q. Have you run this type of study on other substances, sir?

A. I am now conducting studies of a similar nature with supersaturated water in the Pacific Northwest, with good portions of the life cycle of the Pacific salmon.

Q. Is that the only other nine month life cycle toxicity study that you have conducted?

A. Duluth has just finished a two-year study with

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1248 and 1260. These are also nine month studies; they have also completed one test which lasted approximately two years with brook trout.

These are probably restricted to EPA labs because we have the time and the resources to handle the long, very complicated tests of this type.

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Q Dr. Nebeker, would you turn to your Table 6 in that exhibit?

Now, are the tissues that are analyzed to determine the results shown in this table taken from the same fish that were in the toxicity study?

A Yes, in the 1254 study.

Q Yes.

Looking, for example, at the mean PCB concentration of 0.52 micrograms per liter and, say, looking at the number of males in Tank B, Table 2 shows four and as I read the table, Table 6 indicates that there were five males in Tank A.

A This is from Table 2?

Q Would you agree with that?

Excuse me. Table 2, as I'm trying to relate the two tables since the same tissues apparently were used in--

A This is pooled samples in fish.

May I make a statement also?

Q Surely.

A I was not requested to address myself to bioaccumulation in these hearings. I was requested to address myself just to toxicity data, so this is part of the total exhibit. However, I will respond.

This is .52 on Table 2.

Q Yes.

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Q Yes.

Look at Tank B, and under the number of males which shows four.

Then if you look at Table 6, 0.52, Tank A or, rather, Tank B, the males.

Now as I read the table there were two fish analyzed separately and then four fish were pooled.

A These are samples and not necessarily whole fish. These could be samples that were possibly run for replicate -- to run replicates of an individual fish for checking for error in the methodology, so it would not necessarily be the fish; it would be samples representative of those fish.

I also did not run these samples. These samples were run in Columbia, Missouri. Often you run replicate samples of an individual so you can check your error, so it would not necessarily be the whole fish used in that particular sample.

Q Dr. Mebeker, why were the fish tissues not analyzed at the Duluth Laboratory?

A We didn't have the capability. This is a rather sophisticated, time-consuming methodology. Dave Stalling had the only available facility at that time. This was 1971. Gil Veith had not come on board. We had no one capable. I am not a chemist. This is not my background.

Q Let me ask you to stop back just a moment, a

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hypothetical question not on this table.

If a given fish with some unknown quantity of PCB in the fatty tissues were to be analyzed on a wet or whole fish basis, would the resulting PCB content be greater than or less than if fatty tissues only were analyzed or the fish were analyzed on a lipid weight basis?

A If you analyzed the fish on a whole body your figures would reflect a lower level.

Q And if only the lipid portions of the fish were analyzed the results would be higher?

A Right.

Q Could it be possible that since these tissues were not analyzed at your laboratory but were sent some distance away and analyzed at a laboratory in another state that the results could have been -- the analysis could have been made on the basis of fatty portions only?

A No.

Q How can you be sure?

A These were frozen, sealed, and shipped for whole body analysis.

Q Well, do you know for a certainty that the laboratory did not do what is quite often done and that is remove the fatty portions for analysis?

A Fathead minnows are small, miserable beasts and it would be very difficult to dissect fatty tissues from.

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Q But again --

A It's potentially possible if they wanted to take the time. I would very much doubt it. He was very pressed for time.

Q Well, is your answer-- Do you know for a certainty that the laboratory that actually analyzed the fish did not remove the fatty portions only and analyze those?

A I'm assuming from the data that he sent me that fatty tissues were not dissected and analyzed separately.

Q You still are not answering my question, Dr. Nebeker. Is it possible that the fatty portions only could have been extracted--

A Certainly.

Q -- and analyzed?

A Certainly.

Q In which event, if that had been the case, the results reported would be higher on a parts per million or billion than if the whole fish had been analyzed?

A (Nodding affirmatively.)

MR. PARK: The witness nodded Yes.

BY MR. PARK:

Q Looking at Table 6, Dr. Nebeker, -- or keeping that in mind -- what is the highest level of PCB that has been found in fish in the wilds, in the environment as far as you are aware?

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A I'm not really familiar with field data. I have not spent much time on this.

Q Would you have any ballpark guess? Would it be five parts per million?

A There are records in Dr. Stalling's and Meyer's paper that refer to levels around 200 parts per million in fish from the Hudson River with background levels--

Q I was just asking about--

A I have not concentrated the concentration factors.

Q What would be the next highest level in fish that you're aware of, in the wilds now?

A That's the only record that really comes to mind. I think data from Dr. Veith shows levels near that range in certain areas of Lake Michigan.

Q And certainly they would be the highest that anyone would have found anywhere in the environment. How do you account for--

MR. ECKERT: I object to that. That's argumentative. The witness didn't testify to that at all. You're assuming that.

BY MR. PARK:

Q On the basis of your experience, Dr. Nebeker, how do you account for a level of a thousand parts per million which Table 6 would indicate in fish that are apparently thriving and reproducing? These are fish that were sacrificed

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at the end of the nine-month life cycle toxicity period.

A It is typical of these primary grazers that these materials will be stored in the fat. As long as they are not starved, it is non-effective at relatively high levels as long as they are not starved and release this back into the blood stream.

Q So are you saying that levels in these amounts are apparently not harmful to the fathead minnows?

A Based on this data we would have to see if reproduction was affected. This was what I was actually looking for. A long-term characteristic of PCB's is that they are a chronic, long-term food chain problem. The initial exposure to many animals can be relatively high and not affect the animal itself. However, reproduction is affected.

Being consumed by predators, it affects the larger predators in the aquatic system.

Q Well, it is a fact, isn't it, that some of these fish that were sacrificed were at least apparently in good health after nine months with the level of 1,000 parts per million PCB?

A Yes.

Q In your judgment, would a level of PCB in fish of, say, .1 of the level shown in Table 6 be more consistent with your experience in fish toxicity studies?

A No. If you look at fish that are found in natural

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situations with continuous exposure to these levels, they would have tissue levels that high.

Q But the highest level of fish-- Again the highest level of PCB in any fish in the wild of which you are aware you feel-- In other words, I'm not holding you to this but--

A These are survivors that were found by the fisheries biologists in the field. I cannot account for all those that were destroyed prior to the survey.

Q Dr. Nebeker, you mentioned earlier that this was a life cycle toxicity study for the duration of nine months, and then you did mention that you were not really prepared to speak in connection with the concentration factors.

But I note that Table 6 on the right-hand side does contain two columns entitled "Concentration Factors." Should these two columns not have been part of the table?

A No, that's data that was accumulated by our chemists during the course of the study. We also gave some fish to the University of Minnesota for analysis of ATP systems or effects of PCB's on these other systems with which I am not very familiar.

Q Which tank were they from? A or B?

A These were from all tanks.

Q You did not sacrifice all fish yourself?

A I sacrificed these fish, right. We have a routine method of utilizing our additional fish that are sidelines to

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the main. We have offspring reproduced and we check for additional survival after.

Q But you say some of the fish whose tissues are recorded here in these tables were given to other parties?

A Yes, sir. This is recorded in the text.

Q Was that before or after analysis?

A This was before analysis. These were prior to the onset of spawning so they weren't involved in the reproductive portions of the test.

Q But were these fish that were survivors at the end of the nine-month time period?

A No.

Q Did they die during the test?

A No.

Q Were they not fish that were included in these tests?

A They weren't included in the reproductive portion of this test, no. They were incidental to the reproductive portion of these tests.

They requested that I expose some fish for them for another on-going test because I had the only facility. We do this routinely with gas work in Oregon. We have the only facility for treating fish in this particular manner, so we try to make this available to graduate students.

Q But these are other fish you're talking about, aren't you? You're talking about other activities of your laboratory?

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A Right.

Q I'm sorry. I assumed you were talking about these fish here.

A No.

Q Who analyzed the water samples shown on Table 6 and Table 2?

A I analyzed some. Frank Puglisi analyzed some. David Defoe analyzed some. Other chemists under the direction of Gary Glass also ran routine analyses of these waters. We have a very detailed analytical program to characterize-- We use Lake Superior directly, without any treatment or changes. We like to characterize the lake at all times, so we have a good feel.

This is mainly for our metals work. We have a good feel for what is in the water that might affect metals, so we feel we have a very good analytical program for giving us the water chemistry backup.

MR. PARK: That's all we have. Thank you, Dr. Nebeker.

BY MR. WILLS:

Q Dr. Nebeker, since I haven't had the opportunity to fully take a look at your exhibits, I only have a few questions raised generally by the discussion in here and also a cursory review of the exhibits.

Taking 1 and 2 together for a second --

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A Exhibits 1 and 2?

Q Right, to your testimony.

Apparently they were done in 1970 and '71.

A Yes, sir.

Q And they are just now being published?

A Yes, sir.

Q Can you tell me what the objectives of your studies were back in 1970 and '71?

A Our initial objectives were to, number one, see if PCB's were toxic to aquatic organisms.

Number two, if they were, at what levels and to what organisms.

2B

Q For what end purpose?

A For protecting the aquatic environment from potential toxicants.

Q You mean setting up standards?

A Initially this was just to determine if they were toxic, and to see if EPA would have some involvement with them.

Q Were these set up merely as screening type tests or laboratory evaluation of the effects of a toxicant upon a particular organism.

A Screening?

Q A screening test as has been referred to in other testimony, which is where you dose, at sort of a regular

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concentration, various species just to see whether or not there's a level of toxicity and then design your experiments from that.

A We did initial surveys of a screening nature with Daphnia, yes.

Q Is that a nice test organism?

A It's a very good test organism.

Q Is EPA promoting that as its standard organism?

A We use it as one of many organisms.

Q Going back, as I understand it, you were looking to see whether or not these were toxic to your animals and whether or not they should be controlled.

Were there any sort of protocols established so far as conducting experiments or test procedures?

A Well, we started right from scratch, so we had to establish whatever methods. Mr. Papageorge was very helpful in providing us with some background and the test materials to use.

We got a full series of 1221 through 1268 and we used these initially with the Daphnia.

Q No outside agency or nothing except within house?

A Pertaining to what?

Q So far as protocols, test procedures, selection of species?

A We have an on-going bioassay methods committee.

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We also have several outside agencies with committees formed to develop methodology, to criticize methods that are presented, to evaluate tests that have been conducted using those methods.

Q Do they get the tests that have been conducted before they appear in the published literature?

A The test methods?

Q Yes.

A Yes.

Q Is this somebody like the National Center for Toxicological Research?

A I don't know.

Q You don't know whether or not they have taken a look at your test methods and made any determinations with respect to them?

A I am not familiar with that, no.

Q Well, why three years between the end of the experiment and now being published?

A It's very simple. Changes in editors of the transactions of the American Fisheries Society.

Q Changes in the editor?

A This is a routine problem. In some of our journals we do have some lag time, up to two or three years. The final report was written in '72 and submitted to EPA at the conclusion of this work, fulfilling my obligation as far as

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EPA was concerned.

I tried to make it in a more usable form for our researchers and other people. And we have been delayed significantly between the submission of the final EPA report and publication of the data in a designated scientific journal that we were to utilize.

Q When was the final EPA report accomplished?

A April 1972, as I recall.

Q I take it it is sort of fortunate it wasn't published prior to that anyway. You have already made one correction to one of your tables.

A That's really more of a clarification than a correction, the nominals. We calculated the nominals and measured concentration factors.

Q Did you receive any comments from anyone who reviewed these exhibits prior to now, pending publication?

A Comments?

Q Yes. Did anyone technically review them?

A The referees of the Fisheries transactions, the editorial review board of the National Quality Laboratory, our editorial specialist we have on contract at the University of Minnesota. We have a very rigorous editorial policy.

Q Do you know if the Sager Committee received a copy of these?

A I don't.

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Q Did Dr. Thompson?

A Copies of these were mailed to Dr. Thompson, yes.

Q When?

A Which time?

Q How many times?

A They were mailed the latter half of March, approximately. As you know, you received portions of mine junt Friday. This was the third mailing, as I recall.

Q Okay.

When was the first time?

A Dr. Thompson sent a letter to me requesting that I address the Objectors and this was done, and I mailed this to him. I mailed-- The completed copy was mailed after April 2nd, because this is when I received Johnson's testimony from Columbia, Missouri.

Q In other words, you didn't make this available to the HATS Committee or to the EPA prior to the publication--

A Oh, this material? This material was submitted April, 1972.

Q To Dr. Thompson?

A Not to Dr. Thompson, to the EPA National Water Quality Laboratory Review Board.

Q Was this in raw data form or was it a rough draft of your final results?

A It was in the final report form submitted to EPA.

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Q In other words, similar to what we have here today?

A No. There were 40 data tables that were included in the EPA report. Editorial Review suggested I not submit that many for publication.

Q Okay. So that I'm clear:

You're talking about a Editorial Review Committee for publication?

A Right.

Q What about the people within EPA for technical review for use within the agency?

A It was accepted in total.

Q Accepted until Dr. Thompson threw it out last November and just used the Water Quality Criteria?

A No, Dr. Thompson didn't receive a copy until-- Oh, apparently he received no copies at all so he has had no interaction with this stuff at all.

Q Nothing at all?

A No.

Q So far as you're concerned neither Exhibit 1 nor Exhibit 2 were used in the formulation of the standards we're talking about here?

A I really don't know.

Q I say as far as you know.

Have you ever had any trouble with Columbia Labs, getting data out of it?

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A Yes, I've had some difficulties.

Q Dave Stalling was a member of the National Academy of Science Review Panel?

A Yes, sir.

Q Do you know whether or not he had duplicate samples evaluated when he did your bioaccumulation studies, or the residue analysis which went to the bioaccumulation?

A You mean possibly another laboratory?

Q Another laboratory, or duplicate samples within his own laboratory by different people?

A I don't know if he had different people do them. I know they do duplicate samples routinely for checking their own accuracy.

Q Do you do that, too?

A Yes, sir. Everything is at least replicated where physically possible.

Q Okay, where physically possible. It could be one percent or a hundred percent of the time.

A For any valid test it will be replicated.

Q And you never find any differences?

A We do find differences, yes. That's why we replicat

Q In some of the literature they talk about a difference of a factor of two between two samples or three samples. Is that common, in your experience?

A A factor of two, like ten as opposed to 20? This

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is common.

Q Why were the particular species in Exhibit 1 and 2 selected?

A They're abundant, wide-spread in their distribution, significant fish food organisms primarily.

Q None of them are particularly sensitive to toxicants more than others?

A No. There are more sensitive and less sensitive animals available.

Q Is there any cross-feed between your laboratory and the Gulf Breeze Laboratory?

A We try to communicate. It's difficult but we try.

Q Your present laboratory is really a part of Gulf Breeze, isn't it?

A No, it is not.

Q It's not?

A No.

Q I stand corrected. You're an associate laboratory.

The work of Mr. Hanson down at Gulf Breeze, did you have that available when you were at Duluth or has that just been developed with respect to development of new bioassay techniques?

A Which? I don't know which one you're referring to.

Q Well, he developed apparently a new bioassay technique at some time --

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A All of us do, --

Q -- in March of '74.

A -- in the course of our testing. This is routine because we start from scratch. No one makes our equipment for us. About everything we do is new, and this is why we have reviews of our methods.

Q But you don't have any reviews of your methods outside EPA, do you?

A Yes, sir. We have the MPAC Committee that is set up.

Q The who?

A I'm sorry, the Manufacturing Chemists-- I don't recall the-- We have Columbia, which is outside of EPA and which has reviewed. We have several universities that utilize our methodologies and we get feedback from them as to what is good and what is bad.

We have contractors who are utilizing methodologies and giving us good feedback as to the usefulness or utility of these methods.

Q Moving just a second off of your Exhibits 1 and 2 and going to the other one that you furnished under separate cover, which would be Exhibits 4, 11, 13 and 14:

With respect to Exhibit 4, what do you know about conditions under which this experiment was conducted?

A These were conducted under the general direction of

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Dr. Beisinger, who developed the methodology for Daphnia testing.

Q Do you know how the particular experiment was conducted that you have used in your reference?

A I was not present when these were run.

Q Okay. You've answered my question.

A He was using beakers, 200 milbeakers with glass covers, five Daphnia per beaker and using methodology recommended by the National Water Quality Laboratory Bioassay Committee.

Q Do you know when he ran them?

A November 1973 or probably '72; I'm not certain. I suspect it's '73 because this data took some real scrounging to find.

Q But it's fair to say you don't know?

A Right.

Q We can speculate all day.

Going to Exhibit 11 --

JUDGE SWEENEY: Is Exhibit 11 being offered?

MR. ECKERT: No, it is not.

JUDGE SWEENEY: Perhaps you should restate now the exhibits. As I understand it, it is 1 through 4, and 13 and 14.

MR. ECKERT: Right.

I certainly have to objection to cross-examination

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of the witness on the references but I don't think it is going to serve much purpose on the record since the reference won't be in the record.

MR. WILLS: Then are we saying that you are going to strike the -- or you will join in a motion to strike that portion of Dr. Nebeker's testimony which is on page 8 at the bottom with reference to Exhibit 11?

MR. ECKERT: Absolutely not. It's been our practice right along that only that material for the record which is not in the published and open literature.

JUDGE SWEENEY: Go ahead with your cross-examination on Exhibit 11 if you care to.

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On page 2 of your statement you state that -- and this is in the middle of the page:

"The environmental impact of the PCB-containing discharge depends upon factors such as the types of the PCB in the effluent, the sedimentation rate of the receiving water, the types of biological food chains present, and the existing load of other toxic materials in the receiving water."

Could you tell me what data you have concerning the relationship between the sedimentation rate of the receiving water and the environmental impact of PCB discharges?

A The data that we have was obtained by our laboratory in Maryland, and it related rather substantially the inventory of PCB's in the environment as probably being influenced by the sedimentation rate more than any other single item.

Q Well, what was the effect of the sedimentation rate?

A Well, sedimentation, for example,-- The sediment in the water system acts as an absorbent material apparently, attracting and absorbing PCB's selectively and removing it from the water or biosphere into the sludge or into the bottom sediment of rivers and systems.

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Q Have you provided us any of the data upon which that conclusion is based?

A No, I have not.

Q Is there a report upon which that conclusion is based?

A Let's see, with regard to whether or not the report is written-- Is the report written on that?

VOICE: I think a qualified Yes.

BY MR. ECKERT:

Q Let me put it this way:

Once the PCB's get into the sediments, do you have any data on the relationship between the PCB's in the sediments and the PCB's in the receiving water adjacent to the sediments?

A Again, we find-- I would say we have a little bit of data. What we have does not indicate that we have any equilibrium established between these two concentrates. This I think is a part of a larger problem in which we try to assess the environmental lifetime of PCB's.

What we are saying is PCB's that are adsorbed and trapped in the sediment apparently remain there for a very long time;inasmuch as they are typically in a non-oxidizing atmosphere, they remain for quite a time in that role, and we do not have evidence that it is quickly reintroduced into the active biosphere, for example, as in the case of methyl

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mercury.

Q Well, now, let's talk about the PCB's in the sediments.

Once the PCB's do get into the sediments, are they then not available to bottom feeding and benthic organisms?

A One would say on a theoretical basis that they would be available. On a practical basis we have seen no evidence of equilibrating bottom sediment, either with the flora or the fauna or even the water quality, even in conjunction with areas of high volume sediment PCB.

I would have expected to have found higher concentrations of PCB's in the water and in the aquatic organisms than was found.

Q In the testimony submitted by Monsanto there was an article by Nimmo, Wilson, Blackman and Wilson. Have you read that article?

It's entitled "Polychlorinated Diphenyls Adsorbed from Sediments by Fiddler Crabs and Pink Shrimp."

A I think in the distant past, I did, yes. It is not current to my knowledge at this moment.

Q In that article the researchers state:

"We have demonstrated experimentally that Aroclor 1254 can enter the estuarine food chain from sediments."

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Do you agree with that statement?

A I mentioned earlier that I thought it could be theoretically possible and probable that this could occur.

Q He says "demonstrated experimentally," not theoretically possible.

A To me that's perfectly acceptable and I would find no great quarrel with that. The question is equilibrium and the quantity mass transfer. I think that's the issue, and the paper does not address itself to that.

Q What data do you have with respect to the relationship between the types of biological food chains present and the environmental impact of a PCB discharge?

A This is a general consideration that can be made of almost any environmental contaminant. We are concerned with its pathways, its reconcentration steps, and its vector back toward man. Without a consideration of the particular food web that's involved one is very hard pressed to make any scientifically valid estimate of the magnitude and direction of that vector.

Q Well, you mentioned man. Is man the only organism which we should be concerned about at the top of the food chain?

A No, there are other -- certainly other animals that we have a high concern for; high trophic creatures of all sorts have an excellent opportunity to reconcentrate these

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materials.

Again, the particular food web that's involved is imperative to understand what magnitude risk is involved.

Q When you refer to the existing loading of other toxic materials in the receiving water, do you have evidence that PCB's exhibit synergistic or additive effects with other pollutants?

A No, we haven't. We have studied the problem of other pollutants and in combination and noting synergistic effects which-- EPA I understand is quite familiar with these and it's a constant concern to any scientist working in the environment: are there going to be synergistic effects between this and other things.

We have noticed nothing in the PCB -- as far as PCB's are concerned.

Q Well, now you've raised the question here yourself of existing loading of other toxic materials, but you haven't provided us the data. Don't you think the data would be useful in setting a standard?

A My position here is to recognize that EPA's role is very broad, very important, and they will have to consider if there are synergistic effects that they should be included.

The purpose of this statement, sir, is not to suggest that PCB's, by any comparative basis, don't need

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regulating. It's just a case of saying are there other considerations that we have to combine with PCB's.

Q Well, I'm not arguing with that. I'm just asking why, if these things are not important-- I'm sorry, let me rephrase that.

I'm asking why, if these things are important and should be considered in setting the standard, you didn't provide us the data that you have been working up in your laboratories on these very points.

A With regard to the synergistic effects, we have absolutely no data that would either support or deny synergistic effects.

Q But you do have data on the sedimentation rate?

A When you say "rate," that question has not been raised before; on sedimentation, yes.

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Q On page 3 of your statement you refer to a 0.5 ppm level as unduly conservative because this limit, proposed by FDA, applies to feed stock levels only.

Could you explain to me what a feed stock level is and how this relates to the tolerances published by FDA?

A Yes.

My feeling, my understanding of it is, again, back to the reconcentration food web, the magnitude and direction of the vectors that would be associated therewith.

If, for example, if the purpose of the standard has various levels of importance, protecting man would be among the first considerations one would make. One would say, "Where do we have a 0.5 ppm source level that has a vector as a feed stock demand in water systems and may contain PCB?"

Alternatively, the same question would be asked if we have any other form of animal husbandry, any other creatures that are being raised. We have to take a good hard look at the 0.5 ppm level in that case, because where it's controlled feed stock, then you have something quite a bit different from just a statistical end variable PCB concentration pickup in the food chain.

Q When you refer to this limit proposed by FDA, are you refering to the tolerances, temporary tolerances, published on July 6, 1973, by FDA in the Federal Register?

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A I don't have that reference before me as to the exact date, but we are referring to FDA source material.

Q You state that other Federal agencies routinely incorporate consideration of the actual food chain consideration on a case by case basis in establishing and enforcing regulations.

First, which other Federal agencies are you referring to?

A The agency that has probably done more that this agency, than all the other agencies put together, is the Atomic Energy Commission, in which their concern, of course, is radioisotomic buildup and reconcentration; and without some knowledge of the specific food web involved one would never get a dose rate.

Q Do they do this type of analysis in establishing regulations or in issuing licenses?

A First of all, they require in the regulation that the total dose, they set a total dose level that is permissible.

Then, alternatively, because there are a great many different ways in which that dose might be rendered, each of those alternatives are examined on a real case by case basis for the facility in consideration for its license.

Q But doesn't AEC, in fact, have an effluent or an emmissions standard for nuclear reactors that limits th

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discharge that can come from any given reactor?

A. Yes, of course. But that in itself constitutes an envelope.

Q. It constitutes the maximum to which you could go?

A. I believe it is issued as a guideline as opposed to a regulation.

Q. Are you familiar with the studies that were conducted by Platonow on minks in the Lake Michigan area?

A. Aware; but not intimately familiar.

Q. You've referred here to the unduly conservative 0.5 ppm level.

A. Yes.

Q. Do you recall what the level of PCB's was in the that that was fed to the minks in the Platonow experiments, Doctor?

A. I think it was on that order level. I also would identify the mink meat condition as clearly a feed stock condition.

In other words, I have no quarrel with that point by ppm when used in a feed stock, as in the case of the mink, no quarrel.

Q. What if the feed stock were fed to humans instead of to minks?

A. FDA has suggested a 5.0.

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Q Well, in light of the Platinoff experience, is that valid? Is that defensible?

A Well, I don't know. I don't behave like a mink in very many ways, and I'm not sure how statistically significant that is for the human population.

Q Now, still on page 3, you refer to carbon adsorption. You state you have no data nor have performed any experiments with carbon adsorption.

Have you tried any techniques for treatment of PCB's?

A The word "treatment" requires, I believe, some elaboration.

We have done extensive work in every one of our plants in process control to reduce the PCB's that might be escaping into the environment. This is postulating, and I believe the next page -- on this page there are hypothetical postulations of two possible ways of waste water treatment as opposed to process control treatment or process control management.

Q And those two are simply carbon adsorption and reverse osmosis?

A Yes.

Q But on neither of those have you done any tests.

A That is correct.

Q Could you identify the six Westinghouse facili[illegible]

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which use PCB's in process?

A. Well, I gave you six because I know I could name four, and one is never sure in a large operation like Westinghouse that one has covered all of them.

I gave you the first four that I think I know the most about: the Sharon transformer plant in Pennsylvania, South Boston transformer plant in the State of Virginia, and the Bloomington, Indiana, capacitor plant, and there are PCB's involved in their Phoenix plant -- it's also in the production of transformers.

There are lesser and lesser quantities involved in other plants, such as the Lighting the Lamp division in Cleveland has PCB-containing capacitors and the like in the lighting fixtures for this type lights (Indicating).

Q. Well, let's start with the Sharon transformer plant.

Do you have any figures on the levels of PCB's discharged from that plant?

A. Yes, I have figures.

Q. Could you give them to us, please?

A. I think I would have to check and see if there is any reason why we cannot.

Q. Are you alleging that this is a trade secret?

A. No.

But I got the information, and the information then

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was for my use only, and before I can release it I have to provide some protection to my clients.

MR. ECKERT: I would like to get into this, your Honor. Could we have a five-minute recess?

JUDGE SWEENEY: We'll have a short recess.

(Short recess.)

JUDGE SWEENEY: Back on the record.

BY MR. ECKERT:

Q Let me repeat the question, if I can restate it.

Could you give the concentration and the weight of daily discharge and the homologue involved of discharges of PCB's from the Sharon transformer plant?

A I believe so.

The Sharon plant has, as most plants do, a multitude of discharges. That we would first assume we have no discharge from the Sharon plant for some reason, the process itself for the past some years has been -- that we would have fist presumed that Sharon had no discharges, because we had no knowing way in which PCB's got from the plant process into any of the water streams.

Q Before you continue, could you describe the steps that were taken to eliminate the discharge of process water?

A Yes. They're in my testimony. I'm going to have to refresh myself with it.

As a matter of fact, this is a bit of an interesting

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history. May I take a couple of minutes on it?

Fine.

We were sort of running parallel courses, apparently, with FDA in 1970, and in some very broad examinations of fish from many parts of the United States that we had taken on other environmental studies, we asked our laboratory, analytical laboratory, to make a determination of the pesticide content in these fish in 1970.

And we were astonished at that time to find that in many cases we could not find the DDT content because the chromatographic spectrum for the pesticides was simply obscured by quantities of polychlorinated biphenyls, which we at that time did not know were in such widespread use in the environment.

We raised this question to the Westinghouse management, and we immediately became concerned, knowing that Westinghouse was also processing PCB's.

So following that time we said, "Boy, we'd better start looking up the sediments and the fish downstream of the Westinghouse plants as well."

Parallel with that the FDA made their proclamations, and our work was underway before they made theirs. Also parallel, or in the same year, Monsanto took steps to warn all its users that there was a problem here.

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So I would say 1970 was a very major turning point

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in the recognition by industry that we had a potentially dangerous substance here that we would have to deal with entirely differently than the way it had been dealt with in the past.

So among the things, and there are others who could give the chronology of the actions of the plants better than I, but I think we have most of the net results.

One is we went in and sealed all of the floor drains in all the PCB areas of the plant so that in no way any drippage could get joined with the process or sewage from the power plants.

Secondly, we modified substantially the spill procedures for PCB's in the plant, that from this point on we were using industrial adsorbance materials collected together and finally incinerated offsite by a contractor.

We have testified, I believe, as to several steps in the process, and I am going to have to look again at where this is in my testimony.

We stopped short of instigating clean-room procedures; they're very expensive, and as far as I'm concerned, not warranted. But we did not go that far, but we did consider it.

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The switch from 1254 to 1242 occurred in the late '60's and the rapid switch from 1242 to 1016 occurred in a subsequent time period and we predominantly use 1016 at the moment.

Again, part of the reason was the 1016 was more biodegradable and represented less, we felt, of an insult to the environment.

Various other steps in the process that were taken have been a large number of administrative procedures, for example, of when and how various processes are run. The process has been examined a number of times to look for even the remotest source of PCB's back in the waterways such as the vaporization of PCB's from vacuum systems discharging into the atmosphere, the potential falling out, plating from the roofs, washing out by rain water and in this sector getting back into the watershed.

I think my testimony is better than my memory on this point.

Q When you took these steps to prevent the discharge of PCB's, did you attempt to flush out or clean sewers and drains contaminated with PCB's from old operations?

A I would be the most frightened man in the world to recommend the flushing out of old lines and old drains. I would be very concerned to make that recommendation.

Q You mean because you would be worried about the

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PCB's shock loading on the environment?

A Yes.

Q There wouldn't be any way that you could clean them out and then pond or otherwise dispose of them?

A I'm not prepared to say there wouldn't be any way; I'm prepared to say that I don't know a way right now. I am prepared to say that.

Q Now I gather that your testimony is that despite all these steps, there are still PCB's getting into the effluent. Is that correct?

A I think so.

Q Have you investigated to find out for the Sharon plant what those sources are?

A Yes, we have investigated. We do not know what the sources are.

Q Well, let me ask this:

For what purposes do you use water in the Sharon plant?

A We use it for cooling and we use it for makeup to the steam system. We use it for drinking, washing, sanitary sewers.

Q How many of these uses are direct discharges and how many go into municipal systems?

A Of course the washing and the sanitary sewers go into the municipal system. The process water -- eventual

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process water wastes would go into the river.

Q The two process waters that you have identified are cooling and makeup. Are there any others?

A Well, I'm sure there are. It's a very big plant and even those have a large number of subsets. That is to say there are a large number of independent cooling systems. There are a large number of systems in which water simply has to be removed as a contaminant from oil or other organic liquids of which separation is made.

We don't want the water there; it should not have been there but it's there and we have to get it out. As it comes out it becomes of course a waste product.

Q Now the process in which PCB's are actually used is a sulphur dry process -- is itself a dry process, is it not?

A It's a non-aqueous process.

Q Non-aqueous?

A Yes.

Q Is it physically--

A It's not dry in the sense of liquid.

Q I understand.

Is it physically separated from the other processes in the plant?

A From water processes?

Q From water-using processes?

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A Yes, it is. Again, this is one of the reasons for the floor drains. In other areas of the plant we may have water source from the floors or whatever but in this area, anything that is scrubbed does not go into the floor drains.

What I'm really trying to say is I don't know really what the source is.

Q Well, let's get to the bottom line, as they say in the White House.

What is the level of PCB's discharged?

A Well, the level in terms of concentration or in pounds-- The accuracy and the anomalties that I have on data of PCB contents in our various streams from the Sharon plant are not very satisfying, not very-- Well, I don't have an enormously high confidence level.

I can tell you I have data that range from a fraction of a part per billion up to several -- a few sets of data in the one to two parts per billion range, one data anomalty point at 27 parts per billion.

And I will maybe get to the very bottom line at this point and say that a mixture of judgment and horseback guesses suggest that in combination with our water flow the plant discharges around 45 grams, 40 to 45 grams of PCB per day. I would sure as hell hate to have to swear to all the parts and pieces because you have to make some touch interpretations to come up with that.

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Q Well, we will underscore the uncertainty.

I'd like to know what kind of treatment is used for the process water which is discharged.

A The process water itself, as far as I know, is not-- It's certainly not treated for any PCB removal. Again, we have no knowing point at which PCB's can enter the process or waste waters.

Q What is the receiving water for the Sharon plant?

A The Shenango River.

Q Do you know what the seven day, ten-year low flow of the Shenango River is?

A Well, I have a lot of data on the Shenango but I'm not sure that I have that particular piece.

The Shenango River, unlike maybe a lot of naturally sponsored streams, is fed from a lake and that river is a controlled flow from a lake. The average year-round flow, total quantity by day, is 700 cubic feet per second. In the November, December, January area it is controlled to a minimum flow of 100 cubic feet per second.

I did not answer your question about the ten-year low flow because it is my understanding it has been run according to these specifications, but I cannot say precisely that there was never any deviation.

Q Can you quantify the effluent flow from the facility, how many gallons per day?

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A Yes, I have that data.

Q Would you please give me that data?

A All right.

Let's see, the sanitary sewers, 124,000 gallons per day.

Q Do these go into a publicly owned treatment work?

A Yes.

Q I'm interested only in the direct discharge to the river.

A Okay.

I'll have to ask a question. Do the storm sewers go into the sanitary sewer system?

VOICE: No.

THE WITNESS: Do they go into the river?

VOICE: Yes.

THE WITNESS: Okay.

The daily storm sewer water is about 158,000 cubic feet.

There is a Y building outlet, 87 gallons per minute.

And the A and B building outlet, about 263 gallons per minute.

A power house outlet-- This would be blowdown from cooling towers and other things, 175 gallons per minute.

I have several points in the plant, sir, that I

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could give you but all in all, if I add up the total process I think that's really what we're talking about, isn't it?

A Well, that is, but you've raised an interesting point.

Of these various flows, do all of them contain PCB's, or do some of them contain no detectible PCB's? How are the measurements taken?

A Well, let me say first that I don't know. All the effluents have not been looked at.

Secondly, those that have been looked at, I cannot tell you whether or not they all contain PCB's. If I get a number, .13 parts per billion, I don't know whether that has got PCB's in it or not.

Q You mean you think it is below the level of detection for analytical procedures?

A Well, the anomalty of results I've obtained to date on this particular kind of sampling is far broader than that. I think the analysts would generally talk about an error limit but I look at lots of data and wonder how it makes sense, and I would have my troubles.

Q Well, when you see a data point like that are you saying that it is no good from a quantitative or from a qualitative standpoint?

A Both. Again the analyst would say, "Gee, he's not going to see PCB's where there aren't any PCB's."

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And you know what? I would agree with him. But the difference is where do the PCB's come from, from the laboratory apparatus or from the sampling?

These are very practical matters and we're down in the range of really splitting drops, you might say.

Q Have you any evidence to support your statement on page 4 that PCB homologs with four chlorine atoms or less per molecule are biodegradable?

A I have none, but we do-- Well, on the other hand I think I have some.

Our work, work that we have sponsored, has shown in the environment a shift to the heavier homologs in some general proportion to the time of exposure to an oxidizing atmosphere. It suggests that a material that might start off as 1042 could, in a period of time, associated with weathering and natural processes, beginning to look like K-54 and so forth -- excuse me, 1254 and so forth, appear to move up the scale of heavy isomers with time, if-- The only way that could be accounted for would be the shorter environmental half lives of the lower homologs.

There was other data which we did not develop but which we are aware of and which was done by one of the people that will be testifying here today. If you like, I can tell you my understanding of it, or you can address your questions to the expert who generated the data, as you choose.

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Q Well, the problem we have here is that we don't have before us the study that you appear to be relying on. You stated that there's a shift to heavier homologs after exposure to an oxidizing environment.

Is there a written study or report that documents the shift?

A Again, is it written?

VOICE: I don't know if it specifically deals with that particular problem.

THE WITNESS: There is not a report written that deals with that data. What we are saying is that data exists from which that conclusion might be, on a preliminary basis, drawn.

I think more fundamentally it's the work that Monsanto did in looking at the biodegradable forms of the various chlorine content and chlorine isomers.

Q So you think you would be relying in this statement primarily on Monsanto data rather than on data that you are referring to?

A I think so. I think that the other argument is probably valid, but I don't feel that it's a point that I care to make of proof. I think it's a very reasonable assumption.

Q Getting back to the Westinghouse PCB facilities, what is the source of PCB's in the South Boston facility?

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Is it similar to the Sharon facility?

A Well, I never did know what they were in the Sharon facility.

Q I mean in what processes are they used?

A They are used in the production of capacitors.

Q Capacitors?

A Yes.

No, South Boston; I'm sorry. I read Bloomington.

Right, transformers, South Boston.

Q And have the levels of PCB's discharged been measured?

A Well, discharged where? In this particular case we have no discharge into navigable waters, which I understand is the subject of this particular hearing.

Q The total effluent is taken by a municipal treatment works?

A That's my understanding, yes.

Q Have levels of PCB's from that treatment work been measured?

MR. WILLS: Excuse me, your Honor, but previously-- We're talking about navigable waters and you didn't want that information with respect to the Sharon plant, so it is sort of objectionable at this point. Where are we going?

MR. ECKERT: I'll withdraw the question.

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BY MR. ECKERT:

Q Let's discuss the Bloomington facility. That's a capacitor manufacturing plant.

Is that all they do at Bloomington?

A Well, I'm sure they do lots of things in Bloomington. As far as I know, that's the only thing they do relating to PCB's.

Q Well, what proportion, say, of the sales volume from that facility is represented by the PCB-using capacitors?

A It's my understanding that a very large percent of the capacitors is -- what is that; 95 percent?

VOICE: Very nearly 100.

THE WITNESS: For all practical purposes, 100 percent of the capacitors are PCB-containing capacitors; essentially 100 percent.

BY MR. ECKERT:

Q Could you characterize the discharges from the facility in terms of how many there are, and into what receiving water?

A Yes.

There are no discharges into receiving waters at the Bloomington capacitor plant.

Q And in Phoenix?

A The same.

Q No discharge?

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A No.

Q How about the Cleveland lighting plant?

A Well, I suppose if people wash their hands there might be some; it's a very small type operation.

No. There are no discharges into the water system.

Q So, in essence, the only plant that Westinghouse operates that does have a direct discharge is the Sharon facility.

Is that correct?

A That's my understanding. I would like to see a few heads nod if I am wrong.

Okay, fine. Thank you.

Q Have you estimated what the standard would require for the Sharon facility?

A Yes. Yes, I have.

I have calculated it, and I'm going to have to get refreshed whether it was two grams per day or four drops per day; but it was in that order. I'm sure I could make the calculation here very quickly.

I can get it from my notes while we are moving, if you like.

Q Well, let me ask this.

In your qualifications statement you state that you hold numerous patents on pollution abatement processes. Have you ever utilized or studied activated carbon as a

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treatment process?

A Sure.

Q Have you ever utilized it for the control of chlorinated hydrocarbons?

A No.

Q In what types of wastes have you used it?

A Well, your first question did not pertain to wastes, but, for example, in separation of hydrocarbons.

Q Is this a laboratory operation?

A Both laboratory and large plants, large industrial plants; charcoal adsorption.

Q In the process?

A Sure. In the process.

Q Have you ever used it for waste control?

A Well, we are using it in waste control for iodine in our nuclear plants.

Q What is the volume of -- strike that.

Have you investigated for the control of PCB's, what levels would probably be achievable with activated carbon?

A No.

I have no way of anticipating the relative adsorption coefficients of PCB's which would doubtless be diluted with mineral oil, which would doubtless be soluble in minute quantities in a water stream that might be used in the pro-

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I have a tough time being able to predict anything about how well activated charcoal would do.

Q When you say PCB's would undoubtedly be diluted with mineral water, do PCB's coexist -- are they used with mineral oil in the transformers?

A Not at the outset, no.

But there are wastes. For example, all the wastes -- a point I didn't make -- all the waste PCB's that are collected in everything from rags to waste to buckets to drums and finally placed in a tank: if it's any good at all it's processed and reused. If it is not good, it's shipped off the site for disposal.

In that process of recollecting what we call the waste material, it will be contaminated with everything that we have in the plant, including oil and the like, so I'm just extrapolating from that data in saying that any PCB's that happen to be in water would also be contaminated with oil.

Q The materials that are shipped offsite for disposal, are they incinerated, did you say?

A Yes. At high temperature, and , as we understand it, in conformance with regulations that insure their total combustion and destruction.

Q Now, reviewing here: could you give me the total effluent flow from the Sharon plant? You've given me figures for several outfalls. Can you give me the total?

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A. If I can add quick enough.

I'd say apparently it is on the order of five to six hundred gallons per minute.

Q. And is it true that you do not know what portion of that would have to be treated for PCB removal in order to comply with the standard?

A. Yes.

This business of complying with the standard raises a very much different question. For example, it's not apparent to me that if we quit making PCB transformers in Sharon we could comply with the standard.

Q. Is this because of residues from old operations, Doctor?

A. Yes, it is.

Q. Have you made any estimate of what it would cost you to put in activated carbon at the Sharon plant?

A. No, because we would not know how big to make them and whether or not they would do -- you know, what size unit it would take to effect any improvement at all. We would not know what size would be required to make any improvement in the input-output PCB content.

I'd like to add that the activated charcoal and reverse osmosis are simply among the first thing that an engineer would think of as a method for trying to remove small trace quantities from an effluent stream, that it was

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presented in my testimony in hopes of being somewhat helpful, but purely on a postulative or purely speculative basis.

Q On page 11 of your statement you go into alternatives, and you state that:

"Controls on the manufacturing process and/or new manufacturing techniques are not available to meet the proposed standard."

What controls have been investigated to substantiate this statement?

A Well, for example, for the leakage rates at some of our plants which would be, according to the standard, measured against, I suppose, the eventual stream that they're flowing to, or in the case of those going to sewage plants, we are in the orders of numbers of drops per day.

There is simply no process that I know of in which people can handle several million pounds of product a year and be accountable for it within a few drops a day.

There are many places in which the product is extremel high value, where there is every economic inducement you could dream of to try to recover this product; but that's stretching the limits, I think, of our ability to do the job.

Q Well, if the process were run in such a way that there were no discharge of process waste water at all, then you can be certain there would be none getting into the [illegible],

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wouldn't you?

A. Oh, no, not at all. No way.

Q. You would just be certain there was no point source discharge?

A. I think I'm confident that we have no point source discharge now.

Q. If you have no point source discharge, then why are you here?

A. Because you're setting regulations on PCB and we're trying to share with you all the information we have, sir.

Q. Well, let me put it this way:

It's your opinion, then, since there is no point source discharge of PCB's from the Sharon plant, that Westinghouse would be in compliance with the standard tomorrow were it promulgated today?

A. I'm not an attorney. I don't know how that would be interpreted. My guess is your interpretation would be a hell of a lot more important than mine.

Q. Well, let me ask the question a different way, then. I can see Mr. Richel is upset.

MR. RICHEL: You're just talking on two different levels, that's all. Each one has a different interpretation of point source discharge.

BY MR. ECKERT:

Q. When the effluent comes out of the pipe at the

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of the process, does it contain PCB's?

A Ah, so. Oh, yes.

I see. That's your point source. I'm thinking about in the process. Thank you for that clarification.

Q Now, in any of your alternatives here, have you discussed existing plant, existing product, end of pipe treatment as an alternative?

A Yes.

I think this (a) on page 11 dealt precisely with that alternative.

Q Well, you haven't run, as I understood your earlier testimony, any experiments or tests on the use of activated carbon; isn't that right?

A Right.

Q Then on what basis do you say that "controls on the manufacturing process and/or new manufacturing techniques are not available to meet the proposed standard"?

A My understanding of your question was: what could we think about doing at the present plant? One of the alternatives is to refurbish the manufacturing process, to invent, to develop, and to eventually install, when that success became apparent, effluent treatment processes.

But the remark that is made at the end of that paragraph is, however, an accurate description of the present status of that alternative; namely, we have technical limitations

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in that we can't even define it, so it is not even of economic concern.

Q Well, as I understand it Monsanto began around 1970, according to your testimony, to inform its customers that there might be a problem with PCB's.

Did you make any effort between 1970 and the present date to investigate what treatment processes might be used for the removal of PCB's?

A No.

We felt that our first and most profound effect that we needed to do was, we saw many ways which we could and did improve our process control of PCB's, that we think this was substantially improved at every single one of the Westinghouse plants.

This looked to be a far greater way to reach a reasonable --, I must say at some particular cost; you do not do these things cheaply, either -- but it was just that our interpretation was that we needed to fix up the process itself.

Q Now, on page 13, you say that:

"Development efforts indicate a silicone-based fluid may be an alternative to PCB."

Whose development efforts are these?

A At this point I have a lot of trouble making any literature references. This is part of the story we got back

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from what may be going on in Japan, I believe it is. This is in reference to capacitors.

Q Is Westinghouse doing any research to develop alternative fluids for PCB's?

A Yes, we are.

Q And have you developed any promising alternatives, sir?

A Well, the world always abounds with promising alternatives.

The matter is a substitute which -- but if we make a definition now and say a substitute which will have the same or equally efficient properties for capacitor performance, the answer is not only have we not, but to our knowledge no one -- within our knowledge no one has developed a substitute for PCB having the same desirable characteristics. That includes silicone, of course.

Q Well, I guess my question would be wouldn't it be conceivable that some of these might be acceptable as substitutes even though they might not have every property that PCB's have?

A I'm confident that industry-wide contingency planning is in a very high state right now because of these hearings, and we have some units going out on test, I believe it is this summer, that will have a new fluid in it. And research, I guess, has been going on for quite a time. We have

brb 11

have someone with us today who has been in research along these lines for quite a time.

Q Well, I won't try to get into any proprietary information, but can you describe the new fluid which you have developed?

A Well, I could not. There are those here in this room that could, if you would like to have it.

MR. WILLS: I would object to any testimony on that information at this point as being totally proprietary until it is marketed.

MR. ECKERT: It's up to you; I'm not going to insist on it.

BY MR. ECKERT:

Q On page 17 you're referring to the social consequences of the proposed regulations.

In the third paragraph you state:

> "This would not accomplish a reduction in the PCB background and could result in the movement of 2000-5000 workers."

Are these all Westinghouse workers you are referring to?

A Yes.

Q Are all of these workers employed at the Sharon plant?

A No.

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Q How many workers are employed at the Sharon plant?

A Well, I think the question is how many workers are employed at the Sharon plant that are involved in PCB manufacturing?

Q Thank you for restating it. Would you answer that question?

A I'll try.

At Sharon I believe we have a little less than 200, at Sharon.

By the way, that must have been --

Q I will ask you to assume for the time being that discharges into publicly-owned treatment works are out of this regulation entirely and are not covered.

Would it be correct then to state that those 200 would be the only 200 whose jobs might be threatened by the promulgation of the regulations?

A Within Westinghouse?

Q Within Westinghouse.

A I see no reason to doubt that.

Q Could any or those workers, in your opinion, be shifted to production of non-PCB-containing products?

A I could give you my opinion, sir. I don't think it is worth very much in terms of how they would operate the labor force within the constraints of union contracts at the

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Sharon plant.

Q. Well, we have some testimony in here on social consequences, the number of workers that would be displaced.

Is this your work?

A. Yes.

But your question is could we reassign them? That's a different question. In theory, yes. In practice, I don't know.

Q. Now, let's talk about the figure of 3400-8500 workers --

MR. ECKERT: Your Honor, I don't think Counsel should be coaching the witness while he's on the stand.

BY MR. ECKERT:

Q. You referred to 3400-8500 workers that would be affected.

Are these industry-wide?

A. Yes.

Q. Now, out of those there would be, as I understand it, 200 from Westinghouse. On what basis were these figures derived?

A. They were derived on the basis that the regulations for discharge into navigable waters would be extended to pretreatment for sewage in a very short time thereafter. It's an assumption.

Q. So that these figures assume that not only the

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Sharon plant but all of the other plants which manufacture or use PCB's in the process would be affected?

A Yes. That's correct.

Q Do you know what the dollar figure is of annual sales of transformers and capacitors containing PCB's?

A I don't know what it is. I have heard what it is, and this is hearsay.

Q It's perfectly admissible.

A All right.

Between 35 and 45 million dollars a year of PCB-containing transformers; capacitors would, I suspect, be significantly lower.

Q Is this figure the basis for the $68-170 million figure given on the bottom of page 17?

A Yes.

The capacitors plus the transformers would add to be that kind of number.

Q I want to return to the Sharon plant and ask some questions about how the PCB's are handled.

When the PCB's come in, how are they shipped? In what types of containers?

A They're shipped in railroad tank cars. They have no bottom access; they have to be top-unloaded. We extend pipe down into the tank and the material is pumped to one of two major storage tanks.

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Q Is there any possibility of drainage or drippage from this unloading process?

A Yes, there is.

Q Is there water used in washing down around the areas where the tank car is unloaded?

A As far as I know, there is not.

Q How much -- and you can give it to me in tons or pounds -- PCB's are used per day at the plant?

A Well, let me ask you to divide by 365, okay?

Q All right. Pounds per year will be fine.

A About 700,000 pounds per year; and I guess that's about 2000 pounds per day.

Q Are all of the PCB's which you utilize purchased from domestic suppliers?

A Yes.

Q What percentage of this 700,000 pounds is Aroclor - 1254?

A I think it depends on the year. This year, I suspect, none.

Q None this year.

What is the homologue which is purchased in the largest quantity?

A 1016.

Q Which others are purchased?

A Well, 1242 is in the process of being phased out,

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and I believe it has been phased out. But if it isn't, it's in much smaller supply. But it would be the other homologue.

Q So that these would be the only two which would be purchased by Westinghouse?

A Yes.

Q What happens to the tank cars after the PCB's are transfered?

A They're hauled off.

Q They're sent back to the manufacturer without further processing?

A Oh, yes.

Q Is there a direct connection between the pipes which unload the tank cars and the vessels in which it is stored, in which the PCB's are stored in the plant?

A They are stored in tanks outside; but there is -- yes, a direct permanent connection between the unloading pumps and the tanks.

Q Are impervious sumps used in the unloading operation to catch the spills and drips?

A We have sumps around the pumps, and the material that is collected in the pump sump is normally placed in our waste or slop PCB.

Q Is this so designed as to catch all the drippage that might result from the unloading operation?

A Well, all and zero are tough words to engineers.

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Yes, it's designed to collect all the drippage, yes.

Q Have any measurements been conducted of spillage and leakage?

A Any measurements of the quantity spilled or leaked?

Q Yes, which can be accounted for by the sump pumps.

A No.

Q How many drops or what quantities drip off in the unloading process?

A I think about ten times the standard, but it's conceivable -- that's a facetious answer.

Let me take a look.

I don't know. Like, any drop starts using up a large fraction of our standard, and I couldn't tell you how many drops might come off in the unloading process.

Q Are the unloading operations conducted in a covered facility?

A No.

Q So it is open to rainwater?

A Yes.

Q How large an area would have to be enclosed to permit sheltered unloading?

A I don't know. I guess about somewhere between 50 and 30, 50 by 30. I'm not sure we're thinking about the same thing.

Q Well, you stated, as I understand it, that the

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JUDGE SWEENEY: Back on the record.

Who will be next?

MR. ECKERT: Next I would like to call Mr. W. B. Papageorge.

Whereupon,

W. B. PAPAGEORGE

was called as a witness by the Environmental Protection Agency and, having been first duly sworn, was examined and testified as follows:

JUDGE SWEENEY: Mr. Papageorge's affidavit will be identified as Exhibit 83.

xxxxx (The document referred to was marked Exhibit 83-1 thru 43 for identification.)

JUDGE SWEENEY: How many attachments are there? They are not identified in any way.

MR. PARK: They are listed on the last three pages of the affidavit. They're identified by number.

JUDGE SWEENEY: I see. So we can put our own numbers on there. They would be 83 and then subnumbered 1 through 43; is that correct?

MR. PARK: Yes, sir.

JUDGE SWEENEY: Mr. Eckert.

MR. ECKERT: Thank you.

CROSS-EXAMINATION

BY MR. ECKERT:

Q Good afternoon, Mr. Papageorge.

In your first paragraph you list your credentials. You're a chemical engineer. Is that correct?

A That is correct.

Q Have you ever performed any bioassay work?

A No, sir.

Q Have you any training in biology, toxicology, or related fields?

A No, sir.

Q Has Monsanto done any work to ascertain the toxicity of PCB's?

A Yes, we have.

Q Could you briefly describe the work that has been done, and by whom it has been carried out?

A We have sponsored work dealing with laboratory mammals, more specifically the white rat, beagle dogs, and worked with leghorn chickens. This work is being performed in the Industrial Biotest Laboratories in Chicago, Illinois.

We have also sponsored some fish toxicity studies by that same laboratory, and also by Bionomics Laboratory in Wareham, Massachusetts.

That's all I can recall at the present.

Q Were the fish toxicity studies 96-hour tests or

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were they or were any of them of longer duration?

A No, they were the short-term.

Q Have you cited the results of these tests at any point in your affidavit or in the exhibits?

A I don't-- No, sir.

Q Now on page 2, number 3, you propose a definition of PCB's, and you propose to restrict it to those which have been shown to persist and rapidly bioaccumulate in the aquatic environment.

Why is it necessary to restrict PCB's to those which persist and rapidly bioaccumulate?

A From my personal long exposure to the PCB environmental problem there is no question in my mind that what we're all talking about in the final essence are those isomers which appear to resist degradation and the problem seems to be one primarily of presence in the vast majority of the recorded literature.

And if true then we should concentrate our attention to those isomers that are identified in the environment.

Q Now on page 3, you describe PCB's in general and there, at aboutthe third paragraph you state the properties of PCB's, and you list inertness as one of the properties.

Now a material is inert because generally it resists decomposition and degradation; isn't that correct?

A That is correct.

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Q And you have not distinguished in your statement between various isomers of PCB's.

Would it be a fair statement that all of them are relatively inert chemicals?

A No, it would not be.

Q Which ones are not inert?

A The lower chlorinated isomers of chlorinated biphenols are fairly active, reactive.

Q What is an isomer?

A I don't know if I can come up with the correct scientific definition but it is a chemical entity which contains the -- in this instance the same biphenol configuration and the location of the chlorine at a specific point in this configuration.

And as I say that, I recognize it is not very clear.

Q Well, I would like to define our terms early. If we are talking about two PCB's that have three chlorine atoms apiece but at different points, are those isomers?

A Each one is an isomer.

Q Each one is an isomer.

A Together they are referred to as homologs.

Q Now, is a PCB which contains three chlorine atoms and a PCB which contains four chlorine atoms, is one an isomer of the other?

A No.

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Q So that these are referred to a homologs, are they not?

A They are not isomers of each other; they are isomers of chlorinated biphenols.

Q So that you use isomer to refer to any particular chlorinated biphenol?

A I use isomers to refer to the chlorinated biphenol which contains a given number of chlorine atoms which are fixed to the biphenol grouping in a fixed position.

Q Well, perhaps we can clarify this as we go along.

Have you figures on the total production of PCB's for the years -- for approximately the last four years?

A I don't have the exact figures with me, but they range-- The last four years?

One of my attachments is a copy, though I don't know if I even attached it. The PCB Task Force, the interdepartmental task force report on PCB's had, in the early part of that report, a two-page table of the production of polychlorinated biphenols by Monsanto in the years 19 -- I forget, the 1950's on.

Q Is that Exhibit No. 33 to your affidavit?

A Yes.

Q Would you identify where in this exhibit the figures appear?

A This is the exhibit we are talking about.

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(Witness displaying document.)

On pages 6 and 7-- I think I may have misled you, sir. Just a moment, please.

(Pause.)

I did mislead you. 33 is not the reference. It's reference No. 1. My apologies.

Q I see.

I'm not sure I have a copy of reference No. 1. In fact I don't think I do.

In any event,--

MR. RICHEL: Would you like to see my copy?

MR. ECKERT: Yes, I would.

JUDGE SWEENEY: I don't believe that the official record has a copy of it.

MR. PARK: Judge Sweeney, it was not included because this of course was sent out by the Task Force of which I believe EPA was a member. Would it be possible for you to include it by judicial notice or by reference?

JUDGE SWEENEY: Well, just so the record is straigh and has everything in it it should have.

You statedat the beginning that there were 43 attachments and if there are not 43 we ought to correct it.

MR. PARK: Yes, that is an error.

JUDGE SWEENEY: I think there are considerably less than 43.

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Do you have a copy to give to the reporter so at least the official record will be correct?

MR. PARK: We don't have one here. We could certainly obtain one. It being a government publication, we didn't include it. We felt every party already had a copy.

JUDGE SWEENEY: Well, but there's a difference between references cited and exhibits of record.

MR. PARK: Yes, sir.

JUDGE SWEENEY: Now if you just want to refer to it, Mr. Eckert, as a government record rather than an exhibit of record, then we won't get the transcript fouled up and in error.

BY MR. ECKERT:

Q Well, if we look at the figures for sales of Aroclor 1254 for the period roughly 1968 through '72, we find that it ranges from a low of 5000 -- that is say 5,000,000 pounds in 1971 -- Is that figure correct?

A Yes.

Q -- to a high of 12,421,000 pounds in 1970. Is that correct?

A That's correct.

Q And the prospect for 1972 was six million pounds. Do you know what the actual figure was for 1972?

A I don't have that with me, no, sir.

Q Well, in Monsanto's original objection which we

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filed on January 18th-- Do you have a copy of that that you can refer to?

A I believe you're referring to the November 29th presentation to the Effluent Standards and Water Quality Information Committee?

Q Yes, that's correct.

A I have that.

Q Now on page -- I believe it is page 6, there's a bar chart. Do you have that bar chart?

A Yes.

Q Now that appears to show that in 1972-- Am I reading the chart correctly -- between nine and ten million pounds of Aroclor 1254 were produced.

A That is correct. Yes, sir.

Q And roughly the same level for 1973?

A That is the projected for '73.

Q Are actual data available for 1973?

A I just received that this past week. I don't have it with me.

Q Do you recall what the figure was for total production?

A Not exactly; about 40 million pounds total production but I don't remember the breakdown as to type of Aroclor.

Q Now this chart is labelled "Aroclor Production at the William G. Crummich Plant." Are there other plants at

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which Aroclors are produced?

A Not in Monsanto.

Q Not in Monsanto.

Would these data, in your opinion, tend to show that Aroclor production has been relatively steady over the last three or four years?

If you can't answer that question, I rephrase it:

These data do not confirm to date that Aroclor 1254 production is decreasing?

A That is correct.

Q Now Monsanto's concern is amply documented here about PCB's. Has this concern led Monsanto to work on the development of substitutes for PCB's?

A Yes, it has.

Q And what is the status of the research which has been carried out?

A Research of course continues. We have succeeded in finding some alternatives with some trade-off in some properties, some sacrifice in some properties.

Examples include the reformulation of hydraulic fluids for industrial purposes.

Q Well, PCB's are not now used for hydraulic fluids, are they?

A That is correct.

Q I'm referring to the capacitor and transformer

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applications which are alleged to be non-substitute.

A Oh, I thought you meant the total market.

Research continues in finding alternatives for dielectric fluids. So far we have not succeeded in finding any material that possesses the properties we are told by our customers are essential to the application, primarily those properties of resistance to fire and resistance to formation of explosive gases when these fluids undergo stresses in service.

Q On page 6 of your affidavit you state that, "We object to this definition. . ." that is, the EPA-proposed definition of PCB's, "because it implies that all polychlorinated biphenol isomers are of equal environmental concern; i.e., that they all persist and bioaccumulate in the same manner in our environment. It has been well established by academic, government and industrial researchers that this is simply not true."

Now, with respect to this statement, is this supported entirely by the exhibits which you have attached to your affidavit?

A The exhibits I have attached and this particular reference, Nos. 2 through 13, were intended only as typical examples of the kind of reports that are available. I did not intend to imply that I have access to all possible reports generated throughout the world relating to this subject.

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I just cannot get my hands on all reports.

Q Well, let's take a look then at Exhibit 2.

Now as I understand it, it is your position that the lower chlorinated homologs are selectively degraded. Is that correct?

A That is correct.

Q The author of Exhibit 2 states on page 353 and 354 that:

"It might be expected, therefore, that biphenols with fewer chlorine atoms would predominate in planktonic samples unless these compounds were selectively degraded."

And that, I understand it, is the position of Monsanto. Is that correct?

A That's correct.

Q But in the next sentence the author states:

"Alternatively, since the solubilities and partition coefficients with organisms of the individual PCB compounds in a complex mixture present in an aqueous system can be expected to show considerable variation, the compounds detected in plankton would preferentially be those with lower solubilities in water and higher partition coefficients."

Could this not account for the lack of detection of

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lower chlorinated homologs in the environment?

A Will you give me some time to think about that?

(Pause.)

Q Well, let me ask the question differently.

Do you know what the solubility of Aroclor 1016 is?

A I can give you an approximation.

Q Approximately?

A About 200 parts per billion in tap water at 25 degrees Centigrade.

Q And the solubility of Aroclor 1254, approximately?

A Approximately 50 parts per billion.

Q And the solubility of 1260?

A About 25 parts per billion.

Q So is it a fair statement that the more chlorine atoms, the lower the solubility?

A Yes, that is correct.

Q So that you would expect, if what the author here states is true, to find more of the higher chlorinated homologs because their solubilities are lower. Is that not correct?

A I don't quite understand your question. It would seem to me that the more soluble the material, the more easily it would get into the water systems of the world, and therefore more easily detected.

Q Well, the author here states that:

". . .the compounds detected in plankton

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would preferentially be those with lower solubilities in water and higher partition coefficients."

Do you agree or disagree with that statement?

A I know nothing about plankton, so I cannot comment.

Q To your knowledge, have the lower chlorinated homologs been detected in the environment?

A My answer to your question specifically is yes, but I'm wondering if we're talking about the same thing.

Q Well, perhaps you had better explain your answer in somewhat more detail.

A There have been many reports of a material identified as Aroclor 1254 being identified in environmental samples In this material referred to as Aroclor 1254 there are chlorinated biphenols which properly are referred to as the lower chlorinated homologs.

So in answer to your question, have the lower chlorinated homologs been identified in nature, the answer has to be Yes.

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Q Well, you have stated here on page 6 that:

"Environmental monitoring programs have clearly demonstrated that with the exception of direct high-level controllable release near points of manufacture or use, the PCB's found in our environment are the more highly chlorinated ones, i.e., those containing predominantly five or more chlorine atoms per biphenyl molecule."

Do I understand the statement you just made to be a modification of this statement?

A No, sir.

Q In other words, the only time that lower chlorinated homologues are found are where they can be associated with direct, high-level controllable release.

Is that correct?

A Not the only times, no.

There are situations in which living creatures have been found to contain the lower chlorinated mixtures and in those cases it can be demonstrated that the source of the lower chlorinated material was known, identifiable, and of a given type.

Q Do you know what a partition coefficient is?

A I believe I do, yes.

Q Could you tell me what it means?

A I believe it's a measure of the ratio of the abilit

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of a material to be present in one media as compared to another.

Q Would it be a measure of the rate of uptake in animal fatty tissue?

A It could be one of them, yes.

Q Do you know what the rate of uptake in animal tissue is for the various -- how the rate of uptake for, for example, Aroclor 1254 relates to the uptake for Aroclor 1016?

A No, I do not.

Q How are PCB's measured in the parts-per-billion range? What analytical technique is used?

A Electron capture gas chromotography.

Q Does the sensitivity -- or is the sensitivity of that technique higher for higher chlorinated homologues?

A I have never heard that. I do not know.

Q Does the technique depend upon the detection of chlorine atoms?

A No.

Q How does it work?

A As I understand it, it is based on the characteristic of many materials in which their ability to adsorb on certain kinds of surfaces or materials varies with their chemical structure.

And there are devices that have been developed

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in which the material being studied is introduced under certain conditions -- of temperature, primarily.

This material is then, under these conditions of temperature involved, is trapped on this adsorbed material and these other devices are there to help us identify and quantify this material.

Q How precisely is the material quantified?

A I'm not an analytical chemist, so I can't answer.

Q Is salicylic acid cleanup used in the GLC process?

A Mr. Eckert, not being an analytical chemist, I cannot comment.

However, I have with me Dr. Scott Tucker, and if you wish we can consult with him to provide appropriate answers.

MR. PARK: Is that all right?

MR. ECKERT: I would rather, if Dr. Tucker is capable of answering this question and Mr. Papageorge is not, I would prefer to question Dr. Tucker directly. But we can do that later.

BY MR. ECKERT:

Q You have referred in the next paragraph to the lower polychlorinated biphenyls degrading rapidly enough to prevent bioaccumulation.

What is degradation? What do you mean by "They degrade"? What happens to them?

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A. As I underst nd your question, it consists of two parts: what do I mean by degradation?

To me, degradation means that the material has lost its initial chemical identity after undergoing changes brought about by any one of several influences.

Now,what happens: I don't quite know how to answer that except that the chemistry of the final material differs from the chemistry of the initial material.

Q. And your statement, with respect to degradation, is based upon papers 17 through 21, and 37.

Is that correct?

A. Yes, sir.

Q. Do any of those papers deal with PCB's having more than three chlorine atoms?

A. Oh, yes.

Q. Which ones?

A. They all do.

Q. Well, let's take a look, first, at 17: that's Evans and Lunt.

How many chlorine atoms are in the PCB's that were involved in this experiment?

A. We are looking here at a summary of a paper, and as I read this summary it refers in the last paragraph to chlorinated biphenyls. That is the only reference I see to the chlorinated biphenyls, so I have no way of knowing from this

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summary the scope of this work.

Q How about the next one: "Metabolism of Biphenyl by Psuedomonas Putida"?

In this paper there are no chlorine atoms in the biphenyls.

Isn't that correct?

A I see no reference to the chlorobiphenyls: that is correct.

Q Now, reference 19 is --

MR. PARK: Could I raise one question here?

I have a feeling, just as in Dr. Thompson's original testimony that was presented some time ago where we found out that he did not put it all together himself, Mr. Papageorge has done the same thing here.

A great deal of this -- or certainly some of it -- was provided by our Dr. Tucker, who is here. Is it possible, or would there be any objection to letting Dr. Tucker and Mr. Papageorge confer on the questions that you're asking?

MR. ECKERT: Yes, I think there would be an objection.

I don't see any point in having Mr. Papageorge testify to something that he knows nothing about. Now, if that's your position, that Mr. Papageorge is not competent to answer this question we will hold it for Dr. Tucker later on.

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MR. PARK: That's not the point I thought I was making here.

Again, assuming we're after the truth, let's keep in mind that Monsanto is not directly affected by the toxic pollutants regulations that are the subject of the hearing. We're here simply to try to provide what we feel is some reason to the standards that will be promulgated by the EPA.

We are a manufacturer of a product. We have some experience in dealing with it. We're trying to assist in finding the truth.

I thought that I -- at least, I certainly received the impression in the early days of the hearings, when the EPA witness was on the stand, that he made clear that a number of people came together to put forth and to prepare and develop the documentation that the EPA had relied on at that time.

I fail to see why you would object to allowing two people here to respond to the question.

MR. ECKERT: I'm just trying to keep the proceedings from getting confused. I would like to talk to people who are knowledgeable on the subject matter, that's all.

MR. PARK: Well, let's let the record indicate that we have another man here who might well be able to answer the questions raised.

MR. ECKERT: I will pass over this for the time

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being.

BY MR. ECKERT:

Q I would like to turn to reference 4.

That, I believe, is the Jensen paper.

On page 248, the authors state:

"We found that the principle PCB components were PCB numbers 7 through 14 (low number is equal to a low chlorination degree), but the mussels also contained the lower numbers."

Does this not lead to the conclusion that PCB's with lower numbers also accumulate in aquatic organisms?

A Yes.

But it tells us nothing about the source of that PCB and the proximity of the mussels, in this instance, to that source.

Q That's true; it doesn't.

Does it tell us anything about whether the PCB's degrade?

A Not in this instance.

Q In reference 17 -- and I'm going to be referring now to your statement that the chlorinated biphenyl isomers readily undergo bacterial degradat on; the rate is dependent on the number of chlorines per biphenyl molecule.

The first exhibit to substantiate this is Exhibit 17.

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Now, Exhibit 17, as we have already established -- I believe we were going to hold this for later questioning.

Exhibit 18, as I recall, is unchlorinated biphenyls, so we come to Exhibit 19, "Degradation of Polychlorinated Biphenyls".

I think on this one I had better hold that for Dr. Tucker.

What I would really like to ask you about is the study that was carried out by Monsanto -- Oh, this is another study by Dr. Tucker. I really think all of these questions had better be held for Dr. Tucker.

In the next paragraph it's stated that:

> "The rapid metabolism of these chlorinated isomers, and their lack of importance as contributors to the chlorinated biphenyl tissue is evidenced in the results of numerous studies."

Now, to your knowledge, have metabolites of PCB's ever been identified?

A I do recall reading reports in which some attempts have been made to identify the metabolites of chlorinated biphenyls.

Q Which reports?

A I do not remember. I don't recall them now.

Q Nothing you have supplied us here?

A I don't believe so.

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Q Can you state with any certainty that metabolism has occurred, unless you have identified a metabolite?

A No.

Q In other words, you would agree that the data which you have provided us here don't support the rapid metabolism set forth in the bottom paragraph on page 6?

A I note, in that one paragraph, when I start the paragraph I do refer to rapid metabolism. Later, if you will read further, I also use the expression "and/or excretion", as I remember.

Q Rapid metabolism or excetion?

A Or excretion.

My intent here was to show that there was a disappearance of that material.

Q Where does the material go? Has that been identified?

A In this instance here?

Q Yes.

A I do not know.

Q In Exhibit 28 -- this is the study by Mr. Ryter at Woods Hole -- on page 9 a series of concentration factors are given.

Do you have that before you?

A Yes, sir.

Q There it says that for isomers with two chlorines

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the concentration factor is 1000.

Is that right?

A Yes.

Q And for three chlorines it was 7500?

A Yes.

Q And for four chlorines, symmetrical, 8000?

A Yes.

Q And four chlorines, asymmetrical, would be 12,000?

A Correct.

Q Do these data, in your opinion, support a conclusion that the lower-chlorinated homologues cannot accumulate?

A I sense here some confusion, either in my understanding or in your understanding, Mr. Eckert, and I don't quite know at the moment how to clarify it.

Q Well, why don't you answer my question first, and then you can clarify the misunderstanding?

A Your question, as I understand it, says that I made a contention that the lower-chlorinated isomers do not accumulate, and I don't know that I ever said that.

Q It states here on page 6, and I am quoting you now, sir:

"The lower polychlorinated biphenyls degrade rapidly enough to prevent bioaccumulation."

A Again, we've got to look at this with the proper perspective. Are we talking about the oyster that's exposed

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to this material at the source of discharge, or are we talking about a creature in the environment remote from any immediate discharge of these materials and eventually exposed to these materials we call chlorinated biphenyls?

Q Well, let's talk about the latter type for the time being, since that seems to be what you're stating won't accumulate any biphenyls.

Is it your position that organisms which are not directly at the point of discharge will not accumulate lower-chlorinated homologues?

A My position is that the creatures in the environment are not apt to accumulate lower-chlorinated isomers of chlorinated biphenyls to a degree that would be expected from the amount of chlorinated biphenyls that have been introduced into the environment, which would indicate that some of these isomers have been made inactive or have been chemically changed to the point where they are no longer identifiable in these creatures as isomers with low chlorine content of chlorinated biphenyls.

Q Well, couldn't the lack of finding of the lower-chlorinated homologues in the environment be equally attributable to the difference in concentration factors between lower chlorinated and higher chlorinated homologues?

For example, in this Ryter paper it appears that isomers with six chlorine atoms accumulated at a rate 40 times

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as much as those with two atoms.

Couldn't that account for the lower incidence in the environment of tissues containing PCB's of lower chlorinated homologues?

A. I don't understand your question.

Q. Do you have any evidence that degradation of the PCB's is responsible for the lower residues of lower-chlorinated homologues, as opposed to simple differences in the bioconcentration factors between the homologues?

A. What's the question?

Q. Do you have any data to show that degradation is responsible for the lower incidence of lower chlorinated homologues, as opposed to the differences in concentration factors between higher chlorinated and lower chlorinated homologues?

A. There are some exhibits which I suspect you wish to talk to Dr. Tucker about, or question Dr. Tucker about, in which there is evidence that the lower chlorinated isomers of biphenyls, chlorinated biphenyls, degrade.

There's also other evidence in the exhibits attached- I believe it is reference number 33 -- there's a section in that presentation to the task force in May of 1972 in which we compiled some information that we had in terms of what we know about the amount of chlorinated biphenyl we have sold through the years and the amount that appears to be identified

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in samples from the environment.

There is an inconsistency in terms of the amounts represented in that information of the higher-chlorinated isomers as compared to the lower-chlorinated isomers.

Q. Are the environmental samples ambient samples or tissue samples?

A. What is your definition of ambient, sir?

Q. Samples from the water or the sediments, analyzed directly.

A. The samples I have referred to were primarily tissue samples.

Q. So I ask once again: couldn't that difference be accounted for by the difference in the degree to which these homologues accumulate?

A. I don't know.

Q. You don't know.

MR. PARK: Do you understand the question?

THE WITNESS: I don't understand the question.

MR. PARK: I think the witness is looking at a table here that shows there are fewer lower chlorine isomers concentrating in the environment, and is thinking that that indicates that they degrade, since more are manufactured than the higher chlorine isomers.

MR. ECKERT: Well, perhaps the witness can direct me to the table he's looking at.

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THE WITNESS: This is the article by John Ryther which I have listed as Exhibit 28. On page 9 there is a table and let me refresh my memory again on this.

(Pause.)

As I understand his work, Ryther's work goes to Aroclor 1254 and the investigator then determined the amount of dichloro, trichloro, pentachloro, and so on, diphenol that they found in the tissues of these mussels and from that he calculated a concentration factor.

I don't know that that tells me anything about degradation.

MR. ECKERT: Well, I think that's what we wanted to say, too. I'm glad to hear you say that.

THE WITNESS: This does not tell us anything about the elimination of the material without degrading it. That's the point I'm trying to make.

BY MR. ECKERT:

Q Now on page 7 you state that:

"Similar findings in fresh water and marine fishes were reported by Zitko and Jensen. . ."

When you say "similar findings" what do you mean?

A By using the word "similar" I'm referring to the previous reference, Risebrough No. 2, in which Dr. Risebrough referred to the fact that more Aroclor 1232 had been present than Aroclor 1254, you invariably [illegible] taken in the

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environment, other than those taken near an outfall or material identified in tissue, is referred to as being more similar to Aroclor 1254.

Q The Jensen paper you cite is entitled "DDT and PCB in Marine Animals in Swedish Waters." Is that correct?

A That is correct.

Q Do you have any data on the relative discharges of high and low chlorinated biphenols into Swedish waters?

A No, sir.

Q So that there is no basis for concluding then that the levels which were found are higher than would have been predicted because you don't know what to predict, based on the quantity discharged. Isn't that correct?

A That is correct.

Q Now you stated in the next sentence:

"The disappearance of the lower chlorinated homologs in extracts of tissues from birds and mammals indicate rapid metabolism or excretion of the lower chlorinated homologs."

Are there any data on aquatic organisms as opposed to birds on such excretions?

A I'm not aware of any.

Q Even if materials are excreted, can they not exert direct toxicity?

A I'm not qualified to answer.

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Q I'd like to refer now to the Bagley and Reichel, et al. paper, Exhibit 12, I believe.

Now on page 254 of that paper there are some mass spectrographs.

Am I getting into an area where I should ask Dr. Tucker about the interpretation of these charts?

A I would suggest that, yes.

Q Very well. We'll hold these questions.

On page 8 you state:

". . .there is a definite difference in the toxicity and availability for bioaccumulation of dissolved and adsorbed chlorinated hydrocarbons."

And you cite three exhibits.

I'd like to turn first to Exhibit 24. There it states that-- The authors state in the second sentence of the article that:

"Both organochlorine insecticides and --"

A Let me find it first.

Q Greichus, Greichus, and Emerick.

A All right.

And page which?

Q The first page of the article.

The authors state that:

"Both organochlorine insecticides and polychlorinated biphenyls are stored in the fat

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of birds and are difficult to eliminate from the body. Therefore, it could be expected that PCB's would also be concentrated in the food chain of carnivorous birds."

Do you agree with that statement?

A I find no quarrel with it.

Q Does this lead to the conclusion that PCB's are rapidly eliminated or excreted?

A This doesn't tell me which PCB's he's referring to.

Q Now you cited this paper on the difference in toxicity and availability for bioaccumulation of dissolved and adsorbed chlorinated hydrocarbons. Could you point out to me where in this paper the difference in availability of dissolved and adsorbed PCB's is discussed?

A Let me refresh my memory. I haven't read it for some time.

(Pause.)

MR. PARK: Judge Sweeney, would it be permissible to let the record show, in deference to the witness, that these materials were submitted just about two months ago, and at that time the witness was much more familiar with all of the attachments and citations than now.

MR. ECKERT: Well, I would expect your witness, just as our witnesses, to be ready to be cross-examined on any of the materials they have submitted. I certainly [illegible]

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not expect any loss from our witnesses when they are on the stand, Mr. Park.

MR. PARK: Well, Mr. Eckert, let the record indicate that some of the materials that I understand are coming from your witnesses have yet to be received by us.

MR. ECKERT: That's not the issue. The issue is whether or not our witnesses will be prepared to answer questions from Industry Counsel.

MR. PARK: I was just pointing out that the time period between preparation of your witnesses' testimony and their cross-examination and that between our witnesses' preparation and his cross-examination is widely different.

BY MR. ECKERT:

Q With all due deference I think we should try to move along here and not delay any longer. If you come up with something--

A I can't find it. When it was initially put in I thought it was relevant. At this moment I just can't find the specific paragraph or statement which at the time I thought was relevant.

Q When PCB's appear in sediments, in your opinion are they then removed from availability for uptake into organisms or do they remain available?

A The availability of the PCB's to adsorb on particulate matter to organisms will vary on many conditions and

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as the type of organism, its proximity to the sediment, its ability to -- let's call it digest the sediment if you will, or extract the PCB from the sediments.

Q Could you not have a situation in which the sediments in the ambient water were in equilibrium and in fact there was an interchange, an exchange of PCB's between the two media?

A Yes. The answer to your question is Yes.

Q You also cited Exhibit 35 for this same proposition and I would like to ask you to turn to Exhibit 35.

Exhibit 35 deals with Endrin. Isn't that correct? And isn't it true that Exhibit 35 does not directly deal with PCB's at all?

A That is right, but the reference is to chlorinated hydrocarbons and this was introduced as an example of the types of things that investigators are finding with chlorinated hydrocarbons.

Q Well, now, this paper-- Let's take it on its own merits. Does it say anything with respect to the difference in the toxicity and availability for bioaccumulation of dissolved and adsorbed chlorinated hydrocarbons?

A As I understand this paper, it attempts to demonstrate that a chlorinated hydrocarbon is available to the particular species of fish referred to there, primarily through its gills rather than through the digestive sy[illegible]

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Q Does that have anything to do with the difference between dissolved and adsorbed chlorinated hydrocarbons with respect to their bioaccumulation potential?

A I would think so.

Q What conclusion do you think can be drawn from this paper?

A The conclusion I drew from this paper is that this particular material, Endrin, accumulated in the fish that were studied to a high degree, primarily through the gill.

Q But does the paper specify whether the accumulation was through the taking in of dissolved or adsorbed material?

A I assumed it was dissolved material.

Q But the paper doesn't say that?

A It doesn't say it is on particulate matter either.

Q It doesn't say either one so there is no basis for a conclusion; isn't that right?

A Okay.

MR. LORANT: Mr. Eckert, before you leave that, could you give me the citation of that paper since I don't have a copy of it here?

MR. ECKERT: The paper I'm referring to here is "The Pathway of Endrin, Entry in Black Bullheads, Ictalurus melas," and it's by Ferguson and Goodyear and Copeia, 1967, pages 467 to 468.

BY MR. HOWARD:

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Q Finally, we come to Exhibit 36, Polychlorinated Biphenyls Adsorbed from Sediments by Fiddler Crabs and Pink Shrimp."

Is there any data here with respect to the difference between dissolved and adsorbed chlorinated hydrocarbons?

A If I recall the question, you said "Is there any data" in this article that refers to the availability of dissolved or adsorbed chlorinated hydrocarbons.

Q The difference in availability between the two forms.

No, this article just shows that fiddler crabs were found to contain Aroclor 1254 after being exposed to sediments containing Aroclor 1254, it does not attempt to show difference between that and any other type of exposure.

Q This paper does show that even after Arocolor 1254 is -- has entered the sediments, it still remains available for biological uptake, does it not?

A That's right.

Q Further up on page 8, you have stated, "We have found if waste water streams are not sampled properly, the PCB levels found depend on the sampling procedure employed and bear no relationship to the amount of PCBs discharged."

Now what would be the effect upon the levels detected of improper sampling procedures? If your procedures were improper, would you expect to find more or less PCBs than are actually there?

A It could go either way.

Q What would be the effect of an improper sampling procedure? What are the improper sampling procedures? Could you describe the difference between a proper and an improper sampling procedure?

MR. PARK: Mr. Eckert, let him go ahead and answer the question, but I just wanted to say that this is something Dr. Tucker could answer much more ably, if you would wish.

MR. ECKERT: All right. We could hold that.

Is the same true of the discussion on page 9, testing by other laboratories?

MR. PARK: Yes.

BY MR. ECKERT:

Q On page 10, you state in the last paragraph on the page that cumulative sales of PCBs have been estimated to be about 500,000 tons.

Has anyone, or has Monsanto made an attempt to ascertain where those PCBs are today? How much of those PCBs can be accounted for?

A The only attempt to answer that question was made by Dr. Serafim from the Massachusetts Institute of Technology and he included a summary of his thoughts in that Exhibit No. 1 that we were looking for earlier.

Q And I hope we will be provided with a copy of that, too.

MR. ECKERT: Will we be provided a copy of that before the close of today?

MR. PARK: It's an EPA publication, Mr. Eckert.

THE WITNESS: No, it is not.

MR. PARK: I'm sorry.

THE WITNESS: We assumed something, that everybody interested in PCBs had this. It has become the bible.

MR. PARK: It's a governmental publication. I recognize it's our responsibility to bring the thing in.

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JUDGE SWEENEY: Well, could he borrow your copy overnight?

MR. ECKERT: My consultant has a copy which he has just handed to me, so I think the problem is solved.

THE WITNESS: We apologize.

JUDGE SWEENEY: You will supply one for the Reporter?

MR. PARK: Yes, sir.

BY MR. ECKERT:

Q About one-half of the PCB's, you state, were used in an application where containment was difficult and losses into the environment were common.

Is it your opinion that all of these PCB's were lost to the environment, or are some of them still out of the environment uncontained?

A When you say "all", do you mean the half?

Q The half, yes.

A It's my opinion that they went out to the environment fairly rapidly.

Q It states that:

"Extensive harm predicted by some theories has not been found and documented."

Can you tell me what theories you are referring to here?

A I can give you some examples that come to mind. The demise of bird populations due to thin eggshells: that

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has been disproven following the initial emotions that arose in the late '60s and the early '70s.

Q Who predicted this would happen due to PCB's?

A I'm trying to remember some of the articles.

Dr. Risebrough was one of the proponents of the theory covered very emotionally in the San Francisco Chronicle in '69.

I don't have all of those articles with me. There was, I believe an article in the Environmental Reporter. I don't recall all of them.

Q Are you familiar with the work done by Platonow on minks?

A I have read the reference to the Platonow work; I have not been able to get a copy of that paper.

Q That would be an example where some harm evidently did result.

Isn't that correct?

A Not having seen the paper, I do not know.

Q Are you familiar with the term "Yusho disease"?

A Yes.

Q To what does it refer?

A It's the expression used to describe an epidemic that occurred -- at least, it was referred to as an epidemic: symptoms that occurred among a group of about 1000 people in Japan and is attributed to the presence of PCB's in rice oil used for human consumption.

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Q Do you recall what symptoms these people experienced?

A Yes.

I recall such symptoms as headaches, dizziness, and running of the eyes, nausea, loss of appetite, skin eruptions, infants born with pigmentation problems that cleared after three months, as I recall.

Q Of the adults who were afflicted: did the problem go away quickly or did it seem to linger on for a long time?

A I believe it varied from person to person; at the last I read there were still some of those people that exhibited some of the symptoms.

Q And how long ago was their exposure?

A The late '60s, about 1968.

Q Are you familiar with any data on damage to cows in England that was attributed to PCB's?

A No.

Q On page 11, you state that the lack of extensive harm, or the lack of evidence of extensive harm, indicates that -- and I am paraphrasing you; correct me if I do so incorrectly --

A Would you give me the paragraph? I find when I'm looking for it I can't listen to you.

Q The top of the page, page 11.

A All right.

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Q "This lack of evidence indicates that all of the PCB's do not persist in the environment as a result of factors such as the biodegradation we have discussed previously."

Isn't it equally possible that the total amount which has been discharged has not yet, on a world-wide basis, reached harmful quantities?

A No, I can't accept that.

From my understanding of the uses of polychlorinated biphenyls, the amounts introduced into commerce, I find it very difficult to conceive that this material has not been introduced into the environment by now.

Q Not that it has not been introduced, but if you spread all of the PCB's that have been introduced into the environment evenly over the world, what sort of concentrations would you expect to find, for example, in the aquatic environment?

A Very low.

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Q In fact it might well be below the limit of detection, might it not?

A Yes.

Q And so the fact that you do not find them doesn't necessarily mean that they are not there. Isn't that also true?

A That's true, but when I say lack of evidence I'm talking about effects rather than presence. It would seem to me that the effects, if any, were to be--

Q It seems to me this sentence does not talk about effects. It talks about persistence. Can you draw any inferences at all with respect to persistence from the lack of effects?

A Did you say resistance or persistence?

Q Persistence.

A Well, when I worded this, the word "evidence"-- I had intended it to refer to the last sentence on page 10. I was referring to evidence of extensive harm.

Q Well, the evidence of extensive harm-- Let me ask you this:

Just because harm has not been found has nothing to do with persistence or non-persistence; true or false?

A I can't answer that.

Q You stated that the lack of evidence of harm, as I understand your testimony, indicates that PCB's do not

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persist. But couldn't it just as easily indicate that PCB's world-wide have not reached quantities -- and I'm talking of the lower chlorinated homologs -- have not yet reached harmful quantities?

A You're talking about reaching harmful quantities world-wide--

Q That's right.

A -- but before they reach harmful quantities world-wide they must have reached harmful quantities locally, and since nothing happened locally, how could we expect it to happen world-wide later?

Q Well, I think we've established that some local harm has occurred or perhaps we haven't established that with you, but even passing that on, can you draw any inferences at all with respect to persistence from evidence of harm?

A Would the Reporter repeat the question?

(Whereupon, the Reporter read from the record as requested.)

THE WITNESS: No.

BY MR. ECKERT:

Q Now on page 11 you state:

"The PCB's that do persist may not be available because of some factors not clearly understood at present."

Do you see that?

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A Yes, sir.

Q Do you have any data to substantiate this statement?

A Well, there is this evidence that I referred to earlier in Exhibit 33, in which we attempted to show that the amount of material that was sold and presumably introduced eventually into the environment differs from the kind of material being identified.

Q But in fact you don't know why this is; isn't that correct? There could be any number of--

A That was the intent of that sentence. There are factors that you and I -- or let me say that I don't quite understand that could conceivably affect the availability of these materials and subsequent effects if any.

MR. ECKERT: Your Honor, we have come to 4:30 and I have a good deal more examination. I would like to read Exhibit 1 before I go any further, and I would also like to examine Dr. Tucker. I think it is going to take considerable more time. Could we adjourn until tomorrow?

JUDGE SWEENEY: All right. We'll adjourn until nine o'clock tomorrow.

MR. RICHEL: Your Honor, before you adjourn, one or two brief comments.

Dr. Lauer is to be available. Do you now perceive any difficulty in cross-examining him tomorrow as opposed

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to some future date?

MR. ECKERT: Not at all. I'll be through with him tomorrow.

MR. RICHEL: Second of all, earlier in the day I addressed myself to the problem of EPA's introduction of new materials upon which we did not base -- upon which our witnesses did not base their initial response.

I indicated earlier that I would discuss with EPA Counsel whether or not EPA is considering authorizing or countenancing introduction of new materials by industrial objectors.

I had a very brief discussion on the subject and Mr. Eckert indicated he would take no position. I am asking for your ruling, your Honor, that industrial objectors be allowed additional time to respond to new issues raised by EPA's rebuttal testimony.

JUDGE SWEENEY: I don't think there is time for that.

MR. RICHEL: Is there any requirement, your Honor, that there be cross-examination? If we found the time to submit the evidence, is there any requirement that anything further be done on your part?

I recognize the problems inherent with that. I recognize that material such as that is not ordinarily entitled the weight of materials submitted and subjected to

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cross-examination, but I submit that that approach would not in any way affect your ability to give the Administrator his record so that three or four days later he could make a decision.

JUDGE SWEENEY: He's going to need more than three or four days I think.

MR. RICHEL: I would think so.

MR. LORANT: Your Honor, extending that comment just a bit, the rebuttal affidavits of EPA, to the extent that they are not truly rebuttal but in fact reflect new matter, are they, in your view, admissible? I think this is another way of saying what Counsel has just said. I find it difficult to consider adequate response merely by cross-examining EPA's witnesses on new matter not necessarily raised in the original objections and support thereof.

JUDGE SWEENEY: You can object to it when the time arises.

MR. LORANT: Okay. Thank you, sir.

MR. RICHEL: Do I have a negative ruling on my motion?

JUDGE SWEENEY: Yes. There is no time for further receipt of evidence from the objectors and it is their position that they don't have the burden of proof, so they don't have any right to answer the rebuttal of EPA.

MR. WILLS: Your Honor, are you saying the time

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that EPA has to finally submit all these documents in rebuttal to the evidence with respect to my motion this morning?

It was my understanding we would get copies of the unpublished data of Dr. Veigh and a few other individuals.

JUDGE SWEENEY: I thought that was to be given to you at noontime.

MR. ECKERT: That data is here right now. It's available for you right now.

MR. RICHEL: If an exception to your negative ruling is needed it's done.

JUDGE SWEENEY: All right.

Well, there is no rebuttal to rebuttal.

MR. LORANT: Well, when there's new matter there is no way of responding to it.

JUDGE SWEENEY: Well, they call it rebuttal. I haven't seen it myself.

We will recess until nine o'clock tomorrow.

(Whereupon, at 4:37 p.m., the hearing in the above-entitled matter was recessed to reconvene at 9:00 a.m. the following day.)

ederal Reporters, Inc.

May 30, 1974

Ace - Federal Reporters, Inc.
415 Second Street, N.E.
Washington, D.C. 20002

Gentlemen:

Re:		
In the matter of:	:	FWPCA (307)
TOXIC POLLUTANT EFFLUENT STANDARDS	:	Docket No. 1

A review of the Transcript of Proceedings for the above-referenced matter for May 8 and 9, 1974, has revealed several transcription errors. Appropriate changes should be made in the Transcript so that anyone reading the Transcript of these Proceedings at a later date will not be confused or mislead by an incorrect transcription.

The changes which should be made are as follows:

Page 2751, lines 8 and 12;
page 2752, lines 4, 6, 7 and 9;
page 2757, line 13;
page 2758, line 10;
page 2760, line 14;

the word "biphenol" should be "biphenyl" with a "y" instead of an "o".

Page 2758, line 19; the word "misture" should be "mixture".

Page 2763, line 4; the word "adsorbed" should be "adsorbent".

Page 2774, line 7; the word "diphenol" should be "biphenyl".

Page 2774, line 24; the number "1232" should be "1242".

MONS 065410

Page 2774, line 25; the word "in" should appear between the words "invariably" and "samples".

Page 2775, line 1; the word "or" should be "the".

Page 2785, line 25; the word "soil" should be "oil".

Page 2802, line 22; the second word "that" should be ", and then".

Page 2803, line 3; the word "to" should appear between the words "submitting" and "you".

Page 2804, line 24; the words "I have no" should read "Do I have a".

Page 2805, line 12; the word "and" should appear between "salmon" and "PCBs".

Page 2806, line 16; the number ".5" should be "5.0".

Page 2809, line 1; the words "I am, but I have to pass on to you that" should be "I am. What I have to pass on to you".

Page 2814, line 3; the word "curved" should be "curbed".

Page 2817, lines 8 and 9; the word "insulation" should be "installation".

Page 2818, line 6; the word "every" should be "ever".

Page 2820, line 13; the word "as" should be "in" and line 17; the words "chemicals there" should be "chemicals. There".

Page 2823, line 20; the numbers "100" and "500" should be "100,000" and "500,000" respectively.

Page 2827, line 24; the word "respectively" should be "relatively".

Page 2828, line 1; the word "main" should be "man". Line 23; the word "mainly" should be "namely".

Page 2877, line 17; the words "imply parts of the design that" should be "insure that parts of the design".

Page 2812, line 21;
page 2816, line 1;
page 2817, line 13;
page 2833, line 21;
page 2839, line 13:

the word "Crumridge" should be "Krummrich".

Thank you for your cooperation in revising the official Transcript to reflect these changes.

Your very truly,

Phocion S. Park

/jf

cc: Honorable William J. Sweeney
Alan W. Eckert, Esq.

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MONS 065413

MAY 2 2 1974

P. S. PARK

Transcript of Proceedings

UNITED STATES OF AMERICA

ENVIRONMENTAL PROTECTION AGENCY

In the matter of:	:	FWPCA (307)
TOXIC POLLUTANT EFFLUENT STANDARDS	:	Docket No. 1

Arlington, Virginia

Thursday, 9 May 1974

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UNITED STATES OF AMERICA

ENVIRONMENTAL PROTECTION AGENCY

In the matter of:	:	FWPCA (307)
TOXIC POLLUTANT EFFLUENT STANDARDS	:	Docket No. 1

EPA Conference Room
Room 1112
Building No. 2, Crystal Mall
Arlington, Virginia

Thursday, 9 May 1974

The hearing in the above-entitled matter was reconvened, pursuant to adjournment, at 9 a.m.

BEFORE:

WILLIAM J. SWEENEY, Administrative Law Judge

APPEARANCES:

(As heretofore noted.)

eb

C O N T E N T S

Witness:	Direct	Cross	Redirect	Recross
W. B. Papageorge Continued		2801	2828	2837
E. Scott Tucker		2840	2874	
Paul Wright		2877	2882	2885
Gerald J. Lauer		2887	2910	2912
			2920	2921
Daniel R. Marks		2927	2994	

Exhibits:	For Identification	In Evidence
82		2922
83		2886
84	2926	
85	3006	3006

- - -

P R O C E E D I N G S

JUDGE SWEENEY: We have this room for the remainder of the month of May, except for the 14 and 15 of May. That's Tuesday and Wednesday of next week. Those two days we have hearing space in the Tariff Commission which is located on F Street North West between Seventh and Eighth, and the hearing room is on the third floor. It is right opposite the elevator.

MR. ECKERT: Is that North West?

JUDGE SWEENEY: Yes, [illegible]

MR. PARK: Yesterday the point was made that apparently our Exhibit No. 9 had not been -- was not in the hands of the clerk. But apparently others did not have that also.

We'd like to change the status -- or I should say Reference No. 9, from being classified as an exhibit to simply a reference.

JUDGE SWEENEY: That's in --

MR. PARK: This is in our references cited.

JUDGE SWEENEY: This is in Mr. Papageorge's affidavit?

MR. PARK: Yes, sir. This is a great big bulky document and to disseminate a number of copies of that would be an enormous undertaking.

So that's simply a reference.

mea-2

Exhibit No. 1 -- again as I say, I think we just assumed that everyone interested in PCB would have one or more copies of that, but it was apparently an incorrect assumption and so we are having some of those delivered today which we will distribute, and I'm sure we can obtain additional copies as necessary.

I'd like to apologize to you, Judge Sweeney, and to those parties present for not having introduced to the hearing yesterday the two other persons who participated with our Mr. Papageorge in the preparation of Monsanto's testimony.

As I pointed out yesterday, Monsanto is in a position where it is not directly affected by these standards. They will not apply to our operations.

We are familiar to some degree with PCB and with their effects, such as they may be, on the environment. We felt a responsibility to come forward to participate in these hearings to try to do what we can to bring such knowledge and experience as we might have gained in our manufacture and association with this product before the hearing for use by the EPA in establishing the most rational and appropriate standards.

Now, these two men are Dr. E. S. Tucker, who has a Bachelor of Science Degree in Chemistry from Michigan State and a Doctor of Philosophy in Analytical Chemistry from the University of Iowa. He is currently a research group leader

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in our company.

For the last two years he's been an active member of the National Academy of Science, Ocean Affairs Board, and is at present the Chairman of the American Chemical Society of St. Louis, Society of Analysts.

Dr. Tucker could be classified as an expert in analysis of PCB.

The other man present today is Dr. Paul Wright, who is presently Manager of Toxicology at our company. He has a Bachelor of Science Degree with Highest Distinction from Purdue University and a Master of Science in Biochemistry and Ph.D. in Biochemistry from the University of Wisconsin.

He has both taught and has performed research in areas of toxicology and biochemistry.

These gentlemen, as mentioned yesterday, participated with Mr. Papageorge in preparation of this testimony which was submitted on behalf of the Monsanto Company. The testimony was signed on behalf of the company by Mr. Papageorge, who could be classified as the project leader. These other two gentlemen did prepare portions of this testimony and are expert in areas of examination, some of which took place yesterday. We feel that they can add a great deal to the development by the EPA ultimately of the most appropriate standards, reasonable standards. I think they can bring something to this hearing that probably no one

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else can bring.

I hope and I trust that full use will be made of their experience, education, and capabilities.

Judge Sweeney, I would like to have them sworn, if we could, so they can participate, please, in answering questions.

JUDGE SWEENEY: It all depends on whether Mr. Eckert wants to question them or not.

MR. ECKERT: Well, I'm sure you'll recognize that we have a problem here trying to find out who swore to what in this particular affidavit, since it's not identified on the face of the affidavit whether it was Mr. Papageorge, Dr. Tucker, or Dr. Wright who's speaking.

I didn't want to have this turned into a panel discussion either.

JUDGE SWEENEY: We don't have time for that, Mr. Eckert.

MR. ECKERT: That's right.

MR. RICHEL: That's the only lasting principle we have, I think.

MR. ECKERT: The only thing I can suggest is what I suggested yesterday. I have a number of questions that will get into chemistry, but I would like to examine Dr. Wright briefly on those questions when I am finished with Mr. Papageorge.

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Q Well, just the same, would you say, based upon those values, that values in excess of 100,000 for bio-concentration might not at all be unusual?

A I would say, based upon that data, it is entirely possible that there are concentration factors that high.

I would also say that those concentration factors may not really truly represent the concentration factors that exist because of not knowing the past exposure history of the fish.

That's exactly why I propose that there's a need to evaluate not only the toxicity but the bioaccumulation on a site-by-site basis and that is because of the uncertainties and the variability that can exist.

The concentration factors could in fact be higher than 100,000; they could go either way. And that's exactly the reason why I propose that. It needs to be looked at in relation to the actual discharges that occur, and the types of biota and water bodies that are involved in those individual discharges.

Q Well, have you read Exhibit or Reference 23 to Monsanto's testimony, the study by Duke, Lowe and Wilson on Escambia Bay?

A Yes, I have. I don't know if that is their exhibit number but I have read the-- I read the testimony that was submitted by Dr. Duke.

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Q This particular one is a Monsanto exhibit but I think it might be instructive to have your opinion on it since it bears on your testimony.

Do you have a copy of it that you could refer to?

A As I say, I don't know if that's the same as you're talking about.

MR. RICHEL: Is it the same as the material that--

MR. ECKERT: I don't believe so.

THE WITNESS: If it is not the same, then I don't have a copy of it.

BY MR. ECKERT:

Q This is one of the exhibits to Dr. Duke's testimony.

Let me ask you, do you have a copy of an article entitled "A Polychlorinated Biphenyl (Aroclor 1254) in the Water, Sediment, and Biota of Escambia Bay, Florida," by Duke, Lowe and Wilson?

MR. RICHEL: Did you say this was a reference attached to Duke's testimony? Which reference or attachment is it?

MR. ECKERT: I don't know. I don't have it in front of me. It may have been one of those literature citations which were available openly and not distributed.

JUDGE SWEENEY: Did you want him to look at something in there?

eb3

MR. ECKERT: Yes, I did.

JUDGE SWEENEY: Well, he can look at my copy if that will help.

THE WITNESS: I really don't think I have what you're talking about.

(Document handed to the witness.)

BY MR. ECKERT:

Q Now I'd like you to look at page 176. I gather you have read this article before, have you not?

MR. RICHEL: Do you need time to study the text?

(Pause.)

THE WITNESS: I don't believe I've read this particular article, but I do recognize some of the data in it, some of which is summarized in this testimony of Dr. Duke. So-- Well, let's see what the question is.

BY MR. ECKERT:

Q The question is simply this:

The figures on page 175 given directly in the middle of the page for concentrations measured in the river are lesa than 0.1 ppb at Station 2. Station 2, as you can see from Figure 1, is at the Escambia River.

Now that figure is 0.1 parts per billion; is that correct?

A Yes, that's what it says.

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Q The end of that sentence says ". . .it was not

eb4

detected in lower bay water," meaning presumably that if there was Aroclor there it was below the limit of detection, whatever that might have been, certainly lower than 0.1 ppb.

Do you think we can infer that from what it says right here?

A That would seem appropriate, yes.

Q Now I'll ask you to refer to Table 1 and the data given there for croaker, menhaden, pinfish and menhaden. These are the fourth, fifth, sixth and seventh data points listed. Do you see those data?

A Yes, I do.

Q Now are these fish salt water species?

A Predominantly.

They run up into estuarine type situations but as a general characterization, I would say you could characterize them as salt water.

Q So you would not expect to find them then in the-- They would not ordinarily venture into a fresh water river, would they?

A Probably not beyond some point in the salt gradient at least. They do exist up into brackish water situations but generally are not found in fresh water.

Q Now referring to the far right-hand column, the residues in those fish range between 10 and 12 parts per million, do they not?

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eb5

A Yes, they do.

Q Wouldn't this tend to indicate that a bioconcentration factor of at least 100,000 and possibly well above 120,000 was operating here?

A No, I wouldn't-- It could, but I would not say that it necessarily does.

Q Well, what would be the mitigating factors?

A Well, these fish are coastal water fishes, for the most part, and there is not anything really indicated about their size or age in here, but simply, the problem with making that direct association has to do with not knowing what their past history was.

It could well be that they existed in some other area or body of water where the concentrations of the Aroclor were much higher than they are here in some previous time, or it could also indicate-- Another possibility is that they were only recent occupants of this area and that they may not have reached a threshold concentration or a stabilized type of concentration in their tissues, so that in fact the estimates could be low.

I just don't think you can make a definitive conclusion about that. In any case I would also say that there's a problem with these bioconcentration factors anyway because it does indicate in the context of that paragraph that the presumption is that the source of the PCB in the water is from

eb6

the sediment and there are many different routes of entry, potential routes of entry of PCB's into fish. And it could be from the water and it could be directly from the sediment and it could be from the organisms that the fish have eaten.

That being the case, it i.-- That's an inherent problem with looking at bioconcentration when it is strictly referred to water concentrations because that's not the only source of access for organisms living in the environment, so that's a generic problem with bioconcentration factors.

So no, I would not say that these data represent a concentration factor that I would look at with confidence as really representing a true bioconcentration factor in fish relative to concentration in water. There are too many other variables, and it could be high or low.

Q Apart from the data which EPA has presented, have you developed any data of your own on bioconcentrations in the environment?

A No, I have not.

I just would make the observation, though, I have high regard for the researchers in EPA. There have been some statements made by Dr. Veith, for example, that the solubility is inversely proportional to the amount of chlorination and that the bioaccumulation is inversely proportional to the degree of chlorination, as a general kind of proposition, and I don't find any real argument with any given piece of data.

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eb7

What I am saying in my testimony is there is so much variation amongst the data that exist that you really can't make good sense out of it in terms of coming up finally with a conclusion as is done in the proposed standards, that you will take one concentration value for one species of fish, not even from this continent, and maybe not from the same kind of conditions that exist relative to the discharges, and apply it to other biota and fish species, including fresh water species, and come up with an across-the-board, nationwide standard that is really realistic.

If we have to balance the matter of what is going to be permitted to be discharged into aquatic systems against the other societal values that are part of the over-all equation and that need to be taken into account by regulatory agencies and by society as a whole, that's the main thrust of my testimony.

I would not argue that any one of these pieces of data is the relevant piece of data that ought to have been used instead of what was used. My main point is that in fact there was some more relevant data I would have picked to have applied to fresh water situations that has been developed by the Duluth Laboratory that should have been used in the standards.

I don't know why EPA doesn't use their own laboratory's data-- It's the best that exists -- in coming up with

eb8

these standards when it's there, instead of reaching out to some ambiguous salmon data that the authors of which even question the validity of at this stage of the game.

I know the people in the Duluty lab pretty well. They are all old peers of mine in the Public Health SErvice and they are constantly ignored on all of these questions, including thermal standards and I don't understand why.

Q Well, I'm glad to hear you say that. As you can see by the affidavits we've distributed, we're doing our best to get the lab data into the record of this hearing so we can use it.

Now on page 4 you refer to the wide range of bio-concentration values, and you state that that defies generalization.

But I think perhaps if we turn to Table 2 we might see a trend or two here.

For example, take a look if you would at the figure for Daphnia given under 1254 about two-thirds of the way down the page.

A On page 2?

Q No, on Table 2, page 1.

A Okay.

Q Do you see the data for Daphnia under 1254?

A Yes, I do.

Q After one day of exposure the concentration factor

eb9

was 24,700. Is that correct?

A That's correct.

Q And after four days it was 47,000?

A That's correct.

Q Now if you will take a look at bluegill-- I'm sorry, not bluegill but-- Well, yes, the bluegill figures given under 1248.

These are considerably higher figures, are they not, 26,000, 71,000?

A Well, the one is on the same order. The 71,000 I would say is quite a lot higher than the four days, 47,000 figure for Daphnia.

Q Then if you look at the data for channel catfish after 60 days, that's 72,030.

Based on these data, even though the points do seem disparate, would it be a fair summary to say that the longer the residence time of the species in the test, the greater the degree of accumulation?

A There is a tendency in that direction. Certainly accumulation is a time-related function and as a general proposition, the rate of accumulation tends to be much faster in the earlier exposure time than it does later on.

I think Dr. Veith pointed out it's a first-order type of reaction and the time at which the levelling off occurs varies from species to species and from condition to

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eb10

condition. And as I think he appropriately pointed out, you have to evaluate the potential for accumulation based upon the conditions that exist for the ecosystems in question, so I concur totally with what he said in his testimony regarding that.

It's a matter that you have to look at according to the conditions that exist where the problem is that you are addressing yourself to.

Q Well, assuming that we're talking about a concentration that exists over long period of time, wouldn't you want to predict bioconcentration by the use of rather long-term studies?

A Yes, I would think so.

Q In the second paragraph on that page you refer to available data summarized by Dr. Simons.

Which data indicates that homologs containing four or less chlorine atoms per biphenyl do not accumulate in tissues of fish and wildlife?

A In that respect I'm referring to the conclusions that he drew from the references which are indicated in his testimony on page 10 of his testimony.

Q I have before me page 10 of Dr. Simon's testimony and I don't see anything -- any statement to the effect that homologs containing four or less chlorine atoms do not accumulate. Perhaps you can help me out.

eb11

A I'm referring in that instance-- My reference in that instance is made to Nos. 1, 2, and 3 in the middle of that page 10, and the references are cited for that.

The first reference refers to the bacterial degradation rate increasing as the chlorination decreases.

Item 2 refers to the residue storage levels in rats decreasing exponentially as the weight percent chlorine decreases.

And No. 3 refers to the PCB residues found in wildlife being dominantly penta, hexa-, hepta-, and octa chloro biphenyls.

It's those three references that I was referring to.

Q Would it be a fairer statement that homologs containing four or less chlorine atoms per biphenyl do not accumulate in tissues of fish and wildlife at as great a rate as those containing more chlorine atoms per biphenyl?

A Well, that certainly is an outcome of the situation, and I think that's a desirable outcome.

Q But you can't say, can you, that the homologs do not accumulate at all?

A Not based upon those papers. There is a remarkable lack of data in the literature that is available, both that I had available at the time of writing this testimony and in the more recent submissions by the agency itself on the lower homologs, as far as reporting residuals are concerned.

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eb12

That has to be for some reason. It could either be for the reason that they degrade quicker or that they are not taken up in the first place. There are some indications that degradation -- a greater rate of degradation for the lower chlorine homologs is a factor in this, and I think Dr. Veith referred to that in his study of the Milwaukee River situation as one of the possible explanations for seeing a greater rate of loss of the lower chlorine homologs with distance moving downstream compared with the higher chlorinated homologs.

So both mechanisms could enter into the equation and cause the same result, and I think there is some importance to finding out whether one or both of those mechanisms are involved.

But I think the most important end result is their apparent scarce -- if occurrence at all in the accumulation in the residues, in the organisms in question. Environmentally that's the most important thing as far as the consumers of those organisms are concerned.

I think there is still some more work that needs to be done to find out which role either of those two plays, individually or in combination, in effecting the fact of lower chlorine residuals of the lower chlorinated forms in biota.

Q Thank you very much, Dr. Lauer.

MR. ECKERT: No further questions.

eb13

MR. RICHEL: I just have one or two questions if I may.

REDIRECT EXAMINATION

BY MR. RICHEL:

Q Prior to your appearance here today, Dr. Lauer, we had some discussion about this problem of localizing the standard, did we not?

A Yes, we did.

Q And for the moment, let's just call the act of localization an impact study.

Now a moment ago Mr. Eckert questioned you as to the potential cost of such a study. Do you recall that?

A Yes, I do.

Q And we can all imagine, I take it, that the cost could be great.

A Yes.

Q You indicated to me the other day, did you not, that there are problems with funding these studies from a public level, with public funds, in other words. Is that right?

A Well, I would think so. I cannot speak for the whole public sector of people responsible for the public sector, or the decision-makers responsible for providing money for research. But judging upon past recent history, for research funds available for addressing these

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environmental problems, it has been the history that the agency involved who are given these kinds of funds aren't given anywhere near the amount of funds that are required to do the full job, so it was based on that kind of experience that I made that remark to you.

Q Right.

And I take it if you did want to have such an impact study for a site and if public funds couldn't foot the entire bill, that the use of private funds by perhaps the industrial facility at that site could be used to supplement public funds? Would that be an acceptable solution?

A Well, this is being done right now in many respects and as I would view it in the over-all ecological context, regardless of where the moneys come from directly, eventually society and the consumers pay the bill ultimately.

So really it's a question of where the moneys are readily available and visible to fund this kind of research, but in fact, the burden of financing studies and research to come up with some of these answers is progressively falling more and more toward the private sector in trying to evaluate these environmental impacts.

MR. RICHEL: Given this, all I wanted to do was to assure the representatives of EPA that I have authority to say the following, and that is:

We would participate in the funding of studies that

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eb15

would carry out the concepts that have been indicated by Dr. Lauer as, of course, related to our sites.

MR. ECKERT: One quick question on recross if you are through, Mr. Richel.

MR. RICHEL: Yes. Sure.

RECROSS-EXAMINATION

BY MR. ECKERT:

Q Now these localization studies, as I understand you were referring to-- I believe it was Dr. Simons who testified with respect to a facility discharging into a river which was already rather badly polluted and in which only carp resided.

Do you recall that testimony?

A I was not here when Dr. Simons testified.

MR. WILLS: I believe it was Dr. Wright and Dr. Munson.

BY MR. ECKERT:

Q If you were confronted with such a situation--

MR. RICHEL: What situation?

BY MR. ECKERT:

Q A situation in which the discharge of PCB's was into a receiving water which was heavily polluted by other industrial sources, and in which only carp and some other more resistant forms were living, how would you do a localization study for such a stream?

eb16

A Well, it could be done on two bases. As far as the decision on which bases it should be done on, it does not rest solely with the biologist. It could be done on the basis of the conditions which exist that you describe as one approach, because that's what exists right now.

And on the other hand it could be done on the basis of some other level of environmental quality that really involves a societal kind of decision.

For example if the kind of hypothetical stream you're talking about is one which is that way and because of all the circumstances which accrue is elected to stay that way because of economic, social, and other kinds of problems associated with making it better than it is, then the only realistic approach would be to analyze the situation as it exists and as it is perceived to continue to exist.

If on the other hand that body of water involves one which realistically -- I am not talking about politically, in terms of philosophy, but realistically is one that is going to be cleaned up to some other level and will contain other species of fish, then that poses the question of whether or not the localized analysis of this particular problem should not be done relative to the anticipated cleanup goals.

That makes it a bit more difficult under that kind of a hypothetical circumstance because you can't deal with the system as it is perceived or as it is desired to be but as it

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is, and that becomes much more of a hypothetical kind of study in the instance of trying to address to what the stream might look like, say ten years from now or 15 years from now, if all of the other water pollution abatement efforts are effective and implemented.

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MR. ECKERT: A point of clarification here:

The reference to carp was from Dr. Wright's testimony, from Westinghouse.

BY MR. ECKERT:

Q Moving on with this situation now, this hypothetical situation:

If you were interested in cleaning that water up and you were enforcing control measure against the other dischargers on the river, wouldn't it be reasonable to select the sensitive important species that would be likely to exist there if these other discharges were cleaned up, and to base your standard upon them?

A As a general philosophy I would say so. I really think these kinds of decisions need to be made with a lot of different inputs to them, one of thich is biological and aquatic effects.

And in that respect, if the practical accomplishment of the goal is in view, rather than what is being said to be the goal, if there is a goal that can be achieved and there is a schedule for achieving it, and all of the people put forth the money that's required to achieve it, and that's a goal that has been selected, and all of the forces in society say this is what we want for that body of water, then the individual and collective effects of all the pollutants which apply to that body of water have to be taken into

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account individually as well as collectively.

And in that sense the amount of regulatory effort which you would apply to each of the individual pollutants, and to them collectively, would depend upon what the effects of those pollutants were in causing that stream to be different now than is desired to be by the perceived goal.

That's one of the problems that I see in the proposed standards as the exist: there's really some fuzziness involved in the proposed standards. It's pretty clear-cut that part of the standards are addressed to acute toxicity but thereafter it gets pretty fuzzy.

The standards are by word and description defined, and the purpose of them is described as protecting aquatic life. I think there's fuzziness in the chronic portion of the standards wherein the output or the end result of the proposed standards is not really based on protecting the aquatic life per se, but it's all messed up, involved with the bioaccumulation and the potential effects on the consumers of the aquatic life.

I'm not saying it shouldn't be. What I'm saying is that the standards ought to very clearly be defined as to probably three levels rather than two. As to those three items explicitly: acute effects; chronic effects for the aquatic life themselves, flat-out straight, right there; and the the third step -- and have the numbers be relevant, the numbers

brb3

in the regulations be relevant in each of those steps -- and then the third step would take into account what the potential health hazards are for consuming marine or aquatic foodstuffs by the consumers.

And right now, the chronic part of this is all messed up between those two things, and that causes a lot of difficulties and fuzziness involved.

The FDA standards are threaded in amongst this, the 5 part per million limitation gets mixed in with this. There ought to be a clear cut distinction as to what the purposes are for each of the standards proposed and not have this mixed-up treatment involving chronic toxicity with effect of accumulated residuals mixed together.

The end result may not be different, after analysis taking account relevant data to the situations of the individual discharges, but it ought to be clearly defined what each of those regulation objectives are and what the limits are that are being promulgated to meet those objectives.

I just find that an awkwardness in the standards as they are proposed. There's too much mixed up in the chronic, in the proposed chronic limits, aside from the fact that they aren't really -- they aren't really addressed to, nor do they take into account, the data that exists aht would be more relevant than the ones that were used, which is a separate kind of a problem.

brb 4

But is is not for a biologist to dictate these things, you see, in terms of what the stream standards are. The goal should be all -- I think our role is, and the role of any other technician involved in talking about any other subject, is to say, "You tell us what you want, and then we'll try to do the best we can to analyze the problem and tell you what's required to get there." So I don't think we can set ourselves up as dictators.

In other words, I don't think the standard-setting process should only take into account aquatic biology.

Q Well, I think that's a good point.

Have you gotten into human health -- getting into human health problems, have you measured or attempted to measure, or do you know of data in which any investigators have measured PCB residues in fish taken from the environment?

A Do I know of any data?

Q First, have you done it yourself?

A I have not done it myself.

Q Are you familiar with any data that relate the residues in fish to point source discharges of PCB's?

A I know of -- I'm not sure if I can say yes to the coupling in that question that you have.

I know of data that exist on residuals in fish that have been collected from water bodies. I'm not sure that I

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would agree or say that they have been coupled with point source discharges in a realistic sort of way, but there are data in the literature that exist for residuals in fish, and I am aware of those.

Q You've referred to the FDA guidelines.

Are you familiar with any data on fish taken from the environment which exceeded the levels specified by the FDA for human food?

A Yes, I am.

Q Where were those samples taken?

A In one instance, from Lake Michigan. In another instance, there was one fish -- a carp, as I recall -- in the Hudson River. There are other instances; I just can't recall the specific circumstances that were involved.

Q Do you recall the levels in the carp in the Hudson River?

A This is my recollection. I think it was on the order of 11 parts per billion. But that's subject to correction, because I am recalling information at this point.

Q And subject to correction, roughly where was the fish taken?

A It was taken in the vicinity of Poughkeepsie, as I recall.

Q Thank you very much.

MR. RICHEL: I have one or two additional questions

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raised here by the talk about carp.

FURTHER REDIRECT EXAMINATION

BY MR. RICHEL:

Q As I understand it, Dr. Lauer, the carp was taken from the Hudson.

Is that right?

A That's right.

Q At about Poughkeepsie?

A That's my recollection.

Q At any rate, it would be south of Albany?

A That's correct.

Q As the Hudson River flows from the Adirondacks to the Atlantic Ocean, is it one continuous flow? Are there any interruptions during its flow?

A Well, it's about 480 kilometers long, and along that length there are tributaries coming in, and beginning in Albany there are dams on the upper part of the river.

Q And no dams, no major dams, below Albany?

A No.

Q And would you, when studying the Hudson River, refer to the upper Hudson and the lower Hudson?

A That's commonly done, yes.

Q And would the upper Hudson be one river system and the lower Hudson be another?

A Well, they are a continuum, but the lower Hudson

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is the tidal portion. It's the portion connected with the coastal waters, and it's subject to tidal fluctuations and to salinity incursions into the river. So they are quite different kinds of bodies of water, but of course one is the upper and one is the lower.

Q And the salinity problem that you brought in and the tidal flows: they don't relate to the upper Hudson?

A No.

Well, the salinities don't relate to the upper Hudson, and the tidal flows don't relate to the upper Hudson directly. There is an indirect relationship of where the -- of the position of the salt front in the lower Hudson that is determined substantially by the amount of fresh water flows out of the upper Hudson and the other tributaries.

Q But you'd call them two distinct water bodies?

A Well, they have many distinct characteristics; but they are connected. They're all in the same watershed; the upper runs into the lower.

MR. RICHEL: I have nothing further.

MR. ECKERT: This brings up one or two more questions, and then I'll be through.

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FURTHER RECROSS-EXAMINATION

BY MR. ECKERT:

Q Is the Hudson Falls facility a G.E. facility: that's a G.E. facility?

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A That's my understanding.

Q Is it located on the upper Hudson or the lower Hudson?

A The upper Hudson.

Q Is Poughkeepsie on the upper Hudson?

A Poughkeepsie's on the lower Hudson.

Q The lower Hudson?

A That's correct.

Q Thank you.

MR. ECKERT: That's all.

JUDGE SWEENEY: You're excused, Doctor.

(Witness excused.)

JUDGE SWEENEY: Exhibit 82 is received into evidence.

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(Exhibit No. 82, marked for identification, was received into evidence.)

JUDGE SWEENEY: Who's next?

MR. ROGERS: Mr. Marks of the Velsicol Corporation.

MR. ECKERT: This concludes the cross-examination of the PCB witnesses, your Honor. We're going to move into Endrin now.

MR. RICHEL: Your Honor, before we leave PCB's, I'd like to clarify exactly when the EPA witnesses on PCB's

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will be available for cross-examination. That date fluctuates, as does the number of people who are testifying.

MR. ECKERT: I think we can be firm on both of them.

The number of people testifying, as I indicated on the record yesterday, is four, and I named them on the record yesterday. And the date on which they will be testifying is the 28th of this month. This is necessitated by Dr. Duke's scheduling problems.

JUDGE SWEENEY: Well, what's happened to the toxaphene, the industry toxaphene witnesses you had scheduled on the 28th?

MR. ECKERT: We will move them to the 29th. We just shift the 28th and the 29th.

MR. RICHEL: Do you anticipate that cross-examination will be on one day?

MR. ECKERT: That's our present anticipation.

MR. RICHEL: And if it weren't to go one day -- I am not indicating that it is, but if it weren't to go one day, what date would follow for cross-examination of PCB witnesses?

MR. ECKERT: Well, we would simply have do do it seriatum. If we went over to the 29th, we would have to go over to the 29th.

Now, I must point out at this point that I am

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discussing with Counsel for Hercules the possibility of an off-the-record meeting, technical meeting, similar to the one that was held on benzidine, but I don't have anything final to report on that.

MR. RICHEL: What impact would that have?

MR. ECKERT: That would mean that there would be no hearings on toxaphene.

MR. RICHEL: And what would that do to the proposed date for cross-examination of PCB witnesses?

MR. ECKERT: It would not change it al all.

JUDGE SWEENEY: IT would give you an extra day. It would give you the 29th, the 28th and the 29th.

I'm not saying I'm agreeing with any of this. If we have some free time in between we're not going to take time off, we're going to move somebody else in there.

We've had enough of this running out of witnesses; we've wasted at least two days, that I know of, by quitting in the middle of the day, running out of witnesses.

MR. RICHEL: I would hope we will get ample notice. I must note for the record that the decision on the cross-examination on industrial witnesses on PCB's took place in the absence of any representatives of PCB objectors, and indeed changed the order entirely from what we were led to expect.

I would simply hope at this point that if the date of

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end 3A

cross-examination of EPA witnesses is to change, that we get ample notice at this time.

Whereupon,

DANIEL R. MARKS

took the stand as a witness and, having been first duly sworn, was examined and testified as follows:

JUDGE SWEENEY: The testimony, the written testimony of Daniel R. Marks will be identified as Exhibit No. 84.

(The document referred to was marked Exhibit No. 84 for identification.)

MR. LORANT: Your Honor, will that cover both affidavits?

JUDGE SWEENEY: No, just the one I said.

MR. LORANT: There are two affidavits of Mr. Marks.

JUDGE SWEENEY: Oh, there are two?

MR. LORANT: Yes. One is headed "Testimony of Daniel R. Marks Respecting Technology to Remove Endrin from Water," and the second is "Testimony of Daniel R. Marks Respecting Two Formulas of Endrin."

JUDGE SWEENEY: I only have the one.

MR. ROGERS: I only have the one, too.

JUDGE SWEENEY: Which one do you have?

MR. LORANT: "Technology to Remove Endrin from Water." Look at the last page.

jrb 2

MR. ROGERS: Oh, I see.

JUDGE SWEENEY: Well, in answer to your question if that is what you were referring to, the two of them will both be identified with one number since they are attached.

MR. LORANT: That's perfectly satisfactory. What was the number again, 84?

JUDGE SWEENEY: 84, yes, sir.

MR. LORANT: Mr. Rogers, I take it you hadn't seen that before.

MR. ROGERS: Yes.

CROSS-EXAMINATION

XXXX

BY MR. ROGERS:

Q Mr. Marks, I am going to ask you several questions about the manufacturing facility in Memphis, details of the operation.

Before we get into that I want to ask you essentially what your duties are, and then I want to get into the formulators. I'm just trying to give you an idea of where I am going to go here.

A All right.

Q Would you give us very briefly what your duties are as Technical Superintendent at the Tennessee plant?

A My duties are supervision of the quality control laboratory, the chemists who do process development work, and environmental matters, both air and water.

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Q You are responsible, I take it, to some extent for keeping track of regulations both State and Federal, and seeing that the Velsicol operations are compatible with those standards?

A Yes.

Q You have always been with the Velsicol operation since graduation, is that correct?

A Not always.

I started -- after graduation, I started to work with E. I. du Pont, then went into the service. When I came back I started work with Hayden Chemical Corporation which was bought up by Velsicol in 1950. I worked there until 1952 and then I went to U.S. Industrial Chemical Company, Division of National Distillers in Huntsville, Alabama for three and a half years. And in 1955 I came back to Velsicol and have been there since.

Q All right.

Well, let's turn to the formulators and try to cover that rather quickly.

I had asked your counsel to provide us with a list of locations of endrin formulators, and he did give me a piece of paper this morning. I would like to read quickly those names into the record, and if there are any incorrect, will you stope me and make sure we have them correct?

There are 14 of them. The first one is

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Arlington, Tennessee --

MR. LORANT: Those are the locations, Mr. Rogers.

MR. ROGERS: Yes.

Brownfield, Texas; West Monroe, Louisiana; Hanover, Pennsylvania; New Orleans, Louisiana; Landale, Arizona; Macon, Georgia; Memphis, Tennessee.

A I have one correction there. Memphis is their corporate headquarters. I believe their fomulating plant is in Helena, Arkansas.

Q Is that Helena Chemicals?

A Yes -- no; Riverside Chemical. That's at Marks, Mississippi.

There's another one here. Helena Chemical that I gave you is Memphis, which is actually in Helena, Arkansas. Riverside is -- the plant is in Marks, Mississippi.

Q So we don't have any formulators in Memphis, is that corect?

A Right.

Q Greeneville, Mississippi; Greely Colorado; Port Valley, Georgia; Syracuse, New York; and Lockport, New York; is that correct?

A That's correct.

Q And Marks, Mississippi?

A Yes.

Q Now, these are all formulators that take technical

jrb 5

endrin from your operation and make it into various consumer products, is that correct?

A Yes.

Q Is there more than one formulation for endrin?

A Yes.

Q Could you briefly list the formulations?

A I'm not real familiar with formulations since we deal at the Memphis plant only with the technical product; but I do know that endrin is formulated with methyl parathyon. I believe the endrin content I believe is 1.6 pounds per gallon. Endrin has been formulated, I don't know how much of it is presently used in this form -- as a straight 1.6 pound per gallon formulation.

And also there have been endrin dists formulated, although I don't know for sure that any of that is still being used.

Q Well, the reason I asked that, we've gone through several pesticide hearings, for example, aldrin and dieldrin is made into several types of products. But we are basically talking about a liquid formulation?

A Yes, I believe the majority of endrin is formulated as liquid.

Q And that it is sold by the formulators to farmers or custom applicators, is that correct?

A This I believe is correct

j-b 6

Q Does the Velsicol corporation sell the endrin to these formulators, or is it a custom contract operation?

A It has been both. We are now in the process of getting ready to do some formulations ourselves, but in the past it has been either contract or an outright sale to the formulator.

Q You mean at the Memphis plant you'll be doing some formulating?

A Yes, some.

Q Now, you've given us a list of these 14 sites, have the number of formulators remained relatively constant in the last ten years or has it gone down or increased?

A This I don't know.

Q When are these formulators in operation?

A I don't know for sure. I believe in the fall and winter months primarily, before the growing season.

Q And isn't it a batch formulation process or a constant flow process?

A All that I've heard of has been batch.

Q Let's clarify that for the record.

What do you mean by a "batch" process?

A A batch process is when a fixed quantity of formulation is made up in a single vessel where there is no continuous feed of raw materials and draw-off of product on a continuous basis, but everything is done in one vessel,

jrb 7

and contained until the final finished product is drawn off and packaged.

Q How does the formulator get the technical endrin? Does it come in in a railway car?

A Usually by truck.

Q In a powder or liquid?

A It's a crystalline product.

Q Now, are these trucks designed specifically for endrin or do they carry other chemicals?

A They are common carriers.

Q How do they clean out their holds, if you will, following carriage of endrin?

A This I would not know, I have not observed.

MR. LORANT: Possibly there is a misunderstanding on the part of the witness, Mr. Rogers; are you implying -- assuming that they are shipped in bulk containers like a tank car?

THE WITNESS: Endrin is packaged in drums.

BY MR. ROGERS:

Q The reason I am asking these questions, as you know, we are not simply dealing with the Memphis plant; we're trying to locate all the point sources and try to determine what the particular problems might be and what the discharges might be.

A Right.

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jrb 8

Q What concentration of endrin is the technical, is it completely pure endrin?

A The technical runs from 95 to 98 percent pure endrin.

Q Have you ever visited a formulation plant?

A No, I haven't.

Q Well, in your affidavit you say in II, "Having conducted a survey of the formulator customers of Velsicol Chemical Corporation" -- et cetera, what kind of survey was this?

A This was a telephone survey in which I contacted officials in each formulator, and inquired if they had an effluent, and if they did, where it went.

Q Well, are you generally familiar from your long dealings with these people with their general operations, how they formulate?

A Not having seen -- actually been in a formulating plant, I could not say.

Q Well, let's talk about this telephone survey.

Could you give us some details about the response to your question on discharge quantities or discharges into navigable waterways?

A Yes.

The majority of the formulators reported that they had no effluent, that any spills were absorbed on an

jrb 9

absorbant, a clay or some other type absorbant. This was swept and cleaned up and buried in an approved landfill.

Therefore, they considered there was no effluent to a sewer. They avoided all possibility of -- in most cases they mentioned they put dikes in the floor and so forth, so that any spills would be contained and capabile of being absorbed.

Q Well, you said the "majority" were in this category? Is that correct?

A Yes.

Q What about those that were not?

A There were two who went to the city sewer treatment system.

Q Who were those?

A Cottonstates -- no, I take it back, there were three. Cottonstates, Miller Chemical and Fertilizer -- that would be West Monroe, Louisiana; Hanover, Pennsylvania; and New Orleans. I'm not sure, I believe that New Orleans has a treatment system. It may be like Memphis.

Q So we're basically talking about three plants that would discharge into a public system and eleven that have no discernible discharge?

A Yes.

Q Well, do the 11 that have no discharges have an evaporative system, or do they have --

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jrb 10

A Some of them are, it depends on the location. Brownfield, Texas, has an evaporative system. They said it had not rained in 10 months.

Helena said that they go to a closed lagoon that evaporates. Those are the two evaporative systems.

Q Are you through?

A Yes.

Q Well, how do the others achieve a no-discharge?

A By absorption of spills and landfill disposal of the absorbant.

Q Well, they must have a closed system for the water usage?

A Yes.

Q How much water is used in formulating endrin?

A I don't know.

Q Well, I take it that there has got to be quite a bit for you to have 1.6 pounds of endrin -- is it per gallon?

A Per gallon.

Q Of water?

A No. This is an organic solvent. It's non-aqueous system. The formulations are non-aqueous.

Q That's the question I'm asking.

A That I know, but how much water they may use incidentally in the plants, I don't know; but there is no water involved in formulation of these pesticides.

jrb 11

Q Well, maybe we should be talking about the organic solvent, then, where that goes. Do you know whether it's a completely closed system, and we are just talking about leaks?

A Yes, it's a closed system. The solvent is put in, the endrin is put in, and it's dissolved; and this is all drummed up as product.

There is no -- except for incidental leakage would be the only way that I can imagine that there would be any spills.

Q Has this type of formulation been the practice throughout the years?

A As far as I know it has.

Q The reason I asked that tomorrow we're going to ask Dr. Polen several questions about residues of endrin in the Lower Mississippi; and some of the studies I am going to refer to are 10 years old. And I was just wondering if indeed they had used closed systems then why these reporters concluded as they did that endrin formulation plants were the main source of contamination of the Lower Mississipp.

Do you have any thoughts on that?

A No, I don't.

Q What are the formulatin plants in Pennsylvania and New York making the product for? What types of crops?

A This I don't know. I believe the one in Pennsylvania makes rat poison or something of this sort.

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My only contact with these formulators is our laboratory does, since a lot of it is contract formulation for Velsicol, we do quality control checks before we allow anything under the Velsicol name to be shipped out. So we get it analyzed in our laboratory continuously, the samples from these formulators.

Now, I know that this is a dust formulation of endrin. I don't know in what quantities it's made, I have been told it was for rat poison or mice in orchards, I believe, is actually the usage; but I really don't know of my own knowledge that this is true.

Q Well, I take it that these formulators make other products? I think I asked you that?

A Yes, as far as I know they do.

There are no exclusive formulators of endrin products that I am aware of.

Q To your knowledge has there been any cross contamination?

A Not to my knowledge.

MR. LORANT: Pardon me, Mr. Rogers, just by way of incidental information one of the uses for endrin is in post-harvest to an orchard floor for mouse control; and that's shown in a table in Dr. Polen's affidavit.

BY MR. ROGERS:

Q The major use of endrin is for cotton, isn't that

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correct?

A Yes. I would say so.

Q What other major uses are there, and maybe we should be referring to some of Dr. Polen's charts.

MR. LORANT: I wonder, Mr. Rogers, this witness is a plant man and is not concerned officially with the utilization of endrin as such and consequently may not be able to give you the type of accurate information you would desire.

I have no objection to his conjecturing as to some of these things and to be as helpful as he can; but I wonder if it will be very productive.

MR. ROGERS: Well, I can save the questions. It's just that I don't believe Dr. Polen answers this question of what the major uses are, the percentage uses. He lists certain uses, but doesn't give us an idea of the relative magnitude.

Now, if this witness doesn't know, we'll go on.

THE WITNESS: No, I don't know for sure. I have no numbers on that.

BY MR. ROGERS:

Q Do you have any information on how the endrin is applied in the field?

A No, not definitively.

Q Is it applied by airplane?

A In some cases in the South, I think it is.

jrb14

Q Well, aren't some of your duties to keep an eye on the possible sources of contamination of endrin in the environment?

A As far as the Memphis plant is concerned, yes. As far as the environment, this gets a little bit out of my territory.

MR. LORANT: Again, Mr. Rogers, by way of clarification, when you ask him with regard to state regulations and so forth, I think the witness was talking with respect to the Memphis plant, but maybe you were thinking in the broad regulatory aspect of pesticides. And that would not be this witness' responsibility.

BY MR. ROGERS:

Q You said you get some of the analyses from each of the formulators, is that correct?

A Yes.

Q Is this true of their discharge, if any?

A No, we have no information about their discharge, only the finished product they are making and only that that they make for Velsicol.

Q You are concerned with the efficacy and efficiency of the product, aren't you?

A This is correct.

Q Do you know if these formulators have laboratories?

A Some of them do, I don't know whether all of them

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do or not.

Q Well, how firm can you be that the formulators do not have a discharge; is this simply on the basis of your telephone calls?

A This is simply on the basis of the telephone inquiry and their own statements.

Q Well, I take it is your position -- meaning Velsicol's -- that the proposed toxic standards would not affect the formulators?

MR. LORANT: This witness would not have a position relative to that.

MR. ROGERS: Why not?

MR. LORANT: Because that would be, I would venture to say, a policy decision.

MR. ROGERS: Well, if they don't have any discharges and he says that in his affidavit, "It is believed that none operate facilities constituting a point source discharge into navigable waters."

MR. LORANT: That's correct. That's a factual statement, and that's the extent of his inquiry.

BY MR. ROGERS:

Q My next question, then, is, ergo, they would not be affected by whatever number, directly affected by whatever number we come up with in these toxic hearings; is that correct?

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A This would be my impression, yes.

Q Except to the extent, perhaps, that the manufacture is affected by the numbers?

A Yes.

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Q With the three plants that you mentioned that have connections with a city sewage system, what liquid wastes are they discharging to the system?

A I didn't go into detail with them. I just asked them did they have a water discharge, and if so, where did it go? I didn't go into any detail with them about where their process had criginated and so forth.

Q Well, can you state for a certainty that all the formulators use a non-aqueous formulation technique?

A To the best of my knowledge, yes.

Pesticide formulations -- Endrin is not, as far as formulation is concerned, not different from toxaphene or other pesticiees.

I believe the object of a formulator is to make as concentrated a solution as possible. This, of course, involves the use of an organic solvent. To the formulation are added additives like emulsifiers so that the user can disperse these in water to some desired concentration and then apply that.

But the formulator, as far as he is concerned, would like to keep water out of the systems, because of the presence of emulsifiers and --

Q The formulator wants to make as concentrated a solution as he can?

A Yes.

brb2

This is to his advantage, in selling the most in the least number of drums, for instance.

Q That's not true of all pesticides, though, is it?

A Well, I can't speak for others. I would think so, though.

Q Really?

What about the granulated insecticides for farm land, which are -- that's an example, isn't it, where it is not concentrated?

MR. LORANT: Mr. Rogers, I really didn't want to be in the position of objecting, because perhaps this information is interesting.

However, we are far afield of the expertise of this witness, and I would further state that all formulations of Endrin that are permitted in the United States are registered with the EPA, and I think the punch of a button will give you all the formulations that are so registered, and would give you that information far more accurately than this witness can.

MR. ROGERS: Well, that's one area; you hit upon, perhaps,one point.

But there are many aspects of Endrin sales and formulation where we do not know the actual day to day occurrences, and we really want to know those because, as we are going to talk about tomorrow, we have Endrin toxicities lower

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than any other chemical known to man in the parts per trillion range, and we want to know how this Endrin can get into the environment from point sources, for example.

Now, that's the reason I'm pursuing this with this witness who has been employed by Vesicol for 19 years.

MR. LORANT: We are talking now about point sources and not agricultural applications. If we are talking about agricultural applications, we would have had someone here to that point. But I can't see where it's relevant to this inquiry.

MR. ROGERS: Well, Shell has maintained in the other proceeding, as you well know --

MR. LORANT: That's the proceeding on tolerances and cancellation of agricultural labels.

Your Honor, again I think I would like to move to limit the inquiry of this witness to the more relevant aspects of his knowledge and, indeed, to the relevant aspects of this hearing.

MR. ROGERS: Well, I want to submit that fertilizer blenders and formulators are definitely point sources.

MR. LORANT: This witness has testified that he inquired of Vesicol's formulators and that they either had no effluent, water effluent, or else they went to a municipal sewer with secondary treatment.

He didn't do more than that, as he has already

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testified, so how can he say more about what they do? He has never visited a formulating plant.

MR. ROGERS: There is an inherent inconsistency in even what he said.

Do the formulators use a non-aqueous solution, all of them? Do some of them use water in their solution? Why are they going to sewage treatment plants at all, if they have completely closed systems?

I asked that question; he didn't know.

MR. LORANT: These are not Endrin formulators uniquely, as he has already testified.

A formulator deals with many things. When he's dealing with Endrin, he's dealing with Endrin. But when he's dealing with toxaphene or, indeed, I think you're correct in what was implicit in your previous question: some toxicants, pesticides, are formulated in the parts per million concentration, growth regulators and so forth. However, this witness aan't testify to the entire spectrum of pesticides when his whole experience has been at Velsicol, Memphis.

BY MR. ROGERS:

Q Let me ask this question.

When you asked these formulators whether they had a discharge at all, or where the discharge went, were you asking them specifically in terms of Endrin?

A No.

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Q Well, what difference does it make what they do with DDT or with methoxychlor? Really, what difference does that make? What's the value of your inquiry if you didn't ask them about Endrin?

MR. LORANT: Again, Mr. Rogers, if they have no effluent --

MR. ROGERS: Mr. Lorant, in the affidavit it says it's believed none operate facilities constituting a point source discharge into navigable waters.

MR. LORANT: Because he asked the question and it was answered to him, and he has now given it in his affidavit.

JUDGE SWEENEY: Well, let me answer the question, Mr. Lorant.

MR. LORANT: All right.

JUDGE SWEENEY: It's his affidavit, not yours.

BY MR. ROGERS:

Q Was that sentence in your affidavit in terms of just general pesticides or Endrin?

A It was in terms of effluent, aqueous effluent, period. This is what I asked them.

Q What about in terms of effluent, liquid effluent, from Endrin formulation? Do you know whether they discharge any of that?

A If they told me they had no effluent from their

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plant, I did not see pursuing it to whether it was Endrin or something else that they weren't putting in.

Q Well, what about the ones that did say they had effluent from their plants?

Was that Endrin?

A I only talked personally to one of these. Someone else talked to the other two, and the one I asked if there was any Endrin in his effluent, he said, "I don't know; I never analyzed it." But he did not think there was any Endrin in it.

Q But he has never analyzed it?

A Right. He couldn't give me a number, therefore.

Q You talked to one?

A Yes. Only one of the three who went to the sewer.

Q Who talked to the other two?

A Mr. Mitchell.

Q General Counsel?

A Yes.

Q Did they have Endrin going to the sewer?

A Well, this I don't know, since he just gave me a not saying that he had called them, those two, and gave me the list for the rest to call.

Q So, to sum up, you're not sure whether the Endrin formulators across the board have closed formulation systems or not, are you?

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A Well, I haven't seen them, so I just have their word.

Q Are the formulators under any type of guidance or control by Velsicol?

A In what way?

Q Do you warn them of the unbelievable toxicity of Endrin?

MR. LORANT: I object to that.

MR. ROGERS: I'll withdraw that.

THE WITNESS: I had no contact with them; I don't know.

BY MR. ROGERS:

Q Well, who does have contact with them? Do you have any environmental quality control people who keep in touch with the formulators and keep them informed of toxicity problems?

A I don't know.

MR. ROGERS: Would Dr. Polen know?

MR. LORANT: Surely.

BY MR. ROGERS:

Q Are there any fertilizer blenders for Endrin?

A I don't know this.

Q Or custom applicators?

A I couldn't say.

Q Well, is Endrin put on by the farmer, or do you have

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a license to do it? Surely you know that; you've worked for the company for 19 years, sir. Surely you know whether a farmer can go out and buy Endrin or whether it has to put on by a licensee?

JUDGE SWEENEY: He didn't say he didn't know, Mr. Rogers. Give him a chance to answer.

BY MR. ROGERS:

Q Go ahead.

A I don't know.

Q All right.

Well, let's turn to your manufacturing plant at Memphis.

Is this the only manufacturing site for Endrin?

A To my knowledge, it is.

Q In the United States and the world?

A In the United States. I don't know about the world.

Q Has it always been Velsicol's only manufacturing site?

A For Endrin, yes.

Q What other pesticides are manufactured at this Memphis plant by Velsicol?

A We make heptaclor and we make chlorohepton.

Q How long have you been making Endrin at the Memphis plant?

brb9

A. The commercial plant started production at the end of 1955.

JUDGE SWEENEY: Mr. Rogers, I think we'll take a recess now.

MR. ROGERS: All right.

JUDGE SWEENEY: We'll take a recess until three o'clock.

MR. ROGERS: Fine.

I imagine I have 45 minutes more.

JUDGE SWEENEY: All right.

We'll finish today, anyway?

MR. ROGERS: Certainly.

(Recess.)

end 3C

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JUDGE SWEENEY: On the record.

BY MR. ROGERS:

Q Let's go back to the manufacturing site, Mr. Marks and we'll try to run through how the material is made and some of the details of your process.

Let me just quickly get back to the products that are made. You make heptachlor, chlorohepton, and endrin, at that plant; is that right?

A Yes.

Q Are all the pesticides being made at the same time or do they have to be made at separate times?

A Well, the heptachlor plant is separate from the endrin plant.

Q Separate in the sense that --

A They are completely separate units.

Q Different waste streams?

A Yes.

Q But the chlorohepton, where is --

A That's made at the heptachlor plant; it's just a mixture of solvent and heptachlor.

Q So we can talk simply in terms of endrin plant and what goes on at the endrin plant?

A Yes.

Q All right.

Is endrin being made year-around?

jrb2

A Yes.

Q Is it a batch process? Or is it a continuous flow?

A Batch process.

Q So you would have a batch discharge, also you would not have continuous flow of water from the pipe?

A Well, we have continuous flow of water from pipes in the plant, cooling water, heat exchanger, cooling water, things of this sort, that are continuous but are not in contact with endrin, with the exception of one small stream that is a vacuum jet tail water.

Q All right.

Well, let me just talk about the streams that have or which possibly could have endrin in them. Are those streams fairly constant or do they fluctuate a great deal.

A They are fairly constant.

Q At what flow?

A From the endrin plant there is about 450 gallons a minute total flow at the present time.

Q Now, how do you maintain a constant flow when you have a batch operation?

A Well, the batch operation goes on inside the vessel; as soon as one batch is finished and pumped out, another one is started.

They don't necessarily turn off the cooling water

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jrb 3

on the jacket on a heat exchanger, they just leave it running.

Q Okay.

Then I guess my question is: From the batches themselves, do you have any discharge of liquid?

A No, only through leakage and spillage. The endrin as produced in the reactor comes out in a slurry form, crystals, and in an organic solvent. It is centrifuged to separate the solvent, dried in a rotary vacuum dryer, and packaged.

Q All right.

Let me see if I have this correct, then? You have a vessel at the Memphis plant in which you put the various raw materials from which you derive endrin; is that correct?

A Yes, right.

Q And all those materials are in such precise quantities that they mix perfectly and you get a batch of endrin?

A Right.

Q And you don't have a runoff of X-chemical or Y-chemical?

A No, it's all contained in the reactor.

Q Have you ever attempted to measure the leakage from a vessel like that?

A To answer your quetion as you asked it, no. We

jrb 4

made surveys of the water coming from the plant to try to determine losses, you know, adventitious or otherwise of endrin; but to say, to go up to a reactor and measure what's leaking, you know, there's nothing leaking as far as endrin is concerned.

Q All right.

A It would be awfully hard to measure.

Q You do have endrin in your discharge flow, correct?

A Yes, we have some.

Q Where does the endrin come from?

A Some of it comes from -- on our vacuum dryer blender we have a filter system, and air type filters system, to filter the vapors being dried off of the endrin. Sometimes there will be some very fine endrin dust carried through. This gets into the vacuum jet tail water and is one source, a small source, of endrin contamination.

We have a distillation system for recovering the organic solvent and this is endrin in an organic solution and sometimes there are leaks, flange leaks or something of this sort that can drain into the system. We are now engaged in a program to eliminate these sources insofar as humanly possible.

Q You gave a gallons per day or gallons per minute figure earlier. Was that for --

A That's for the total endrin plant. Now, a lot of

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this is made up of un-endrin contaminated water; that's the total effluent from the plant.

Q What is the flow of the water that could possibly be contaminated by endrin?

A Well, the total flow from the entire plant is about 2,500 gallons a minute, goes to the city in an intercepto sewer, and there's another 800 or so that goes to a city storm sewer.

Q Why don't we back up. I want to make sure we have these definitions exactly precise and the numbers right.

In your endrin plant you have certain types of water that don't really get involved with the endrin manufactur In other words, --

A Right.

Q -- you have laboratory wastes and things like that?

A Yes.

Q I take it you have several sets of pipes. Now, do all these pipes lead to one major outfall?

A yes, from the endrin plant, they do. In other words all of the watter, effluent from the endrin plant, regardless of whether it comes from contaminated sources or not at the present time goes into a single sewer system, which then combines with other sewer systems from other producing units to become the final plant effluent.

Q Now, that was the 2,500 gallons per minute?

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A Yes, that's the final effluent, that 2,500 gallons per minute.

Q Well, why did you give a figure of 800 gallons per minute? Where does that go?

A Well, we actually have three discrete flows. The 800 gallons a minute is made up of two surface streams, some cooling water, uncontaminated cooling water is just put out into a ditch to runoff from surface drainage to the city's storm sewer.

Q That would be in addition?

A Yes, that's in addition to the 2,500.

Q But we need only talk about the 2,500 in terms of possible endrin concentrations?

A There is a little bit of endrin in the other picked up from the soil, adventitious pick-up, not direct process.

Q Do you have any idea of how much?

A It runs on the order of a tenth of a pound per day or less.

Q In the 800 --

A In the 800 gallons.

Q Now, the 2,500 gallons per minute goes to the city sewage system?

A Yes, interceptor sewer.

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Q And from there it goes into the --

jrb 7

A Into the Mississippi.

Q After treatment?

A Memphis has no treatment plant at the moment. I have been invited to the ground-breaking of the new North Treatment Plant later this month.

Q So that the flow goes into a piping system which is the interceptor?

A Yes.

Q And from there it goes into the Mississippi?

A Yes.

Q What is Cypress Creek or Wolf Creek?

A This is the storm sewer that I am speaking of.

Q I see.

A Now, it flows into Wolf River, which is a tributary of the Mississippi.

Q The reason I asked that, Dr. Polen has referenced several studies which show Cypress Creek, I think is the name of it, to be at one time heavily contaiminated with endrin. Now, were the discharges at that time the same way they are now, or has there been a change?

A There has been a tremendous effort to try to clean up the Cypress Creek, in other words, eliminate any possibility of contamination; and in addition, the city has -- it used to be just a dirt ditch with pools and things laying on the bottom. The city has come along and with the

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exception of about three-quarters of a mile of it, of the tail end, it's now just a six-inch, sixty-foot wide concrete open trench.

Q But does your endrin -- strike that.

Does the 2,500 gallons per minute flow go into Cypress Creek now?

A No.

Q It goes directly to the Mississippi?

A It goes directly to the Mississippi.

Q Through underground piping?

A Through underground piping along with other industries' wastes.

Q Let's talk about the 800 gallon flow for a minute.

How does the endrin get into that flow when it's only cooling water?

A Mainly from contact with soil. We're in the process now of trying to pin down exactly where this is coming from. We have traced it back up into the actual plant pipe where the water comes out, and the endrin is not there; so it's picked up after it contacts the soil.

Q Well, how does it get in the soil?

A I don't really know for sure. It could have been spills over the years.

Q Volatilization?

jrb 9

A Any kind of mechanism. I really don't know.

Q Well, could it be dust or volatilization from the plant?

A It might be possible, I couldn't say at the moment. I don't have enough data to pin it down.

It's something similar to the problem as described about PCB's, you know, in other nonproducing areas of the plant. Endrin has been produced for a good many years.

Q Well, all right.

You mentioned you had a vacuum dryer?

A Yes.

Q And that is vented or that has pumps?

A No, it has a steam jet vacuum source.

Q Well is it vented?

A Only through the steam jet when there's endrin in there, when it's in operation.

Q Is this one way endrin can get into the environment?

A Yes, this is one of the direct streams that I mentioned to you before. This is a very small amount, however.

Q Now, this goes to the 800 or the 2,500 gallons?

A This goes to the 2,500.

Q How has your manufacturing process changed over the years, if at all?

A Well, the basic process itself has not changed

jrb 9

with one exception: we have made improvements in materials-handling equipment. The original plant used screw-type conveyers for conveying the wet endrin from the centrifuge, and to the dryer and to the blender from the dryer. We changed the process to eliminate a separate dryer. We now have a combination dryer-blender which eliminated one transfer of potentially dusty material.

We now use centrifuges instead of -- I mean slow speed basket centrifuge instead of high speed, constant speed centrigures. When the knife came up, the centrifuge discharge knife, hit the cake at high speed -- endrin is a rather brittle crystal and it converted it into dust. In the early days of endrin production we had a tremendous dust problem.

We have tremendously improved this by going to a centrifuge that doesn't break the crystal, so it remains crystalline and much less dusty.

We've improved our housekeeping considerably, recognizing endrin being the problem that it is. We have areas of the endrin plant diked off so that if water spills on the floor it goes to a sump and we have to pump the sump out and send it to the incinerator, things of this sort.

We're trying to contain the endrin if it gets out and try to contain it in the system; but if it gets out, try to isolae it from any effluent capability.

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Q How many pounds per day do you discharge?

A We are averaging on the order of 1 to 2 pounds a day. Some months we might discharge as much as 3, but this figure has continually been coming down to about the 1-1/2 to 2 pound level generally.

Q Well, for example, how many pounds were you discharging five years ago, if you have any idea?

A I don't recall the exact figure. I am sure it would be more.

Q Do you have any figure or the concentration of endrin in your waste stream?

A Yes, I do.

It runs on the order of, the general order of 10 parts per billion, or less sometimes.

Q Have you ever measured the point at which the sewer line hits the Mississippi for endrin concentration?

A We have not, but EPA has.

Q Do you remember the figure?

A I don't recall it offhand.

Q Where do you get the water which you use in your plant?

A If we want it essentially iron-free, and there are a couple of process uses that we don't want iron in, in the total plant, we buy it from the city. Of course all our drinking and sanitary water is city-supplied water. The main

jrbll

plant cooling water supply is from our own wells. We draw the water from the same stratum that the city does, but they aerate it and pick up iron; so, therefore, we do have some higner iron in our well water than we do in our city water, but it even comes from the city mains or from our wells. The ultimate source of it is the same.

Q How long is the sewer system from the point at which you enter it to the point where it hits the Mississippi?

3 D

A My best guess would be five to six miles.

DE dr-1

Q Are there other chemical products that are given off in the manufacture of endrin?

A Yes. We find some intermediates in some of the water.

Q Well, is it Aldrin and Dieldrin; aren't they given off?

A We don't find Aldrin and Dieldrin. They are not, apparently, as far as I know, made in the process that endrin is.

The front end of the process is different.

Q Well, Aldrin and Dieldrin are byproducts at your Memphis plant, aren't they, for heptachlor or one of the --

A No, not to my knowledge.

Q Well, if you know, what chemical byproducts are being discharged?

MR. LORANT: Byproducts of what?

MR. ROGERS: The endrin manufacture.

A Well, the three intermediates can be detected in the water. What we call hexavinylchloride, Diels-Alder, adduct of hexachlorocyclopentadiene and vinylchloride.

The second product is what we call Hex-PCH, which is hexachlorobicycloheptadiene.

And the third product is isodrin.

Q Q In several of the reports that Dr. Polen refers to in his testimony, residues of X and Y show up.

dr-2

A All right. That's the --

MR. LORANT: Which report are you referring to?

MR. ROGERS: I think in almost every one of his references from the Pesticide Monitoring Journal X and Y either appear or were looked for. And I wondered if those are compounds you have referred to.

A Two of them are, yes.

X and Y are the first two.

MR. ROGERS: I see. Okay.

BY MR. ROGERS:

Q Are these metabolites of endrin?

A No, they are intermediates in the process of making endrin. They are the steps.

Q Are they persistent? Or do they metabolize into other forms?

A I don't have any personal knowledge of their metabolic processes.

Q Where, in the process of endrin, do you lose these intermediates?

A Well, the hexavinylchloride is converted into hex-PCH, and hex-PCH is converted into isodrin, and the isodrin is converted into endrin.

Q You said these can convert, one to the other. Do they do so?

A Chemical reactions.

dr-3

Q They cannot do it in the environment, is that correct?

A I would not think so, under the conditions that it takes for a reaction. I cannot conceive of it in the environment.

Q Has anyone studied whether in fact these reactions have taken place in the environment?

A Not to my knowledge.

Q Well, if we find isodrin or the other two compounds you mentioned, which I'm not going to try to name, in the water, can we be confidant that they come in some way from endrin manufacture?

A This would be a conjecture on my part. I don't know of anyone else making these materials, so I might be brought to conjecture, you are right.

Q Do you have any idea of the quantities of these other compounds that are being discharged daily?

A In a general order of magnitude.

I don't know about isodrin. But the hex-PCH hex-vinyl in the order of magnitude of a half to one part per million.

Q A million?

A Yes.

Q And you're talking now the total of all of these?

A Individually.

Ir-4

Q So we could be up to three parts per million, total?

A If you throw those two in, possibly yes; I don't know about the isodrin, however. I don't recall any numbers for it.

Q What about pounds per day?

A I think we're talking about something in the neighborhood of possibly 40 or 50.

Q Mr. Marks, have you ever done any toxicity studies, or are you aware of any toxicity studies on these other products?

A We have -- in our laboratory, we have exposed fish to Hex-PCH. They apparently live, at least on a 48 hour TL_m type test.

Apparently saturated solutions have no effect on them as far as we can tell.

Q Well, can you site, or can you lead us, to any studies which would give us an idea of the toxicities of these other products?

I take it this was some unpublished work.

A Right. I know of no published work.

Q Let me ask you some questions about your laboratory.

Do you monitor and analyze right at the Memphis plant yourself?

A Yes.

MR. LORANT: Are you talking about the effluent

ar-5

stream?

BY MR. ROGERS:

Q The effluent stream?

A Yes.

Q How often do you monitor?

A Daily.

Q Once per day, or --

A Well, we take a composite sample, and make one analysis a day.

Q And I assume you monitor for endrin and these three other products?

A We don't monitor for isodrin. We analyzed the normal analysis as Hex-PCH, hexvinyl, endrin. As far as the endrin plant is concerned we analyze for some other things also.

Q What are those?

A Heptachlor and heptachlorepoxide.

Q I'm confused now, because I thought you said that these three things are the other chemical products that appear in the stream, and I asked you about some of them in the plants.

A Right. Well, the plants are separated, but we monitor the three streams as they leave our property. This is the sampling point.

Q I see.

A Therefore, in effect they are combined at that point. But they start out separate as far as the plant itself is

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Q Are the pipes combined, then, before they, as a unity, come into the sewage system?

A Yes.

Q And you monitor after the combination?

A Right. We monitor the final effluent. This is what the state has required.

Q Just out of curiosity, what are the heptachlor ranges, if you remember?

MR. LORANT: I object.

I can't see the relevance to that in a hearing on endrin.

MR. ROGERS: Let me give you the relevance.

We've had someone in the industry when this is talked about: lack of cynergistic effects; we've had much testimony about additive effects; we've had a lot of testimony about why the EPA should go out and look at every situation as a case by case situation and determine whether there are any other pollutants present, determine the types of water that it's going into, whether it's hard or soft -- all these specific situations which could affect the toxicity of the chemical.

And here, clearly we have a situation in which several toxic chemicals are together; and if EPA should, in fact, follow industry's advice and try to do it on a case by case basis, these are the types of things we would like to know: how many toxic chemicals are being put into the stream,

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and in what quantities.

MR. LORANT: Go ahead.

A It runs generally on the same order of magnitude as endrin.

BY MR. ROGERS:

Q Three points maximum, and three parts per billion?

A Three, maybe five, something of this sort. Sometimes a little more.

Q Are there any other -- is this heptachlor or heptachlorepoxide?

A Well, there's very little, if any, heptachlorepoxide. We only analyze for it because the state requested we tell them. It's usually a part per billion to undetectable, in that range.

Q Well, let me just quickly sum this up, then, and then we will go on.

You can have in your final effluent stream between 40 and 50 pounds per day of isodrin and the other two biproduct compounds?

A Well, as I said, I don't know what the isodrin is. We don't normally analyze for that.

Q So these are the other two?

A These are the other two.

Q Could I call them X and Y?

A If you like.

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Q All right.

MR. LORANT: Why don't you call them by their chemical names.

MR. ROGERS: Because I can't pronounce them.

MR. LORANT: Well, hexavinylchloride and hex-PCH is what you're talking about.

MR. ROGERS: All right.

BY MR. ROGERS:

Q With those two, we have 40 to 50 pounds per day?

A Yes, as best I can estimate.

Q And we have endrin up to three pounds per day, but you think it is more one to two pounds?

A The last few months it's been running more closely to two, or less.

Q And an undetermined amount of isodrin.

A Right.

Q But we do have between a half and one part per million isodrin?

A This I don't know. I would imagine the isodrin would be less, but I don't really know.

Q And then we have up to five pounds per day of heptachlor?

A Right. Those are average figures I'm giving you.

Q Why are you using so much water in your endrin plant?

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A Mostly, a wholloping part of it is to run the barometric condensers steam jets. We have some vacuum jets over in the endrin plant, other than in the endrin process, too. This is a big part of it.

Q Well, are these contaminated, this great quantity of water? Are these flows contaminated or susceptible to contamination?

A Many of them are not. As I say, we're engaged in the program at the moment to segregate uncontaminated streams, combine all the contaminated streams, and then do something with it.

Q That was my next question. Thank you.

What do you think your flow will be then, from your contaminated streams?

A Well, our plants are to combine the effluent from -- well, to reduce it by internal recycle where possible, or diversion, if not possible to recycle -- separate the contaminated streams.

We are hopeful that we will get down to a total from endrin and heptachlor plants both of 75 gallons a minute.

Q That's a tremendous reduction, isn't it?

A Yes.

Q Am I right: it's from 2,500 to 75?

A Oh, no, I'm talking about just that flow from the endrin and heptachlor plants combined. It's now around 1,030

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gallons a minute. And not all of this will be eliminated. Some will just be diverted into -- you know -- around -- it will still be in the sewer but be delivered around the possible point of contamination. And that balance, on the total outflow, is something like 1,900 gallons.

But the contaminated flow of the contaminated sewer will be, we hope, 75 gallons, which we can deal with.

Q I see.

Well, to return quickly to your statement, and particularly those portions of the statement where you say that there is no available technology that could bring the effluent concentrations down to within EPA's range.

Is that a fair summary of what you have stated?

A Yes. Based on our present knowledge, yes.

Q Do you know of an article published in 1965 by Roebeck et al, and it's in the Journal of the American Waterworks Association?

A I am not familiar with that one.

Q Well, I don't want to pursue this too long, but I did come upon it in a publication by EPA. Let me ask you the question, and I'll give you the article so you can take a look at it.

A All right.

Q In here, they talk about powdered activated carbon and they have a powder plant study in which they bring endrin

dr-11

concentrations down to EPA's -- to within EPA's designated range. That chart is on page 192, and if you would like, I'll show you that.

(Document handed to the witness.)

MR. LORANT: Was the article fully defined, the reference?

MR. ROGERS: I don't know if it was.

BY MR. ROGERS:

Q Perhaps you would like to read into the record the whole article title and the citation.

A Right.

It's title is Effectiveness of Water Treatment Processes in Pesticide Removal, by Gordon G. Roebeck, Kenneth A. Doestel, Jesse M. Cohen and James F. Kreissl.

It says, "a paper presented on June 4, 1964 at the Annual Conference, Toronto, Ontario," by these people who apparently were from the Division of Water Supply and Pollution Control, U.S. Public Health Service, Robert A. Taft Sanitary Engineering Center, Cincinnati, Ohio.

Q Would you give the journal it appears in?

A Journal of the American Waterworks Association, February, 1965.

Q My question simply is, did you have a chance to review that article before you made your statement, your verified statement?

dr-12

Q Do you agree that at least the chart that appears there shows that they are getting endrin concentrations down to quite a low level?

A The data would seem to indicate this. I have a question as to how practical this process would be in actual practice, where they are using batch carbon dosages apparently.

Q Why is that?

A Well, because of kinetics and so forth, the amount of carbon that would be required for the type of problem we have would be so great that I don't believe powdered carbon would be practical from an economic standpoint.

Q Even for 75 gallons per minute?

A Yes.

Now, remember, we're not talking about -- we're talking about reducing the flow. We're not talking about reducing the contamination in that flow from the equivalent of a thousand down to seventy five, because all of the contaminated streams will be in there, but they will just be more concentrated.

We're taking out the dilution water.

Q But doesn't that make the carbon system that much more efficient?

A Possibly. I have no data about treating it. The work that I'm familiar with in the literature, and the work that we have done in our own laboratory, would lead me to

dr-13

believe this would have to be experimentally verified in a pilot operation.

Q Have you or has Velsicol hired a consultant to look into the possibility of activated carbon treatment?

A Yes. We've had consultants look into -- not restricted to just activated carbon, but to find a functional system to do the job of reducing the endrin to a one pound per day maximum limit, which is what the EPA has requested.

Q Who has requested that?

A The EPA?

Q Where?

A Atlanta. Region Four.

Q In what form did this request take?

A Well, I think it evolved essentially, "If you don't agree to this limit, we'll sue you;" this type of thing. It's an enforcement type operation.

Q Well, I want to be very clear about this, because it's our understanding that headquarters of the regions are looking to this hearing for contamination, of what quantities of toxic pollutants will be allowed.

A Well, this agreement came up before the toxic pollutant subject came up, and this is the limit under which we are now operating and aiming to meet.

Q Well, I hope you're aware of -- maybe I should address this to Mr. Lorant, but even permits that are granted

dr-14

now have a specific proviso that they are subject to 307 regulations and that the more stringent regulations will apply.

MR. LORANT: I'm aware of that, Mr. Rogers. That such seems to be the case.

However, that doesn't negate what Mr. Marks just said, that there has been communication with EPA over an extended period of time, and that one pound per day is the goal that they have urged us to shoot for.

MR. ROGERS: Region Four.

MR. LORANT: That's correct.

THE WITNESS: In cooperation with the enforcement division in Denver.

This came about as a result of an EPA survey of our waste streams in connection with a survey of other big industries in Memphis.

BY MR. ROGERS:

Q Let me return quickly to this carbon adsorbtion, and then I want to get into the consulting contract you have let and the type of technology you're looking at.

Were you in Atlanta on April 19th for the technology transfer related to this toxic hearing?

A Yes.

Q There was a paper presented there by Hager and Rizzo of Calgon Corporation; do you recall that?

A Yes. I've talked to both gentlemen about it.

dr-15

Q And the reason I bring it up is that they, too, suggest that with granulated carbon the endrin limits can specifically be met. And they have a chart, Figure 5, in which they actually show the EPA limits being met with their system.

Did you have a chance to review this?

A Yes, I have. And this is really my objection to their conclusions. They used a static system, not time-dependent; an equilibrium system, so to speak, which in our experience in trying to translate activated carbon to using granular carbon, which is the only thing that is really best suited for a stream type application, does not bear our kinetically and otherwise the efficiencies that this theoretical type curve would indicate.

I have some other comments about their work, but that's the main thing.

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4A ebl

Q Mr. Marks, let me quickly ask you some questions about other pesticide manufacturers.

EPA put out a publication some years ago in which they did a survey of the various manufacturing sites and they went to Montrose Chemical, which produces DDT, and Shell, which produces Aldrin-Dieldrin. And at least according to this publication, and also according to our information, those systems have no liquid wastes at all. They discharge to a concrete evaporative area.

Are you aware of that?

A Yes.

Is this the 1972 book?

Q Yes.

A I believe I have a copy of that.

I'm aware of this, but the humidity conditions in the Memphis area would not be conducive, and the rainfall would not be conducive to evaporative systems.

Q Wouldn't you merely make it bigger?

A Well, we have limited space to do it. I suspect Shell had half the Denver Arsenal to put their lagoon in.

Q They have a hundred acres.

A We don't have a hundred acres all told.

Q You have another facility in Illinois, do you not, Velsicol?

A Yes.

eb2

Q That produces other chemicals?

A Yes.

Q And they use, as I understand it, a deep well injection system.

A Yes.

Q Have you ever examined that for your situation?

A Not seriously, because it is our belief that the Memphis Light Gas and Water Division wouldn't stand still for-- You see, the water supply in Memphis does not come from the river; it comes from artesian wells. At the 500-foot level where most of it is drawn-- They go all the way down as far as I know to 3,000 feet below, and it is not exactly the type of environmental situation one would want to dig a disposal well in.

Q No, I can see that.

Let me turn to page 5 of your statement where you refer to this promising technique. Would you give us some more details on this proposal and what you've been doing to look into it?

A Yes.

Last year in February in Environmental Science and Technology, Dr. Kennedy of Rohm & Haas, published an article, the first one I have seen published, on the Amberlite XAD-4 resins-- They have an XAD-2, but the XAD-4 is recommended in this case -- in which he mentioned the fact that it had a

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great affinity for chlorinated hydrocarbons, and it had been used in what apparently was a DDT operation, at least a by-product they were adsorbing, similar to that from a DDT operation.

This developed our interest. At the time, our project with Ryckman, Edgerly & Tomlinson to try to find a functional system to meet the one pound limit was coming to a conclusion with their recommendation that we use solvent extraction, but we rather objected to recycling 600 gallons a minute of something as formidable as heptane, so we were looking for an alternate source, and this came to our notice.

We obtained samples of the resin and tried it out on our actual effluent and found that it did indeed have a very good adsorptive capacity for Endrin as well as other -- the other materials, other chlorinated materials, contaminants in the waste stream.

It seemed to be relatively non-selective.

Somehow, I'm not sure just exactly how, Dr. Bob Swank with the Technology Division in Athens learned of it. I believe there was someone in our R&D Department talking about another matter -- It seemed to be casual -- asked us to come down and talk to him, which we did.

And he was familiar with the resin. He had talked to Kennedy at Rohm & Haas and he was looking for someone who would take on a program in this area to build a demonstration

eb4

plant to show that -- to prove the technology.

And he asked us to request a grant from them, as much from EPA's standpoint so they would have the information and as much from our standpoint to cooperate and work together on the solution to the problem. And of course this was before the-- This was last year, before the toxic standard came out.

We began our work actually last October and during this interim when we were working, this toxic standard came out.

MR. LORANT: You're talking about the proposed standard?

THE WITNESS: The proposed standard, to try to meet this.

So we prepared the grant application which I understand from our last conversation with Dr. Swank is essentially approved and it is just waiting for the accountants in North Carolina to approve the allowable portion of it for his granting of the money.

So any minute we expect to have a proposal from EPA on this.

The work itself, the laboratory work itself is extremely promising with one exception, that we don't seem to be able to get it down below a half a part per billion. We ran activated carbon columns under the identical conditions,

eb5

side by side. The carbon column broke through in two weeks, and by "breaking through" I mean reached the outlet, reached equilibrium with the inlet.

We ran the resin column until about the middle of January from the 12th of October. It had never shown any sign of breaking through.

The resin has an additional advantage from a commercial process standpoint, that it is easily regenerable by a solid. The carbon has to be thermally regenerated and of course this creates other problems, air pollution and so forth, as well as expense.

You mentioned the Hager and Rizzo paper. At Atlanta the costs which they quoted at the meeting were in the range of $5 to $20 a thousand gallons of waste treated.

My preliminary estimated cost for the resin system in the most inflationary conditions I can think of is on the order of $2 to $2.50 a thousand gallons.

BY MR. ROGERS:

Q Which would be 75 per thousand gallons?

A Yes.

Now you see, 75 gallons a minute is around 110,000 gallons a day.

Q So you'd be talking $300 a day?

A Right, as against their cost anywhere from $600 to

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2,000, roughly.

So this is why the resin, from a practical standpoint, looks good to us.

Its capacity-- We don't know what its capacity is. We haven't run static tests like Rizzo and Hager did because we don't feel they are directly applicable to a dynamic column type situation.

We are working with the actual stream samples.

Q Are you through?

A Yes.

Q You said you thought you could -- or that the studies that have been done, the tests that have been run -- get down to .5 parts per billion.

A Right. We have had results as low as that. One of the things we are wanting to work on now is to try to see why they were that low at times, and try to determine what the ultimate point is. But as of the moment our experiments with varying contact time, column height, flow rate and so forth, do not indicate that we can get down -- can expect to get down to .2 parts per billion.

Q Just doing some quick arithmetic, if you currently have about 10 parts per billion and want one to two pounds per day with a half a part per billion you'll have around .1 pound per day. Isn't that correct?

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A Well, no, because we're not planning on treating

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that stream which has 10 parts per billion. The stream, after we reduce and combine and divert, the 75 gallons a minute is what we propose to treat. It will be much more highly concentrated. It will have the same total weight of material per day in a 75- instead of 1,000-gallon per minute flow rate.

Q You are not going to try to treat the stream with the 10 parts per billion?

A No, not as such.

Q Is that the cooling stream?

A Well, it depends on which one you're talking about.

We are planning on treating the contaminated pesticide sewer system that goes to the city interceptor sewer.

Q How many pounds per day are in that?

A That's the two to three pounds average.

Q So you have another stream with one to two pounds?

A We have another stream, two streams, which total roughly .1 pound a day, those going to Cyprus Creek, the 800 gallons a minute surface flow. It's usually .1 pound or less.

Q Well, what is the concentration when you get down to 75 gallons per minute?

A We don't know for sure what that will be. It is hard to predict. We can calculate it on the assumption that

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it would be a direct ratio. We're not sure this is actually in practice what will happen. The feed to the resin column we plan to filter which, in itself, takes out a portion of the pesticide.

Q Well, do you have any ballpark figures on your concentrations when it hits the resin?

A No, I have not back-calculated it to that point up to now.

Oh, when it hits the resin?

Q Yes.

A Yes. The effluent from the filter will be something in the neighborhood of -- oh, 30 to 100 parts per billion.

Q And you're going to get that down to .5 --

A We're going to get that down to .5, and that will be the 75 gallons which goes into the remaining roughly 1800 gallons of other plant effluent.

Q How many pounds per day is that then?

A Assuming that were the only thing, that we cleaned up the 75 gallons and we didn't pick up anything else out of the sewer system, that would be something on the order of a hundredth of a pound per day.

Q Then in addition to that you'd have a separate stream--

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A In addition to that we have a separate stream

eb9

which goes to Cyprus Creek which, say, is tens parts per billion. We get it down to a half, to one part per billion. It isn't itself going to meet the proposed limit, even with the resin technology.

Q But when you do use the resin technology you are going to get it down to an acceptable level; isn't that correct, theoretically?

A Well, we can meet the pound a day limit proposed. The concentration limit I'm not really-- Well, you see this is why we need the demonstration unit.

You know, we can sit here and theorize and throw numbers around but you go out in the plant and try to do something at this level-- You see, you have an analytical problem at this level, too. Can you detect it at that level? So this is not as simple as I maybe seem to imply.

Q We realize that.

We're having some problem because we keep talking about two different streams here, and you're saying that even when you apply the resin technology to the one major stream and get it down to 75 gallons per minute, you still can have a problem with the other--

A Right, our problem is going to be, as I see it, with the concentration limit rather than necessarily on the total poundage.

Q Let me go back and get this clear for the last

eb10

time.

In that stream that goes directly to Cyprus Creek, what is your concentration, what is your flow per day, and what is your pound per day?

A All right.

We have two streams, one about 600 gallons a minute, one about 250.

Now the 250 gallon a minute stream flows through the caustic chlorine plant and really is not connected with the organic area at all, although, due to analytical problems, we do sometimes think we detect, some days, a little Endrin part per billion or less in this stream when actually, you know, it really should not be there.

There is no mechanism one could imagine that could be there, and it just shows up sporadically. We feel this is an analytical problem.

The other, 600 gallon a minute stream does flow alongside the organic area and it has the concentration of, say, five to ten parts per billion of Endrin.

Q And that goes into Cyprus Creek?

A That goes into Cyprus Creek.

Q So we can just calculate that ourselves, taking the flow times the concentration.

A Right. You can calculate that. That's relatively clean water you know.

ebll

Q Well, ten parts per billion is what we would agree to be--

A Well, I'm not proposing that.

Q What is the proposed grant for, what amount of money?

A Well, the total grant is for $464,000, the total cost of which, of course, we will have to pay a portion. EPA will pay whatever portion they arrive at, and that's what we are waiting to hear now.

Now this really involves here again some cooperation with EPA, two distinct demonstration units.

Now there is another process which Dr. Swank is looking at and has invested some money in with a firm called Envirogenics in California, which claims to have a method by which they chemically degradate chlorinated hydrocarbons.

Dr. Swank has asked us-- In fact, as one of the inducements between us, he has asked us to, on a contract basis, build a demonstration unit for the Envirogenics system alongside ours because they need a pesticide plant effluent to try their tests on.

They've done-- I have seen no reported work from Envirogenics on Endrin and therefore I did not include it in this because the thrust of my affidavit was that I knew of no demonstrated process that would meet these limits in actual practice reported, other than some static laboratory

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studies on powdered carbon.

Dr. Swank wants to totally fund, on a contract basis, the Envirogenics work. The problem with the Envirogenics system is that whereas we are removing -- we're not adding anything to the stream; we're removing something already there.

The Envirogenics system apparently does not totally dechlorinate these compound and nobody knows what the toxicity of the products are. The fact they say you can't determine the pesticide coming out doesn't mean that you can't determine other chlorinated materials.

So this is the point and the agreement as proposed is-- You see, what I'm saying is the $464,000 also includes the total cost of constructing Envirogenics' system, which is $129,000 plus our cost for operating it. So the cost of our unit is something like $300,000, to be partially funded by EPA if everything works out.

We're not talking about a little bit of money. This program, to get down to 75 gallons a minute, is costing over a half a million dollars.

Q But in conclusion I take it that you would not be doing this unless you saw a distinct possibility that this method would be practically feasible in your plant?

A Well, I think Dr. Swank and others I've talked to in EPA agree with me that the resin system looks like

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End 4A

the best available technology, whatever it gets it down to; whether it meets the proposed limit is open to question.

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Q A while ago you said you were talking with a company called Rohm & Haas.

What is that?

A Rohm & Haas is a commercial manufacturer of, among other things, ion exchange resins; and this is a particular type of ion exchange resin. It's about eighty percent cross-linked, which takes out most of its ion exchange capacity, but makes a very hard, durable bead.

Q All right. Fine.

MR. ROGERS: I have no further questions.

Thank you.

JUDGE SWEENEY: Mr. Lorant?

MR. LORANT: Might I inquire, Judge: it's about four o'clock. I'm not sure I can finish with the witness today.

JUDGE SWEENEY: Well, do the best you can.

MR. ROGERS: Your Honor, I will have two to three hours tomorrow, and as you know we've been having a problem with witnesses.

If Mr. Lorant wants to do --

JUDGE SWEENEY: Well, you'd better stop having a problem with witnesses.

MR. ROGERS: The problem was simply, we weren't able to get --

JUDGE SWEENEY: You'll never get finished, and we

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won't get the EPA evidence in this month.

MR. ROGERS: The industry counsel were not prepared to go forward with cadmium tomorrow. We were willing to bring people in from Duluth tomorrow, and there were so many involved, and they just simply said they were not prepared logistically to go ahead with cadmium; but EPA was ready to bring the witness in tomorrow.

What I'm saying is --

JUDGE SWEENEY: You're saying that tomorrow we won't have anything to do in the afternoon again?

MR. ROGERS: It may be.

MR. LORANT: Well, we have this witness to finish and we have Dr. Polen, who will be here tomorrow.

MR. ROGERS: Well, your Honor --

JUDGE SWEENEY: Mr. Rogers, this is the third or fourth time I've said this.

You and Mr. Eckert are going to have to get together and get this hearing --

MR. ROGERS: We'll have a witness here tomorrow afternoon.

The problem is, industry counsel are telling us they couldn't be here for cadmium starting Friday afternoon.

JUDGE SWEENEY: We'll just tell them to be hers if you're going to have a witness and if they want to cross-examine, for them to be here. Otherwise his evidence will go

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in without cross-examination.

You've done everything you could to work with the industry lawyers. They're dragging their feet. We gave them a full week already, and Mr. Quarles has gone way out of the way extending the hearing through the end of the month.

The industry witnesses are the ones who asked for this hearing, and they should be prepared to go ahead.

MR. ROGERS: Well, I'm through with this witness, your Honor.

MR. LORANT: Your Honor, again I would request -- there are certain points in the testimony that I thought were a little confused, and I would need a little time with the witness to discuss these points with him so that I could perhaps clarify them.

JUDGE SWEENEY: All right.

We'll take a five-minute recess, and you can talk to him.

MR. LORANT: Thank you.

(Recess.)

JUDGE SWEENEY: Back on the record.

Mr. Lorant, you go as far as you can until about 4:30.

MR. LORANT: Thank you.

JUDGE SWEENEY: Go ahead.

MR. LORANT: Okay.

brb 4

REDIRECT EXAMINATION

BY MR. LORANT:

Q Mr. Marks, to clarify the scene, as it were, is Endrin a solid?

A Yes.

Q And you ship it only in sealed containers?

A Yes.

Q So that there are no such things as bulk shipments of Endrin?

A Right.

Q And, as I understood you to say, this was a batch process operated in the plant at Memphis, Tennessee?

A Yes.

Q Now, you've been with Velsicol for 19 years?

A 19 years.

Q Have you ever functioned in the commercial area with respect to Velsicol -- marketing, utilization of the products and so forth, out in the field?

A No.

Q Have you ever -- in the commercial sense: I am not talking about your backyard gardening, but in the commercial sense -- applied agricultural chemicals in any area, sir?

A No.

Q And have you ever participated in commercial

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formulation of Endrin?

A. No.

Q. So that your experience, even though it is 19 years, is restricted to be commercial operation?

A. Yes.

Q. The commercial operation in the production area, I should say?

A. Yes.

Q. That's true, isn't it?

A. That's true.

Q. Now, with respect to the efforts at containing Endrin at the Memphis plant, which I understood is, at least, within the scope of some of your responsibilities, can you tell us what you have done to minimize loss of Endrin in the effluent from the plant?

A. Well, as I testified before, we have changed the process to eliminate a unit that was producing dust, and reduced the potential for dust getting out of the system by process changes.

We have put dikes and sumps in all of the affected areas to catch and prevent the admission of Endrin to the sewer system.

We have largely eliminated the use of wash water on floors, things of this sort that would produce a possible problem.

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BY MR. WILLS:

Q Except for the brief preface at the top of the table on Exhibit 11 that you have referenced on page 8 of your testimony, is there anything else you know about that particular experiment, such as the number of species of each fish?

A The number of species?

Q The number of individuals within each species.

A No.

Q In fact, you know nothing but what is on this table?

A Right.

Q It's sort of hard to evaluate from that information the way the test was conducted, to assess any validity to the numbers there. You sort of need the background information, don't you?

A I'm relying on the past performance of the laboratory.

Q Okay.

Going to exhibit 13, I find it a little hard to understand where this data came from. I'm assuming that the table that contains the references to the various isomers goes with the letters apparently signed by Arlene Shelhon?

A Yes.

Q And am I correct in that she has compiled this

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table from the work of LaVarre --

A Yes.

Q -- Uhlken when he was an intern in the laboratory?

A Yes.

Q And this work is previously unpublished, and there are no written explanation of test procedures, conditions, anything unusual happening?

A This is what I received from Arlene.

Q There is no showing of the test procedures or the competence by which the isomers were prepared by Ron Webb?

A The test procedures are those accepted by the bioassay committee.

Q You assume that. It is not stated as such in this table.

Is that correct?

A I'm assuming.

Q You're assuming?

A Right.

Q If you were going to evaluate someone's work, would you desire to have more information than what is on these two pieces of paper?

A If I were unfamiliar with the laboratory and the personnel I would like to go to the laboratory and see what they were doing, yes.

Q Or see it written up?

brb3

A. Yes.

Q. In a procedure paragraph.

With respect to Exhibit 14, the four pages, do you know how many individual fish were used for each test? Do you know why the particular pH was selected that was used in the test conditions?

A. It's representative of common pH values where these fish exist.

Q. Where each exist? You mean bluegills, catfish, salmon, trout, and perch all exist in the same place?

A. These pH values will occur within the range of each individual fish species, yes.

Q. The alkalide, the hardness, they all live in the same type of conditions?

A. No.

They all live in a range of conditions ranging from lethal and low pH to optimum to lethal at a high pH. These are representative values that we used in these particular tests.

Q. It so happens they all were the same on table 1?

A. Very likely they used the same water.

Q. Well, with respect to this exhibit, if you were going to present an idea or present a paper, would you care to have a little bit more information with respect to exhibit 14, to give it some weight?

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A He has, I think, adequate references in his cover letter.

Q He does mention several tests; but are all of those at this time still being used, or have some of the bioassay techniques been changed as of 1974?

A Many are not changed; many are used routinely. The few that are changed are changed to try to make better tests. We still, however, do utilize tests that were found to be acceptable.

Q While I was looking at that table it reminded me -- this is your first exhibit, I'm sorry; Exhibit 2. I was looking at table 1.

This is going to be published, I take it, in the Transactions of the American Fish Society.

Looking at the left hand column, "Mean Measured Concentration", "51 - test tanks A and B", what is supposed to be shown by that concentration with no males and no females present?

A This is the number of males and females that were available in that tank for spawning, which means that they were killed by the concentrations prior to spawning.

Q So you didn't -- I don't understand; well, I can see --

Do you know who the Sager Committee is?

A No, not by that name.

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Q It's a statutory committee set up under the Water Pollution Control Act to review and make recommendations to the Administrator.

MR. ECKERT: Just for clarification, are you referring to the Effluent Standards and Water Quality Information Advisory Committee under Section 515 of the Act?

MR. WILLS: Right.

BY MR. WILLS:

Q You don't know who they are?

A I'm not familiar with their operations.

Q You didn't furnish any of your information to that committee?

A Not that I'm aware. I didn't personally, no.

Q I mentioned the word "protocols" a couple of times and I've gotten various answers.

Are there any written or available protocols for PCB work?

A You mean bioassay methodology?

Q Bioassay methodology.

A Yes, there is.

Q Where could this be located?

A The National Water Quality in Duluth; Western Fish Toxicology Station, Corvallis.

I have personal references. I am co-chairman of a committee and I can submit anything you'd be interested

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in.

MR. WILLS: I have no further questions.

JUDGE SWEENEY: Do you have any questions, Mr. Richel?

MR. RICHEL: Your Honor, I have maybe one or two -- honestly, one or two -- and it could take five minutes, so it won't prevent us from shutting the doors before lunch.

JUDGE SWEENEY: All right.

BY MR. RICHEL:

Q Dr. Lauer, in his testimony, said the following. If it becomes necessary for you to look at it I will certainly allow you to, but I'm referring now to one sentence. He said the following:

> "It is noteworthy that results reported by the National Water Quality Laboratory showed that the reproduction and growth of several freshwater species are unaffected by aqueous PCB concentrations in the range of 2 to 10 micrograms per liter, which is 1000 to 5000-fold higher than the chronic limit of 0.002 micrograms per liter used by EPA."

Do you agree with the position stated in that sent: that such information does exist? I'm not asking for your position on the veracity.

A My data indicates much lower levels than that.

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Q I appreciate that.

Are you aware, however, that such data did exist and does exist?

A Data with the static tests with Daphnia are about that level, yes.

Q Now let me ask you just a final question, because it's puzzling to me. And I recognize that I may be stepping into some political problem here, but nonetheless I'll go forward.

You have referred to data from the Duluth laboratory. Dr. Lauer referred to it. Much of the testimony has been in existence -- I'm sorry; you have both referred to data from the Duluth laboratory. Much of that data has been in existence for several years. Why wasn't it used in any meaningful way in the preparation of the proposed standard?

MR. ECKERT: Your Honor, I object to the question. It's completely outside the scope of this witness' knowledge. I think he has already testified that -- well, maybe he hasn't.

My real objection is you haven't laid a foundation for that question. You haven't established whether or not the witness was involved in the preparation of the proposed standards.

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MR. RICHEL: I'm not asking him --

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BY MR. RICHEL:

Q Well, to your knowledge, has there not been much data -- well, to your knowledge, has there been data created, amassed, generated at the Duluth laboratories over the last few years that has not been utilized in the preparation of the proposed standards?

MR. ECKERT: Again I object. You haven't establishe that the witness has any connection with or awareness of the preparation of the proposed standards.

MR. RICHEL: That's exactly what I'm asking.

JUDGE SWEENEY: He can say if it is true, Mr. Eckert.

THE WITNESS: Would you restate the question, please?

MR. RICHEL: Okay.

BY MR. RICHEL:

Q We both identified certain data that has come out of the Duluth laboratories. We also, I think, agree that some of this data has existed for several years.

First, to your knowledge, was this data used in a meaningful way in developing the proposed PCB standard, sir?

A I don't know.

Q Does it reflect itself when you look at the Statement of Basis and Purpose, which I presume -- you've read the

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Statement of Basis and Purpose?

A Yes.

Q Is there any indication there that the proposed standard is related directly to this data?

A I don't know. I haven't been involved with Dr. Thompson in any preparation of the effluent standards.

Q All right.

I really wasn't trying to do anything other than to identify what has been a very puzzling question to us, and I've identified it, I guess; but we haven't gotten a resolution to the issue that is going to come forth on the record.

MR. RICHEL: No other questions.

MR. WILLS: I just have one question.

BY MR. WILLS:

Q Now, maybe I misunderstood, but you did read the Statement of Basis and Purpose for the standards?

A I've read it in the Federal Register.

Q You did not read the --

A I apparently haven't read the --

Q -- the White Papers that were submitted, which was a xeroxed copy of some things that were in the Federal Register, but also the water quality criteria and the National Academy of Science report with respect to PCB's?

A I'm not sure. I'm very familiar with the National Academy of Science report. I don't know if I'm aware of the

brb10

other documents you're talking about.

Q May I ask what you used as a basis for preparing your testimony that was written? Did you have copies of all the Objectors' statements, their testimony?

A I had copies of their statements of March 15, with the exception of Mr. Papageorge. I had his January 18 letter of Objection.

Q And you had the exhibits that were attached to the testimony?

A (Shaking head negatively.)

Q You did not?

A Not of Mr. Papageorge.

Q And you did not have, apparently, the Basis and Purpose document for PCB's?

A Apparently not.

Q I know we've gone through this a couple of times, but you finished your testimony on April 2, is that right, -- or thereabouts?

A Yes.

Q What happened between April 2 and May first, or May 15, to your testimony and your references?

A They were mailed in. I assumed they were being processed accordingly. Apparently they weren't.

Q You didn't check on them, or no one told you that they were mislaid in the mails or anything like that?

brb 11

A. On several occasions I talked to Tom Duke, and the copy I mailed to Tom Duke was lost in the mail and I had to submit another copy to Tom. This was eventually the only copy that was received in Washington.

Q. You submitted it to Dr. Duke, who requested the information initially. Wasn't it Dr. Thompson?

A. Dr. Thompson. I sent this to Dr. Duke because he is the coordinator on PCB's. I sent it for his information.

Q. You sent the original to him rather than to Dr. Thompson?

A. No.

I mailed at least two copies, photocopies, of the original. I have the original in my lab.

MR. WILLS: No further questions.

MR. ECKERT: I have very little redirect, which I think I can get out of the way in a very few minutes, your Honor.

JUDGE SWEENEY: All right.

REDIRECT EXAMINATION

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BY MR. ECKERT:

Q. As I understand it, there are several types of bioassays you can use.

Is that correct?

A. Yes.

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Q And would you state which type of bioassay, in your opinion, gives the best results with respect to the chronic toxicity of a pollutant?

A What we're striving toward is a bioassay where we can test the full life cycle of the animal involved.

Q You were questioned about the analyses which were performed by Dr. Stalling on the fathead minnows. Did you specifically request -- let me rephrase that.

In your request to Dr. Stalling, did you specify whether or not he was to use whole body or fat analysis?

A We requested whole body analysis.

Q In your opinion, did -- no, let me rephrase that.

State whether or not in your opinion Dr. Stalling is a careful worker who can follow instructions.

A He's highly qualified and comes well recommended.

Q Are there any data in existence with which you can compare the figures that he obtained for minnows to determine whether or not they are in the right ballpark for whole body analyses?

A He has volumes of data available for comparison, yes.

Q Are some of those data whole body analyses?

A Many of them are, yes.

Q And will you state whether or not the analyses that were performed on the fathead minnows which you sent

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him for analysis are consistent with the other data which you have seen?

A. Yes, I think they're consistent.

Q. In brief, could you describe the procedure which is followed for outside review of EPA scientific papers which are proposed to be published in the scientific journals?

A. We, number one, submit our rough draft to our colleagues in the laboratory who are familiar with us and our research. After they "tear it apart", we have a rewrite. If it is acceptable, this is submitted to the National Water Quality Laboratory review committee headed by Dr. Spoor.

Usually we have two or three sessions there, then it is submitted to Dr. Dee Smith, the University of Minnesota, for review. If we clear her, then it goes on to the journal that we hope to have accept our data.

They have usually at least three referees from various agencies -- government agencies or universities -- who critically review the manuscript for accuracy and content.

The editor of the journal reviews the material. If it is acceptable, then it is published.

Q. Does the outside review include review of the bioassay procedures which were used, and criticism of those procedures?

A. Yes.

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Q Now, you were questioned by Mr. Wills with respect to exhibit 13.

Are you familiar with bioassay procedures that are followed at Duluth?

A. Yes.

Q Can you state what, in all probability, was the bioassay procedure followed for these tests?

MR. WILLS: Your Honor, I would object to a response to that question, as to a probability. The next will be a possibility or a suspicion.

If he knows, I think he should be allowed to answer the question; if he does not know he should so state, rather than just guess as to the probability of the procedure.

MR. ECKERT: Very well, I'll rephrase it.

BY MR. ECKERT:

Q Do you know what bioassay procedure was used, Mr. Nebeker?

A We used the standard Daphnia bioassay procedure recommended by the Committee so that our results can be comparable.

Q When you say "we", are you including Duluth in that?

A In "we" I am referring to Duluth, yes.

Q In other words, you're stating that there is only one set of procedures that is used?

brb 15

A For the Daphnia statics.

Q For the Daphnia statics.

A Yes.

Q Now, with respect to -- I believe it was exhibit two where table 6 showed levels of fish of 1000 parts per million.

Is that right?

A Yes.

Q Now, in the wild -- strike that.

Was any pathological examination done of fish that were destroyed in this experiment?

A External observations, yes.

Q Well, some of the fish, at the end of the study, were still alive.

Isn't that right?

A Yes.

Q Was any pathological examination done on those after they were killed?

A You mean internal?

Q Yes.

A No.

MR. ECKERT: No further questions.

MR. PARK: Your Honor, I have a couple of recross I would like to ask.

JUDGE SWEENEY: Go ahead.

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RECROSS-EXAMINATION

BY MR. PARK:

Q. You mentioned Dr. Stalling at the laboratory in Missouri in connection with analyses of the fish tissues.

Did he himself actually perform the analyses?

A. Initially he was doing some of these analyses. He was in an administrative position where he did have other people run some of these analyses for him.

Q. Normally you would expect that someone other than Dr. Stalling himself would actually perform the analyses?

A. Yes.

Q. So Dr. Stalling's qualifications as a scientist would not necessarily be reflected in the analytical results of someone else, beyond the fact that Dr. Stalling might be an administrator?

A. I think it would, because he would very likely instruct the people doing the work; the quality control program would keep fairly close track of the work that was being done by his people.

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Q How did you receive the results of the fish tissue analyses from Dr. Stalling? Was it on the telephone?

A No. It was on data sheets.

Q I see. In writing?

A In writing.

Q Could you take a quick look again at these Table 2 and Table 6, and I would just like to ask you, Dr. Nebeker:

Looking at Table 2, it lists six groupings of fish from a control group that apparently had no PCB in the water, and five other groups that had varying amounts of PCB. How would you compare-- Well, strike that.

I note that moving to Table 6, the fish in the water that had a PCB concentration measured at 0.52 micrograms per liter had -- when they were sacrificed, had in the males a mean value of 81 micrograms per gram PCB and the females 105 micrograms per gram. This could be expressed in parts per million I suppose.

A Yes.

Q Moving back to Table 2, it would appear, would it not, that the fish that did contain in their tissues in their bodies 81 parts per million PCB in the males and 105 parts per million in the females were healthier, at least with respect to the column headings here-- spawnings, total eggs, number of eggs per female, and so forth -- than the control group that had no PCB in the water.

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A This is a consistent observation in bioassays, yes.

Q Consistent that some PCB generates more health in the fish than no PCB?

A No, not PCB. About any bioassays we've run on a very long-term basis like this there appears to be a curve prior to death. There are theories proposed. The additional stress is more invigorating at the non-lethal levels. It's a trend throughout mammalian insecticide studies.

Q Calling your attention back again to the exhibits that were tendered here today, 1, 2, 3, 4, 13, and 14, have all of these cleared the review that you've described?

A No.

Q Have any of them cleared the review?

A 1 and 2 have been accepted for publication and will be out in July and October.

Q But none of them have yet been published?

A Not if by "publication" you mean reprints are available, no.

Q Or have yet appeared in any publication?

A No-- They have appeared in PCB Newsletter which you can or cannot accept as a publication. It's disseminated widely to those that subscribe to it.

MR. PARK: No further questions.

MR. ECKERT: Nothing further.

JUDGE SWEENEY: You're excused, Doctor.

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(Witness excused.)

JUDGE SWEENEY: Exhibit 105 and attached Exhibits 1, 2, 3, 4, 13, and 14, are received in evidence.

(Exhibits 105 and attached Exhibits 1, 2, 3, 4, 13, and 14, marked for identification, were received in evidence.)

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MR. ECKERT: I have nothing further today.

JUDGE SWEENEY: I wanted to ask you about some scheduling but I can do that off the record.

MR. ECKERT: All right.

JUDGE SWEENEY: We will recess then until nine o'clock tomorrow morning.

(Whereupon, at 12:25 p.m., the hearing in the above-entitled matter was recessed to reconvene at 9:00 a.m. the following day.)

brb 18

tank cars may drip while they're being unloaded, or there may be some drippage or spillage, and that this operation is open to the weather.

A. Yes.

Q. Now, I'm asking if this were covered over, wouldn't that reduce the discharge of PCB's?

A. Oh.

I think another way -- and it slipped my mind whether we were thinking about this or whether we were doing this -- is just to put the spout in a drip-catcher. We have been thinking about things to make sure that any drip simply went into a glove.

Q. Well, the question I asked was if the unloading area were covered and protected from the rain, couldn't that have the effect of reducing the amount of PCB's that leak out into the effluent?

A. I don't know.

I think it's a kind of a hard thing to say because you could say, "Well, in any one trip it might," but in the overall sense that material is going to move. It transports from a variety of ways -- dust, vapor -- and I could not guarantee it would be negative.

Q. What precautions are taken to avoid accidental spills during unloading operations?

A. Well, of course, there is very strong admini-

brb 19

control in the process, but I think the process itself, with it's top-loading arrangement, goes a very, very long way to eliminate practically-conceivable spillage accidents.

Q How about on the storage tanks themselves? Are there high liquid level alarms on the storage tanks?

A I doubt that there are high liquid level alarms. People, again from good administrative control, know the quantity of PCB in that plant in those tanks at all times.

Q What type of control at the transfer lines and the tank drain valves is employed?

A Tank drain valves?

Q As you drain from the storage tanks.

A Well, yes. Okay.

We put from there into the process. I was thinking about drain on the basis of removing undesirable contents from the thing, and there is no such system.

Q Is that done also?

A No. That's why I wanted a definition of your drain.

The transfer line that goes from the tank to the process is, of course, a closed pipe that is manifolded through valves to be sent to whatever portion of the Sharon plant the PCB's are used in.

JUDGE SWEENEY: Let's take a fifteen minute recess now

(Recess.)

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JUDGE SWEENEY: Back on the record.

Mr. Eckert?

BY MR. ECKERT:

Q Dr. Wright, you have discussed some of the levels of PCB's being discharged from the Sharon facility.

Have you investigated what types of PCB's are present in those discharges?

A Yes.

It is my recollection that our analysis of the homologs present reflect that there is quantities of 1254 and other material that was used in the distant past.

In relation to this I should like to make a correction to the record. At the Sharon plant and our transformer plants, we use 1242, not 1016. I was relating to the capacitor plants.

Q So then the capacitor plants use 1016 primarily; is that correct?

A Yes. That's correct.

Q Do the capacitor plants use any 1242?

A This is where I say it's in the process of phase-out; whether it's completed or not, I don't know.

MR. MC LAIN: No Aroclor 1254 is in current use in the capacitor manufacturing plant in Bloomington.

JUDGE SWEENEY: Do you accept that correction, Dr. Wright?

dr-2

A Yes, of course.

BY MR. ECKERT:

Q So we're still talking about two homologs, 1216 and 1016, and 1242; is that correct?

A At the capacitor plants.

Q Well, but at the transformer plant --

A No 1016.

Q Only one, 1242. Isn't that right?

A Yes.

Q Were you able to quantify how much of the discharge from the Sharon plant was 1254?

A It is my recollection all the material looked like 1254, more nearly like 1254

Q Do workers in the plant who work around PCB areas apply protective clothing?

A Yes, they have protective clothing, administrative procedures, and warning signs.

Q Is the protective clothing laundered on the site?

A No, it is not. They don't wear total protective clothing as we would use, for example, in the nuclear areas -- areas of radiation waste. We don't use cleanroom techniques from the standpoint of total coverage -- shoe covers, and that sort of thing.

Q What happens to leaking capacitors, rejects, and leaking transformers in these plants?

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What's done with them?

A Well, in the case of the transformers, the material is pumped back into good storage; and then the material that remains, if it has to be cleaned, it is cleaned. And the waste material goes into the PCB waste tank, as described before, and sent eventually to oxide incineration.

Q How much time would be necessary to conduct laboratory and pilot scale studies to see if activated carbon or some other treatment process could be used to control PCB discharges?

A Well, there are several levels that one would have to undertake.

If one would amend one's question to say, how much time would be required to develop the design for a cleanup of all of these systems, then that's a fairly major chore. I would anticipate it to be somewhere in the range of two to eight years, depending on how successful you were.

Q Well, assuming, hypothetically, you decided to go with activated carbon:

How long would it take for you to get that on line?

A What size? I mean, I don't know how to design it.

Q In other words, you'd have to know whether it was required to treat the entire waste stream, or part of the waste stream; is that right?

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A Well, I'd have to know at least some of all things. That's only part of it. I would have to know how large to make the through-put.

I would have to know at what velocities I could have through the charcoal, assuming that it worked at all, before I got channeling; and if it didn't work I'd have to know what residual volume to have then so I would have some idea of the frequency with which it should be changed, and to get the change procedures worked out.

From the laboratory to the -- the laboratory work has not been done. After the laboratory work, the problem of engineering design & development work is where really the crucial work would be required. You would simply have to have scientific information to make the design.

Q Well, you referred to the lab. But aren't there several industrial installations in which activated carbon is now used? So that there are full scale data?

A Oh, sure, but for removing of different components from a different stream. Oh, sure.

And their variation in performance is enormous. It depends strictly on what's to be removed, and from what stream.

Please understand that I don't even know if there would be any separation occur by moving PCB containing water through a charcoal adsorber. It may come out the outlet

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in exactly the same content that it went in the inlet.

Q You've suggested that effluent limitations for PCB should be one percent of the quantity of PCB processed.

Under such a limitation, what would be the concentration of PCB in the effluent from the Sharon facility?

A Well, first, let's go back and rephrase -- reunderstand the proposal.

The one percent would constitute the upper envelope. It would have two additional criteria to meet.

One is that the bioconcentration of any element destined for edibility by man would be maintained at or below the 5 ppm level specified by FDA.

Secondly, if there were a particular situation where this PCB-containing water was used in a feed stock preparation, then that limit would be dropped by another factor of ten.

Now, both those constraints, then, are working within the envelope of the one percent release. In other words, this is site-dependent, requiring on-site environmental data to substantiate compliance.

Q Has Westinghouse attempted to measure the PCB residue levels in the tissues of aquatic organisms in receiving waters for its facilities?

A Yes, it has.

Q Can you be specific about the levels which were

dr-6

found and the facilities which were involved?

A Yes, I can; certainly in the case of the Sharon plant.

In the Sharon plant, we found PCB levels on the order of 2 ppm and less in fish flesh.

Q Some were as high as 2 ppm?

A Yes.

Q And this is based on whole fish measurement?

A I believe the key is, the fatty tissue is the principal concern. I believe this particular test was on the whole fish.

Q In which organisms were these levels found?

A My memory is already shown to be defective in terms of what the sample was based on. If you would like to pursue this particular line of questioning, we have Dr. Munson here, who can supply this data to you directly.

MR. ECKERT: Your Honor, this is a bit irregular, but under the circumstances, I would like to call Dr. Munson to examine him on this line of questioning.

JUDGE SWEENEY: Have you finished questioning Dr. Wright?

MR. ECKERT: Yes. As a matter of fact, I am through with Dr. Wright.

And if there is no objection from Westinghouse, I would like to -- let me say this: I'm through with Dr. [illegible]

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if Dr. Munson can be available to answer these questions. If not, then I'm going to have to pursue this with Dr. Wright to the extent he can answer them.

JUDGE SWEENEY: Do you have any questions?

MR. WILLS: I have some redirect.

JUDGE SWEENEY: All right, then you are just excused temporarily, Dr. Wright.

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(Witness temporarily excused.)

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Whereupon,

THOMAS O. MUNSON

was called as a witness by the Environmental Protection Agency and, having been first duly sworn, was examined and testified as follows:

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DIRECT EXAMINATION

BY MR. ECKERT:

Q Would you state your name for the record?

A Thomas O. Munson. I'm a biochemist.

Q You're a biochemist?

A I'm a biochemist, yes.

Q And you're employed by Westinghouse?

A Yes.

Q Could you describe the efforts which were made to measure PCB residues in aquatic organisms in the receiving waters of the Sharon plant, please?

A Yes.

We electroshocked some fish downstream from the Sharon plant. The stream is not a very clean stream. There's quite a bit of other industrial effluent in the stream, so the only fish we got for our shocking were fairly good-sized carp. So the number which Dr. Wright referred to is based upon wet weight in fillets of the carp.

And the number he mentioned was-- I think the highest value we did find was about two parts per million.

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This would have been-- Aroclor 1254 was the closest standard.

Q Were any other homologs found?

A I don't believe so. It has been some time since-- This work was done more than a year ago.

Q Are there any other industrial dischargers or any dischargers at all of PCB's on this river, to your knowledge, other than the Westinghouse plant?

A To my knowledge, and my best guess would be that nobody would be discharging at levels in our order of magnitude. Our plant is very close to the source of the water. We're downstream from the dam just a short ways.

Q Did you measure the ambient concentration of PCB's?

A In the water?

Q In the water.

A No, we did not. At that time we didn't have the technical capability of doing so.

Q At that time was the level of PCB's discharged from the Sharon facility roughly the same, greater, or lower than the numbers cited by Dr. Wright?

A Okay. Let me explain to you.

The sequence of events was that we became concerned about the possible impact that we might be having on the environment around our manufacturing sites. This was several years ago, and at that time we initiated an environmental survey which I performed around the plants.

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We were mainly interested in looking at sediments and at samples of the biota. It was a limited plan, so that in most cases we could not do a very extensive sampling of all levels in the food web. And at that time we were not sampling the effluent discharge or the receiving water, mainly due to technical problems involved in doing this.

So the answer to your question is at the time the biota were sampled, we did not have data on the effluent discharged. That data has only been generated in the recent past.

Q So you're saying that the data on effluent quality which Dr. Wright gave us is data which was taken at some point in time considerably after the study was made. Is that correct?

A Yes, that's correct.

Q To your knowledge, have control measures been instituted between the time the study was made and the time that the measurements of effluent quality were taken that might account for lowering of PCB's in the effluent?

A Yes. My guess would be that if we sampled again today, the conditions would be lower. I should not expect them to be worse.

Q Thank you very much, Dr. Munson.

(Witness excused.)

Whereupon,

JAMES H. WRIGHT

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resumed the stand and, having been previously duly sworn, was examined and testified further as follows:

MR. WILLS: Could we have about a two-minute recess?

JUDGE SWEENEY: You have no further questions of Dr. Wright?

MR. ECKERT: We have no further questions of Dr. Wright.

JUDGE SWEENEY: We'll take a very short recess.

(Brief recess.)

JUDGE SWEENEY: Back on the record.

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REDIRECT EXAMINATION

BY MR. WILLS:

Q Dr. Wright, to clear up one thing about silicon, I believe you said silicon was used in capacitors?

A I'm sorry, if I did and if the record shows that, I should have said in transformers. As far as I know, silicons have never been used in capacitors.

Q Also, you indicated that the discharge into the waters of Sharon was either two grams or four drops. Have you recalculated that?

A Yes. It turns out to be 40 drops or basically two grams per day.

Q Now in response to one of Mr. Eckert's questions, looking at page 17 of your testimony, the 3400 to 8500 figure of members involved was reduced down to 200. How did you

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arrive or what standard were you looking at to get the 200 people?

A I believe, Mr. Examiner, this is a very key point in these PCB's. I believe that it will come up again in the course of these hearings, that what we are basically convinced of is that much, probably 90 percent of our PCB discharges at the present time are the result of PCB that is saturated in the ground, in sewer pipes that may have been sealed but are still leaking to come in contact with ground and surface water to reappear.

I think we have-- At the Sharon plant, for example, I think we have a problem that if we terminate all production, all use of PCB on that site, we would not terminate, by any means, the release of PCB's to the environment down to the level of the proposed standard.

Now this poses, I believe, a very major problem. To say if the standard were instigated it is accurate to say that 200 people, workers at Sharon, would be affected, but we must say if we interpret the standard to apply to ongoing operations only, the active releases from current operations.

If on the other hand the standard is to say from all sources including those which are saturated in the ground from time past and from other sources that we simply cannot identify at the present time, then our only alternative

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would be to shut down the entire Sharon operation and all the people that are employed therein and terminate our relationships with it, because we would never, in our opinion, be able to meet the standard for emissions from the former spills in the area.

And I think this is where we go very quickly in that one plant from a matter of 20[illegible] people, with one interpretation of how the standard would be enforced, to a matter of 45,000 in the alternative of saying that the plant, whether it's binding or not, is discharging it and hence would be liable.

MR. WILLS: No further questions, your Honor.

JUDGE SWEENEY: Do you have any questions, Mr. Eckert?

MR. ECKERT: Just one.

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RECROSS-EXAMINATION

BY MR. ECKERT:

Q You stated that the PCB's would still be discharged if your plant shut down tomorrow. Would one source of those discharges be runoff from the land on which old spills occurred?

A Yes, that would be one source; yes.

Q So that for such lands at least it is your opinion that PCB's in the sediments might still become available to the environment through runoff; is that correct?

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A Yes. I think principally I am worried about what is under that big plant. One of the first questions raised was what about flushing out all of the old lines and everything else like that.

MR. ECKERT: I have no further questions.

JUDGE SWEENEY: Can I ask one question, please?

How long would you have to close the plant down to prove the scientific correctness of your thesis?

THE WITNESS: Well, we are thinking now of doing it. If the plant takes a mass vacation this summer, we will at least have two weeks of opportunity to make these tests, and I have certainly recommended that we do just that very thing.

JUDGE SWEENEY: Exhibit 81 is received in evidence.

xzxzx (Exhibit 31, previously marked for identification, was received in evidence.)

(Witness excused.)

MR. ECKERT: Your Honor, I would like to ask at this time if Mr. Carlson has conferred with his Counsel?

MR. CARLSON: I'm sorry to tell you that I was unable to reach him.

MR. ECKERT: Well, at this point I guess we can defer it. We are very short on time today, your Honor,

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and we have two more witnesses to get through, and I suggest that we move on to Dr. Simons at this time.

JUDGE SWEENEY: Very well.

Whereupon,

EDWARD L. SIMONS

was called as a witness by the Environmental Protection Agency and, having been first duly sworn, was examined and testified as follows:

JUDGE SWEENEY: The written testimony on behalf of General Electric is in four sections. Which ones are you going to examine on, Mr. Eckert?

MR. ECKERT: Well, today I'm going to examine Dr. Simons on Section 2, and perhaps one or two questions on Section 4, which are the two sections of his material.

JUDGE SWEENEY: Will you be examining the other two witnesses.

MR. ECKERT: I'll be examining Dr. Lauer tomorrow morning, and I have no questions for Mr. Farnsworth.

JUDGE SWEENEY: The entire written testimony, all four sections, will be identified as Exhibit 82.

(The document referred to was marked Exhibit 82 for identification.)

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CROSS-EXAMINATION

BY MR. ECKERT:

Q Dr. Simons, I will refer you to Section 2.

A I have it. Thank you.

Q On the second page you give the low flow of the Housatonic River as 14 cfs.

Do you have data on the average seven-day, ten-year low flow for the Housatonic?

A It is approximately I believe about 40, but I do not have the specific data with me. It has been compiled and published by the State of Massachusetts and is available.

Q On the top of the page you say "Application of Section 129.09(c) to a GE plant."

Roughly how many GE plants manufacture products containing PCB's?

A Four.

Q And which plants are they?

A Transformers are manufactured at Pittsfield, Massachusetts, and Rome, Georgia.

Capacitors are manufactured at two closely-related plants, one in Hudson Falls, New York, and the other at Fort Edward, New York.

Q Which of these plants discharge into receiving waters directly and which discharge into publicly owned treatment works?

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A All four discharge directly into navigable waterways.

Q Now as to the Rome facility, what is the receiving water?

A There are drainage ditches from the plant, one of which goes to the Oostanaula River which eventually flows into the Coosa River.

The other drainage ditch goes directly to the Coosa River.

Q Do you have flow figures for those rivers?

A I do.

Q Would you give them to me, please?

A Yes.

On the same basis as the regulations call for, the seven-day, ten-year low flow for the Coosa River 1300 cfs.

For the Oostanaula , 495 cfs.

Q And what is the receiving water for the Hudson Falls facility?

A The Hudson River.

Q And its low flow at that point?

A 1600 cfs.

Q And the Fort Edward facility?

A The same.

Q You've given some detail about the levels of PCB's that would be required to be discharged. Could you tell

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for each of these facilities what quantities and concentrations of PCB's are being discharged now?

A We analyzed to get data for the Refuse Act permit applications. The current discharge from the Pittsfield plant from current production is approximately .1 pound per day.

Q Are you able to isolate discharges from current production and discharges from old production?

A Isolate physically?

Q Well, how do you distinguish-- Let me ask it that way. How do you distinguish discharges from current production from discharges from residues?

A We transferred, at about the end of 1972, from the use of Aroclor 1260 to the use of Aroclor 1254. When samples are analyzed, we attribute any 1260 peaks in the gas chromatogram to residuals from past production and use only the 1254 peaks to establish the levels of current discharge, that is, discharge from current operations.

Q Well, let me ask you about 1260. Do you have data on the levels of 1260 now being discharged from the Pittsfield facility?

A They also run approximately .08 to .1 pound per day; almost the same as that from current production.

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Q Has an effort been made to elucidate or to identify rather the sources of contamination of the waste stream with these PCB's?

A The contamination from past operations, or from present operations?

Q From present operations.

A We have approached the problem of present operations with the same philosophy that Dr. Wright mentioned: that, because these operations in the manufacture of transformers do not require process water, that Pyranol, which is the G-E trade name for its use of PCB's, these operations do not involve water, the Pyranol is used in an anhydrous state.

Therefore, we have taken all of the steps that we thought were warranted and necessary to keep losses from that operation from getting into drainage systems that would ultimately be discharged to the river.

Q Have you identified the sources of the contamination? Because apparently there is some contamination of the effluent despite your best efforts.

Have you identified what these sources are?

A You have to understand that, in the operation of a transformer manufacturing plant, the transformer has to be filled at a particular station. It is done over a deadended sump, with carefully marked special hoses so that there is no opportunity for mistaking what you are dealing with. There is

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a daily check by an engineer who goes around with a checklist to make sure that all of the hoses are in proper position; that the sump is not full; when it reaches a certain level, it is pumped out.

So, all of these stages of building transformers are monitored and controlled as carefully as it is humanly possible to do. With a big transformer which may hold a thousand gallons or more of Pyranol, the kind of losses that we are observing are in order of parts per million of the total amount being used.

Q Well, you have stated losses are in the order of parts per million.

How are these measured?

A I say, if you measure the total amount that's in the effluent stream. That is the only place where we can measure an actual loss from a plant. Inside the plant, the drains are deadended. The sump is deadended. It is pumped out daily.

Q What's done with the residue?

A Any waste material that is not recoverable for further use is transported to an incineration facility that we have constructed on site. This facility is capable of complete incineration of PCB's, with the only effluent being carbon dioxide and water.

So any PCB's that are not recoverable for further

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use are incinerated on site.

Q Well, you have described what you have done, and you have also described that there are PCB's in the effluent.

Is it your testimony that you don't know how the PCB's get into the effluent?

A In handling any big equipment which must be transported from a filling site to a testing site, and back and forth, there is always the possibility of an adventitious loss of a drop here or a half a drop there.

Q Well, the transformers are sealed after they're filled, are they not?

A Ultimately they are sealed. There are operations that must be carried out in the testing of transformers before the sealing is completed.

Q What is done with a reject or a transformer that has been shown to have a leak?

A The Pyranol that is in the transformer is drained, and, as I said earlier, if it is suitable for reuse it is put back into the production system.

If the Pyranol is not suitable for reuse it is incinerated.

Q And the transformer from which the Pyranol was extracted?

A After it has been freed of its Pyranol it is repaired if it can be repaired. There are massive pieces

dr-4

equipment that are not likely to be discarded if there is any possibiility of repair and sending it back through the production line.

Q Is Pyranol a trade name for a PCB compound?

A It is the trade name under which G-E identifies its transformer fluid.

Q What does Pyranol consist of?

A It consists of the Aroclor 1254, and it consists of trichlorobenzine.

Q How much of each?

A It's approximately a 60 - 40 percent ratio.

Q Have you made any attempt; that is, G-E made any attempt to measure PCB residues in receivving waters from any of its facilities?

A We have taken occasional samples from the Housatonic River, which is the receiving stream for the Pittsfield plant.

Q What levels of PCB were observed in the organisms?

A We have not sampled organisms. We've sampled the river water.

Q I see.

Could you tell me what levels of PCB's were observed in the water?

A The report that I have seen show values in the vicinity of the outfalls of between one and three parts per

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billion -- in that range.

Q Would this be before or after reasonable mixing had occurred, in your opinion?

A I could not give you an answer to that, because I have not gotten -- I have not seen a definitive position in the river where this was taken.

Q The sampling was done at only one point?

A No, samplings were made also below the outfall, and at a distance of something between one and six miles -- and I am not sure of the exact distance at this point, but it could be as small as one mile below the outfall--no detectable PCB's.

Q What was the analytical technique used?

A Essentially, the technique recommended by EPA: the extraction of the water with hexane, concentration of the hexane extract, and then injection of a sample of that extract into a gas chromatograph where calibration is done against standard samples of PCB's.

Q The limit of detection of that technique is only one part per billion, isn't it?

A That has been our experience.

Q So that if there were smaller quantities, you'd not expect to be able to measure them, isn't that right?

A We would have no reliance on numbers that would show up in calculation from that chromatogram as being b[illegible]

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one part per billion on an industrial type of sample.

Q Have you measured the PCB levels in the sediments of the river?

A May I check?

Q Certainly. Use any document you like.

A Yes.

Q Could you describe where the samples were taken and what levels were found?

A At the same sites at which this one-to-three part per billion range in the water, the sediments were 130 and 1,300 parts per million.

Q Were samples taken at the second point, the one six miles downstream?

A In areas where it was not detectable in the water, the sediments were 30 to 60 parts per million.

Q Were these identifiable as 1254 or 1260?

A I do not have that information.

Q Do you know when the samples were taken?

A October of 1971.

Q Therefore it would all be 1260, wouldn't it?

A It would probably all be 1260. Correct.

Q Have the control measures which you have been -- let me rephrase that.

You referred to control measures to minimize the discharge of PCB's.

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How long have those control measures been in effect?

A It is an evolving program. For example, the incinerator is a relatively new installation, within the past two years. The diking around the unloading area, or consolidation of filling stations to reduce the number of areas in which Pyranol is handled at the plant -- all of these have been steps that have been taken over a period during the last four years, let us say.

Q Do you have any data on the levels of PCB's in the effluent on or about October, 1971, when the samples were taken in the river?

A I do not.

Q Were any observations made of the aquatic population in the river at that time?

A We have done nothing with the aquatic population.

Q Now, in the Rome plant have measurements been made of PCB discharges?

A Yes.

Q Would you give me the data in the same fashion as you gave me the data for the Pittsfield plant?

A I don't have it in that same form, but our engineers, who have taken samples and made the appropriate calculations from that have estimated that the current discharge is on the order of one pound per day.

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Q Which Aroclor is this?

dr-8

A There, too, 1254 is the Aroclor that is used.

Q Could you describe the control measures currently in effect at the Rome plant in order to minimize discharges of PCB's?

A The same program of control measures is being installed at that plant, but it is not as far along as at Pittsfield.

But basically, the program is the same; that is, containment of the PCB's in the production area.

Q To avoid repetitive questioning, let me ask you a general question.

Have measurements been made of residues in biota for any of the facilities operated by G-E?

A We have made no measurements of biota for any facility of the General Electric Company.

Q Now, for the Rome facility, have any more measurements been made of PCB levels in the -- I believe you stated it was the Coosa and the Oostanaula River.

A The Oostanaula River.

I do not believe that my data on those plants indicate any analyses of rivers, but are basically the data of the plant discharge. I do not know of any numbers pertaining to the rivers themselves.

Q Could you give me for the Hudson Falls plant the levels of PCB's discharged?

dr-9

A These outfalls from the Hudson Falls plant, which are incorporated now in the permit application, in total come to two facilities, is on the order of 25 to 30 pounds per day.

Q 25 to 30?

A Yes.

MR. ECKERT: Your Honor, I think I have a good deal more questioning for Dr. Simons.

Would it be appropriate to break for lunch at this time?

JUDGE SWEENEY: All right. We'll recess until one o'clock.

end 2B

(Whereupon, at 12:00 noon, the hearing in the above-entitled matter recessed, to reconvene at 1:00 p.m. the same day.)

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AFTERNOON SESSION

(1:00 p.m.)

Whereupon,

EDWARD L. SIMONS

resumed the stand and, having been previously duly sworn, was examined and testified further as follows:

CROSS-EXAMINATION (Continued)

BY MR. ECKERT:

Q Dr. Simons, you testified that the combined effluent from the Hudson Falls and the Fort Edward plants is 25 to 30 pounds a day. Is that correct?

A Mr. Eckert, I wonder if I might have your indulgence, before answering that specific question, to add some clarification to the answer that I gave you with regard to Pittsfield, because I think they're germane to the kind of answer I would have to give to your question.

Q Well, perhaps so.

A You asked basically two questions concerning the Pittsfield operation. One was the number of pounds per day that were being discharged and secondly, could we identify the sources of that.

I gave you a number of .1 pound per day of 12?? from current production. I think it's appropriate to indicate the way in which that number was arrived at.

We have two outfalls from the PCB plant where

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effluent has been found to contain PCB's. During 1973, each one of these outfalls was sampled once a week for 45 weeks and each sample was then analyzed both for 1254 and for 1260.

As has been pointed out both in our testimony and in the testimony of Monsanto, sampling of industrial wastes for a material like PCB's is a difficult process whose reproduceability is quite poor. The value of .1 pound per day was calculated by taking the average concentration for all 45 samples during 1973 and multiplying it by the average volume of discharge from those two outfalls. So there was no single number that was measured over a period of continuous measurement for one day and we collected .1 pound.

These were all calculated from single grab samples once a week for each of 45 weeks.

At the same time that I give you an average I have to also indicate that there were certain samples which gave values which were higher than that average and if we took the single highest value of each of these 90 samples and combined that with the effluent flow we would come up with a value of .8 pound per day as a maximum figure.

So there's a wide range, with occasional excursions as high as .8 pound per day on the 1254 and as high as .4 or .5 pounds per day on the 1260.

That puts, I think, the analysis into perspective. It is not a matter of collecting and weighing an actual .1

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pound. These are all calculated numbers. The actual parts per billion in the individual samples were usually in the range from one to ten parts per billion.

When you get down to analyses that are as close as that to the sensitivity of the method, the actual value can become distorted by a very small amount of any impurity that might get in during the actual handling of the sample.

But this is the best number we have and it's the number I gave you, but I thought it would require that additional clarification as to how it was arrived at.

Now let's come back and answer in a little bit more detail the question of where this .1 pound might come from.

To put that .1 pound per day in a possibly more illustrative format that would correspond to a small jigger of whiskey, about one ounce, so we are not talking about a major spill. This is a relatively small volume of liquid.

As I said, our philosophy was that for current production we should try to modify our manufacturing operation to reduce the possibility of any loss of PCB's. I probably am-- A year ago when I officially assumed my present responsibilities -- a little over a year ago -- I was probably in the same position as you in being unable really to visualize what these controls meant in a practical term, but I have made it a point to visit on two occasions the

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Pittsfield plant and examine in great detail the individual handling and manufacturing steps from the arrival of the tank car through the finished transformer, and I have quite a different appreciation than I did before of what a loss of one ounce can mean.

Remember, we are not manufacturing at this plant, only Pyranol-filled transformers. We also manufacture -- and the major part of our production is oil-filled transformers; Pyranol-filled transformers are not the major product at Pittsfield.

We have attempted to reduce to a minimum the number of places in the plant where we handle the Pyranol so that doesn't get spread out and handled everywhere. The filling is all done in a fixed station and I've explained that earlier, but after the Pyranol has been added to the transformer tank it must then go by conveyor to certain highly specialized test stations which have to go through a series of electrical tests to be sure, before the transformer is completely sealed, that it has been filled properly, that there are no air spaces and other things that affect its electrical performance.

This is a transfer operation during which the transformer is not sealed. It then may have to go back for further filling, which is another transfer operation. It eventually has to get a final topping off, all of this before the sealing.

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At any one of the stages when you consider that some of these transformers will hold as much as 1500 gallons, even the loss of a fraction of an ounce on a workman's shoes, on his hands, these are things which I think even the most elaborate containment system in a massive manufacturing operation like that cannot guard completely against.

To put this again in terms that might be a little more illustrative, when it's available we all use gasoline to power our cars, and you know what happens when you use up -- when the attendant or at the self-service station, you yourself use a hose to fill up your tank. Your tank may hold 20 or 25 gallons. There are varying degrees of gasoline lost during that filling operation. I doubt that-- It is seldom as low as a drop or so; more often it's much more than that.

Again I want to indicate that we are applying very strict standards to the filling of this, but these are big equipments. It is inevitable that there is going to be something that gets on the lip, something that gets on the conveyor, and these are things that we try to keep to a minimum.

The goal is zero containment but in a plant as big and as old as this, and with workers around there who have to handle this in order to get it out to the test station, a loss of something of the order of one ounce during

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the day's operations is, we think, a very creditable performance. I don't know of any other really heavy manufacturing operation which handles fluids in which that kind of level of control is displayed.

Now I think I can come to answer your question about Hudson Falls.

One minor correction. I said those numbers I gave you were from our permit application. I meant to say these are the numbers that appear in the draft permit for that plant which we have received from EPA Region 2, which indicate certain initial effluent limitations to be placed upon this plant.

And by the way, as you correctly said, the Hudson Falls and Fort Edward are so close together they are being considered as a single plant for purposes of this permit, so that the number given here was for the outfall that corresponds to the Hudson Falls plant, ten pounds per day as the daily average as the initial effluent limitation and for the discharge from the Fort Edward plant, the initial discharge limitation is 20 pounds per day. That's where the 30 came from, but again these are daily averages.

And once again I must refer back to -- I must refer to sampling procedures. We have not taken samples as frequently at Hudson Falls as at Pittsfield. They are more likely at once-a-month intervals so we have about ten of

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those rather than 45.

These numbers again represent the average pounds per day as calculated from a parts per billion analysis and a flow rate.

There have been excursions which, in proportion, are about the same as we've had at Pittsfield. That is at Pittsfield I said we had an average of .1 pound per day and a maximum of .8. We have seen days when, if we took the analysis at its face value and calculated it through with the flow rate, we would end up with 90 pounds of discharge.

This reflects some of the difficulties in sampling. It may reflect accidental discharges in the plant. We just do not know, but I think that's the way in which these numbers have to be viewed.

An average number over a ten-month period and with maximum excursions can be as high as eight times or nine times as high as that.

Now I think that would represent the clarification I would give, up to this point, and I would await your further questions.

Q Let me see if I understand this correctly.

The 10- and 20-pound a day figures which appear on the draft permit, are those the same as the numbers which you arrived at by calculation from the effluent concentration and effluent flows?

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A These are essentially the numbers that we arrived at from these measurements of grab samples over a ten-month period, averaged them out, and made the computation from the average flow rate through those discharges.

Q What was the range of concentrations which were observed?

A The concentrations observed at the-- I only have the average figure here. I do not have the range and the concentrations.

From the Hudson Falls, 350 parts per billion, and Fort Edward, 4,000 parts per billion, and it's these numbers--

Q I'm sorry, at Fort Edward what was it?

A 4,000.

It's these numbers which combined with the flow rates from those installations were used to calculate the average pounds per day.

Q Has GE attempted to measure the concentration of PCB's in the Hudson River below the plants?

A No.

Q Are the PCB's discharged from the Fort Edward and Hudson Falls plants all 1254?

A No. There are several important distinctions between the operations at these two plants which manufacture capacitors and the two plants that manufacture transformers.

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To answer the first part of your question, it is

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not 1254. The capacitor grade Aroclor 1016 is used exclusively at the capacitor plants. And I would say that that probably accounts for 95 percent of the-- 95 percent of the production is with 1016 Aroclor.

Q What is the five percent?

A I don't know. There may be a few specialized oil transformers, mineral oil for certain specialized uses, but those are not a-- The large bulk of the production--

MR. RICHEL: We've been informed it is mineral oil

THE WITNESS: That's what I said, mineral oil.

BY MR. ECKERT:

Q So far as you know then, no PCB other than Aroclo 1016 is used at Fort Edward and Hudson Falls. Is that right

A At present that is so. We formerly had used the 1242 before 1016 was developed. 1016 is a relatively recent development by the Monsanto Company as a special grade for capacitors from which the higher boiling homologs have been distilled out.

In other words, we believe on the basis of the evidence from Monsanto that the 1916 is the most highly bi degradable of the commercially used Aroclors and that is t reason we switched to that for capacitors.

But there is also another very significant distinction between the use of PCB's in capacitors and in

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transformers. Transformers are, as I mentioned, relatively large units, as big as 1500 gallons capacity, and they are made in relatively small quantities. I guess you could say in the tens of units per day kind of range.

Being a big tank, you can put a hose into it and fill it directly that way.

On the other hand, capacitors are much smaller units and we're talking here about an operation in which we have to fill millions of small units with PCB's, and by "small units" I'm talking about things that might be the size of a pack of cigarettes or less, as small as that.

Obviously, these kind of units are not filled by a hose. They are filled in bulk by putting them in a tray which is sent into a vacuum oven. The whole thing is evacuated and then filled by filling that container with PCB's so that they are sucked into the evacuated cans.

That means, therefore, that when you take these out of that for handling there are not only PCB's inside the can but on the outside, and this must be disposed of, so that all of the handling problems, the units and all, increase the probability of losses by adventitious handling.

And then there's a third important distinction which was brought out in Dr. Wright's testimony, that for the electrical industry as a whole, there are approximately three times as much -- three times the amount of Pyranol or PCB's

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used in the manufacture of capacitors total as are used in the manufacture of transformers, so we're dealing with a total amount of material that is much larger and it is distributed over a tremendously large number of very tiny units which have to be filled.

So there's quite a major difference, all of which -- the processing of all of which accounts for the major discrepancy or difference between the discharge in the capacitor plant and that for a transformer plant.

Q Why are PCB's used in capacitors?

A The basic reason for the use in capacitors is to improve reliability and performance characteristics in a smaller volume of total product.

They also confer the safety factor of the non-flammability of PCB's.

Q Aren't there other diaelectrics that could be used, other than liquid diaelectrics? For example, hasn't Mylar been used in capacitor manufacture for example?

A There are certain capacitors-- You have to recognize that there are basically three types of capacitors and I want to put in one warning here. I am not an electrical engineer so that I cannot speak with the same degree of confidence as I have been speaking on the previous ones.

But it is my understanding and if it is permissible, Dr. Pozefsky from our Capacitor Department has my permission

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to correct me if I make any misstatements.

There are what we would call electronic-type capacitors which are basically -- many of which are a dry type and are manufactured without any PCB's at all and have this kind of aluminum and plastic film.

Then there are the kind which are manufactured at our Hudson Falls and Fort Edward-- Hudson Falls is basically the power transformers which are used in the electrical utility industry and for these there is no substitute for a liquid-filled transformer or capacitor.

The only place where there has been some experimental work that indicates a partial substitution to, shall we say, a dry type which doesn't use any liquid is in some of the industrial type capacitors of a kind that are used in the ballast for fluorescent lamp fixtures and air conditioners and so on, but I believe that the technology for that is not anywhere near the level where it can be considered as a short-range alternative to PCB's.

It would obviously facilitate greatly the production if we didn't have to handle liquids.

Q Why is there no substitute for liquid-filled capacitors in power applications?

A I can't give you a specific answer technically to that. It has something to do with the requirements that these capacitors -- the kind of currents that these have to

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carry. But I would have to defer an answer on that, unless you want to get clarification from Dr. Pozefsky on that question.

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Q Well, perhaps we can pass over that for the time being.

Have you attempted to measure the PCB levels in the sediments observed in the Hudson River?

A There have been no measurements made by us of the Hudson River.

Q Have the workers themselves been monitored? For example, have blood samples been taken and measured for PCB content?

A Before coming down here I checked with the medical director of our Pittsfield plant, who is aware of -- who can speak in terms of direct experience at Pittsfield and is aware of the situation at the other plants that use PCB's, because in our testimony we had indicated that the only medical effects that had been reported during the four decades that we were in this business have been occasional cases of chloracne or other minor skin irritations of a non-chronic nature which disappeared upon the transfer of the employee to some other operation.

I asked the medical director if that statement is still valid today; he assures me it is, and that that is the extent of the medical problems that we have encountered among the employees exposed to PCB's.

Q Well, that doesn't quite answer my question.

I asked if their blood levels have been monitored

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for PCB's.

A No, not to my knowledge.

Q Now, in specific reference to the medical data, I don't have it in your testimony -- yes, it's on page 6 -- the statement here reads that:

"Medical records show that over a nearly 40-year period, the only adverse health effects experienced by U.S. workers exposed to PCB's," -- etc. --"have been limited to occasional cases of non-chronic chloracne or other temporary skin lesions or irritations."

A Yes.

Q Now, I assume that over a 40-year period some of the workers died, did they not?

A That's a reasonable assumption.

Q Some of them might have gotten cancer; isn't that correct?

A MR. RICHEL: I would like to object at this point. The man is having visions of vinyl chloride and has introduced no basis into the record for this kind of excursion.

MR. ECKERT: Well, it seems to me that the basis for the record is the statement here that the only adverse health effects experienced by U.S. workers exposed to PCB's was non-chronic chloracne, and I'm trying to get at whether or not anyone bothered to find out whether these workers might

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have had a higher incidence of cancer than the --

MR. RICHEL: I think the witness has made it clear that all inspection, all we did -- and we're not trying to make anything more of it -- all that we did was react to requests made by employees, and no further tests, no considerations of cancer, no considerations of -- no blood tests; nothing other than what we have said.

But if you further lay the foundwork, if all you further do is leave innuendo, then I think this is grossly improper.

MR. ECKERT: I'm certainly not leaving any innuendo.

BY MR. ECKERT:

Q. Is that your testimony; has Mr. Richel accurately stated your testimony?

A. These medical records are based upon the examination of workers who have come to the medical office of the company with a complaint. And these have been examined, and when they have been convinced that these complaints which were brought to the attention of the medical officials were a result of exposure to PCB's the worker has been transferred to other operations, and the complaint has disappeared.

MR. ECKERT: That's all I wanted to establish. Thank you.

BY MR. ECKERT:

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Q Getting back to the Hudson Falls and Fort Edwards plants; what is the total quantity of PCB's used at these plants per year?

A I've been advised by the Counsel for the affected products departments that they consider the data on total usage of product material as material that would be useful to competitors and should be considered as proprietary information.

MR. ECKERT: Is it your position, Mr. Richel, that this information relates to trade secrets, processes, or methods entitled to protection as trade secrets?

MR. RICHEL: Apparently that's the contention of the Counsel for the affected department, and that's why Dr. Simons indicated as he did. I have no reason to support or reject that contention.

MR. ECKERT: In other words, you don't know?

MR. RICHEL: That's correct.

I do know that it's significantly different from effluent data, and anything other than effluent data is given the opportunity for certain privileges under the Water Act Amendments of '72.

MR. ECKERT: That's not quite correct.

It isn't the only information subject to protection, methods or processes entitled to protection as trade secrets.

MR. RICHEL: That's correct.

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And that itself relates to other than effluent data.

MR. ECKERT: Well, we can dispose of this off the record.

BY MR. ECKERT:

Q I wonder if you would describe the sources, if you have identified them, of effluent contamination at the Hudson Falls and Fort Edwards plants?

A There is one significant source of contamination from the Fort Edward plant, which results from one of these basic differences that I mentioned to you between manufacture of capacitor and of transformers.

The transformer cases, after they are filled, as I stated, have PCB's on the outside just because of the way in which these tiny cases have been filled. That layer -- even after draining there is still a residual layer of PCB on the case, and it had been the past practice to remove them through a washing operation with an aqueous-based detergent; and that has been identified as a major source of water contamination.

There is one case where water was actually -- the only case where water was actually used in the processing of the equipment itself.

Q Excuse me.

Are you referring to transformers or capacitors?

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A Capacitors.

The transformers, that have to be -- because of their size -- filled by this vacuum inpregnation technique, which means the entire capacitor is essentially immersed in a sea of PCB's, and when the tray containing these capacitors is taken out the PCB's are on the outside as well as on the inside of these little capacitor cans.

The vast majority of that PCB is allowed to be drained off and be reused, but there is always a residual film that remains on the can which must be removed before the can can be sent out as a finished product.

And the standard practice had been to remove that by a washing with an aqueous solution. That would represent the major source of contamination of effluent from the Fort Edward plant.

And the management and the operations at Fort Edward have recognized this and have now begun to investigate and are prepared to install alternate means of removing that PCB from the outside of the cans so that that single -- that largest single source of contamination is removed.

Q Now, you say you are prepared to install; but is the water wash still being used at the present time?

A It is.

Q That would account for the Fort Edwards plant.

How about the Hudson Falls plant?

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A. The number that I have given for both plants -- or the numbers that I have given for both plants represent a total PCB concentration. It is not quite as easy to make the differentiation between current and residual in the capacitor manufacturing operation as it is in the transformer because 1016 and 1242 are much more closely alike than are 1254 and 1260.

So --

Q. What's being used at Hudson Falls?

A. 1016 is being used now, prior to the development of 1016 by Monsanto 1242 is used.

1242 and 1016 have very close to the same total chlorine content. The major difference has been the removal of some of the higher-boiling homologues present in 1242 that are not present in 1016.

It is a more difficult analytical procedure to try to differentiate between 1016 and 1242 in a chromatogram of a mixture of these two. It is a much easier job to differentiate as we do at Pittsfield between 1254 and 1260.

And so at Pittsfield we can look at a chromatogram and say, "Yes, this much is caused by residuals, and this much by current production."

It is not as simple an analytical job to do that at Hudson Falls, and therefore a large amount of that could very well be from our residuals of production that has been

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going on there since the early '50s, before any controls at all were instituted.

So the only clearly defined process operation associated with a loss of PCB's directly to the water is that detergent wash at Fort Edward. The other losses we cannot pinpoint and say how much is from a particular current operation and how much is from residuals from decades past.

Q Now, the Fort Edwards plant: what treatment is given to the wash water from the capacitors?

A None.

And rather than institute treatment, there is a process -- I would have to qualify that.

There are three stages in this: there is washing and there is rinsing. The wash water itself is internally recycled. The only thing that goes directly to the river untreated is the final rinse, which itself contains only a trace amount of the detergent so that the bulk of the PCB's that are removed by this washing operation do not leave the plant; they are retained internally and ultimately disposed of through incineration the way other waste PCB's are. It's only the final rinsing stage that goes untreated to the river.

And it is, in our opinion, a more satisfactory resolution of that problem to change the process rather than to try to remove the PCB's from the rinse water before discharge to the river.

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Q When a transformer is installed, does it ever need to have its diaelectric replenished?

A There are times when that has to be done.

Q What is the cause of that?

A I'm afraid I can't give you a specific technical answer to that question.

Q Well, would you infer, if it has to be replenished, that some is being lost through leakage?

A It could be some being lost through leakage; it could also be there may be -- remember that a transformer is not just a big tank filled only with PCB's. There is a very complex combination of wire with insulation, other kinds of materials in there. There's whole guts of very complicated electrical equipment.

Some of that must be thoroughly impregnated with the PCB at the time of the manufacture if it is to function properly. There may be other parts where that is not critical.

And over a period of use, it's possible -- and again I'm speaking only from conjecture since I do not know enough about the details of that -- it is possible that PCB's impregnate parts of the transformer where they don't normally become or are not normally needed, and therefore reduce the level of free diaelectric.

So that's a second possibility that I throw out without the same degree of assurance that I have spoken with

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on other matters.

Q Do transformers ever need repair on the site on which they are installed?

A Usually -- and again I will speak only -- well, there may be certain repairs that can be done on the site. I don't know the nature of all the ills and ailments that a transformer can fall heir to during its thirty years of expected life.

So there may be some malfunctions that can be repaired onsite. There are others that require more extensive repair work.

Q When they need that more extensive repair work, are they shipped back to G.E. for work?

A There are service shops that the General Electric Company and other companies maintain at which transformers can be repaired, along with lots of other heavy equipment; they are not exclusively transformer repair shops.

Q Does G.E. manufacture transformers or motors for electric trains -- I mean, electric locomotives?

A If you're talking about the trains that operate on electrified lines --

Q Either those or for diesel electric locomotives.

A Diesel electric locomotives, as I understand it, do not need transformers. They have their own generators and generate electricity there.

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The main use of transformers in railroad transportation is on the electrified lines, where the electricity is taken from a third rail or from an overhead line.

And yes, we do manufacture the transformers that are mounted underneath the cars of such electrified railroads.

Q These are like all other transformers in terms of their susceptibility to leakage, are they not?

A I assume that they are.

They are designed of a size to fit under the railroad car, but basically the transformer is the same kind of instrument. It's made and welded shut, and so on, and I assume that damage that could occur to one can occur to another.

Q When you receive PCB's from the manufacturer, does it come in in tank cars?

A Yes.

Q How is it offloaded from the tank cars?

A Basically by the same kind of procedure that Dr. Wright described. It is pumped out from there into appropriate storage vessels, and from there piped to the areas in the plant where it's used.

Q Is it unloaded under cover from the elements?

A This varies from plant to plant.

At our Pittsfield plant that station is covered. It's a new station, relatively new. It was built with all the

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appropriate diking and sumping and so on, and that is unloaded under a cover.

I would point out, however, that these are -- these unloading operations are basically infrequent kind of things. You don't get this kind of a shipment in every day. This is not a daily operation, and these are carefully monitored as the transfer takes place.

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Q What precautions are taken to avoid spills during the unloading operation?

A The unloading operation, as I have seen it at Pittsfield, that I can speak of from direct observation, is carried out in an area which is diked and which has deadend sumps, so that anything which does drip or spill during the transfer operation does not get out of that area, is retained by the dike, goes to the sumps, and is pumped for recovery or incineration.

Q Are you familiar with the operations at Fort Edwards and Hudson Falls?

A The tank car there is on an open siding adjacent to the building.

Q Is the area around the tank car unloading platform diked?

A The diking is essentially accomplished by the building itself, whereas at Pittsfield there's an entirely separate area. There was no building there, so a separate dike wall was put up.

Q Are there deadend sumps at the Hudson facility?

A Part of the program that's being undertaken there now is to identify all of the drains accessible to PCB's which could lead into the aqueous discharge, and to block those off.

This was an old plant. We took it over in about 1952. I don't know what the age is, but it was not originally

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built as a plant. It was bought as an existing building, and as we go along through that plant, we find other areas that need attention. And there's a systematic review of all the drains, gutters, and so forth to plug up all the possible avenues of escape of PCB's.

Q Do you use PCB's in any other process than the manufacture of capacitors and transformers at any of your facilities?

A No.

The only manufacturing operations that use PCB's are transformer and capacitor manufacturing.

Q Are the PCB's treated or conditioned in any way prior to putting them into the capacitors or transformers?

A Yes.

Q What's done?

A There is basically a filtration type of process to remove impurities that may have been picked up during transit or from long storage in the tank car, and so forth.

Basically a filtering process through a porous bed.

Q Is the filter, the filtering material disposed of by incineration?

A Our incinerator can handle material, yes.

Q Well, is it handled at --

A Yes. I believe it is also disposed of there. Yes. Because this is a combustible bed.

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Q Do you apply heat and --

A Excuse me, when I'm talking about this, I'm referring to the Pittsfield plant. It's the only plant that has its own incinerator.

Q What is done at Fort Edwards and Hudson Falls with the filter material.

A Combustible wastes are sent to an outside scavenger who has incineration facilities.

Q And noncombustible wastes?

A They are like scrap capacitors and things like that which can't be burned.

These are disposed of in an appropriately operated landfill, an approved landfill.

Q Are the PCB's heated or vacuum treated to demoisturize them before putting them into the capacitors and transformers?

A I don't know.

First, for the transformers, I don't know.

In the capacitors, the operation of filling is at a higher temperature than it is in the case of transformers, but I do not know that it is a separate heating operation.

Q Has any measurement been made of the evaporative losses of PCB's during this process?

A I've been told by the plant people that they have had measurements made of the concentrations of PCB vapors in

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the work area, and it is my understanding that these are below the threshold limit values established under the Occupational Safety and Health Act.

Q Is water employed for equipment or floor cleaning in the Hudson Falls or Fort Edwards plants?

A Water employed for floor cleaning?

Q Floor cleaning, and for equipment cleaning. You know, when they talked about capacitor wash --

A Oh, cleaning. No. If there are any spills, for example, that occur on the floor, they are -- this commercial absorbent material is put over them and that is then swept up and sent out for incineration. It is not washed.

Q If there is no spill, is the floor washed under ordinary circumstances?

A No.

Q The floor is never washed?

A Never.

(Shaking head negatively.)

Q Do the workers wear any type of protective clothing?

A We have seen no need for that. The usual protective clothing that an employee in manufacturing may wear; coveralls, and things of that sort. But nothing that's specifically designed as protection for the particular material they're handling.

Q What is the volume of effluent discharge from the

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combined Hudson Falls and Fort Edwards outfalls?

A. Approximately 2.6 million gallons per day.

Q. Can you break that down as to --

A. Approximately half a million gallons per day from Fort Edwards, 2.1 million gallons per day from Hudson Falls.

Q. Have you monitored the various waste streams within the plant to see which one contained and which ones did not contain PCB's?

A. Well, we don't really have waste streams in the plant, in the sense that, with the one exception of this final rinse in the washing operation at Fort Edward, there is no process water used in the manufacture of capacitors or transformers.

Q. But there are other process waters used, are there not?

A. The bulk of the water is essentially for noncontact cooling.

Q. Has the noncontact cooling water been monitored for PCB levels?

A. As I say, these discharges that we speak of, where we analyze grab samples, the bulk of that water is of a cooling water nature, and we find PCB's in them.

Q. But that's after it has been mixed with the capacitor wash or capacitor rinse water, is it not?

A. No, I'm talking here -- let's say the case of the

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permit composed for the Fort Edward-Hudson Falls, there are altogether four separately defined outfalls.

One of these is the outfall to which the rinse water is directed. Of the other three, only one has been shown on analysis to contain PCB's, and that's the one which has this approximately 2.1 million gallons per day -- no, there are 2 at Hudson Falls and 2 at Fort Edwards -- 3 at Hudson Falls which have the 2.1 million gallons per day. But only one of those has been found to contain PCB's on analysis.

Q Now that one which does contain PCB's, have you gone back up the pipe, as it were, to find out where the PCB's enter the stream?

A We have attempted to -- we have assumed that because there is no process water used in contact with PCB's at Hudson Falls, that these represent a combination of residuals and of adventitious losses from what is essentially an anhydrous process, and our approach has been to seek out all the possible avenues by which PCB's might get into this non-contact water, and block those off.

We have also looked to see whether any possible sources of some of the residuals -- we have found some areas that we suspect, and are taking remedial steps with those.

But it is not an easy job just to go back up the pipeline which has been fed by many different sources of non-

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contact water.

Q Well, is it your opinion that the major part of the 20 pounds from Fort Edwards comes from the rinse water, the capacitor rinse water?

A We believe, sir, that is the major contributor to that one outfall that contains the PCB's.

Q Have you been able, similarly, to identify a major source or major sources of the 10 pounds per day from Hudson Falls?

A That is much more of a problem of conjecture, because, as I said, there is no point in the process, as there is at Fort Edward, where we consciously bring water into contact with PCB's.

And therefore, as I say, rather than try to go around and identify a particular source, we've gone the other way and said, let's try to close up all possible avenues by which PCB's can escape from a process which is essentially anhydrous and get into a stream of water which had never contained them, because it is never used in processing PCB equipment.

Q Now, in the Pittsfield plant, is any of the 1.86 million gallons a day that you've identified as your daily discharge employed in the manufacturing operation directly associated with PCB's?

A No. And that, by the way, is divided between two

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distinct outfalls. That's the sum of those two. There are seven outfalls that appear on our permit application. Only two of them have been identified as containing PCB's, and the sum total of those two is 1.86.

Q. And I would ask the same question here as with respect to Fort Edwards and Hudson Falls: has an attempt -- this is a very large amount of water. 1.86 million gallons per day. Has an attempt been made to analyze the various streams that make up that, to see which ones do and which ones do not contain PCB's?

A. There are so many -- let me back off and give you some perspective here on this one, too.

The Pittsfield plant is about 72 years old. When it was being built up over the years since it was first opened, every time a new building would be put up they would run a drain line across the shortest distance between that building and the river.

The result was a multitude of more than 30 discharges into the river.

When -- and I can't give you the exact date -- but when that plant, which is progressive and looking at its environmental problems, set up a specific environmental protection operation as part of the facility's operation there, the manager of that set about in a systematic program to consolidate those streams, so that we have now reduced

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that down to seven by putting in crosspiping, and so on.

And it would therefore be virtually impossible at this stage, without digging up the whole thing and going underground, to try to pinpoint from which of the myriad of pipes under that plant a particular amount of PCB is coming.

Remember, we're talking about only on the average a tenth of a pound total.

Q You have testified that accumulations of PCB's would result in continued discharge, even if the plants were to completely eliminate PCB's from their current operations.

What percentage of the discharge could be eliminated if PCB's were to be eliminated at Pittsfield?

A If I refer back to these 45 samplings from each of the two discharges over the year 1973, I said the average was about a tenth of a pound per day of 1254, and about .08 pounds of 1260.

We're assuming that 1260 is a representative of the residuals not of current production and the one-tenth pound per day average is what represents the losses from current production. That's not a completely strict division, since there have been improvements in the containment process since the date in 1972 when we switched over completely to 1254. So there may be a small amount of 1254 in the residual, but basically 1260 is the residual, 1254 is the current production.

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Q Have you or has anyone under contract to G-E conducted treatability studies for a waste treatment system to remove PCB's?

A. We have approached the proble[illegible] on the ground that the major priority should be the control of current production, and basically all of our environmental control efforts have been directed towards that.

We have been encouraged in that approach by reports, memoranda, conversations, with EPA officials during the past few years indicating that EPA's major concern was the control of current losses.

They recognized that over forty years of use, there are going to be lots of PCB's -- quite ubiquitous, to use the terminology of the interdepartmental task force -- and that the compelling need was to control the current production. So we have put virtually all of our effort into that, as the desired direction over which we could have some real control and immediate impact.

Q You've referred several times to sampling problems associated with PCB's.

Could you elaborate on why there are problems associated with sampling PCB's?

A. These can arise from several sources. Well, I'm speaking here from information given by our plant people, because I have not been directly involved in the sampling.

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Let me mention some of these.

Sampling is generally done through a manhole that presents you with access to the pipe through which the liquid is flowing. We may specify a certain number of gallons a day going through that, but remember, this is not a uniform flow. It isn't always flowing at a constant rate every minute of the day.

And secondly, this is water which is noncontact cooling water which is going through old pipes and may also contain some runoff. So it is not necessarily a clean water, in the sense of being completely free of suspended material, not material that is readily removable by filtration; I'm talking about very fine particles -- which nonetheless can adsorb PCB's,and the difference in the analysis could come from the amount of this material that may come into the grab sample. These are, as I say, grab samples. It's not a continuous sampling of a nice uniform process stream which fills the pipe to a given depth all the time.

But these are the kind of factors that lead to the wide variability in sampling, as I have been told.

Q Well, now, let's take specifically: the flow is not constant.

But over a long series of measurements, wouldn't that tend to average out?

A We are talking here about taking a sample, one

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grab sample a week. Now, I don't know that those samples are taken at precisely the same hour on the same day of the week, and even if they were, I don't know that one would then still guarantee that that flow would be the same.

But as I say, yes, you say these average out. We are reporting an average of 1/10th of a pound per day, but an excursion can go as high -- the highest value based on those 90 measurements gave us a calculated 0.8.

Q Are PCB's adsorbed in water?

A Yes.

Q So, wouldn't it be possible that they would tend to settle in a stream or in a waste effluent? That is, they would tend to ride down so that a sample taken from the top might contain less PCB's, might it not, than a sample taken at the bottom?

A There are undoubtedly differences in the depth from which you measure this. Part of the problem that we face in these residuals probably arises precisely from that effect, that the pipes, through which uncontrolled effluents have been going in years past, do contain on their walls deposits of PCB's laid down in the fashion you speak of.

Q Do you know what the solubility of Aroclor 1016 is?

A Not offhand. The most recent value I've seen was for 1254, and I believe that some of the other -- the Aroclo

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is, as I recall, on the order of 100 to 200 parts per billion. That's the water solubility.

Q So the concentrations that you've measured in the effluent, which, as I understand your testimony, were 350 and 4,000 parts per billion for the Hudson Falls and Fort Edwards facilities, respectively, are actually well above the limit of solubility, aren't they?

A. That is correct. We are getting this phenomenon that you mentioned.

Some of these are heavier, they get swirled around, and sometimes you find a sample that has a sort of insoluble coagulated PCB.

End 2E.

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Q Now you referred to, as I recall, about 30 pipes discharging into seven outfalls at the Pittsfield plant; is that right?

A A consolidation of individual discharges into a controllable number. I may have the actual number. I know seven are reported now. I don't know the number historically, but it was considerably larger.

Q Now wouldn't it be possible to isolate the -- let me ask it a different way:

Of two pipes which do contain PCBs, two discharges, aren't those two pipes themselves consolidated discharges? Don't they lead back to other pipes which branch back?

A Lead back in which direction, toward the plant or toward the river?

Q Toward the plant?

A Yes, they represent the consolidated output of a large network of pipes that are decades old running under buildings that they don't even service. It's a whole maze of drainage systems from in-plant and surface drainage and so forth, and to get this whole system under control the facilities people said, "Look, we can't just have an uncontrolled number of a couple of dozen discharges. We've got to consolidate this." Because what we have done, you see, is -- Let me tell you some of the reasons why this was done to indicate that we are not -- this was not to make things -- just to hide things and

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say we don't know about them, because we only have seven instead of 37.

I mentioned that Pyranol is a relatively small fraction of the total operations at Pittsfield. Even transformers are not the only things we make at Pittsfield. And the most ubiquitous material is oil, lubricating oils, and cutting oils and so forth, and the environmental people at Pittsfield showed a commendable initiative and technical resourcefulness in developing a relatively simple but effective oil-water separator.

This oil-water separator, just parenthetically, the developers of this received a reward from the National Society of Professional Engineers as one of the ten outstanding engineering achievements in 1972. So it's a good piece of engineering work.

We have installed four of these at outfalls in Pittsfield from which major oil contamination of the river can occur.

One of the reasons for consolidating all of these drains was so that we could funnel all the water, surface runoff, cooling water, everything else, through these, so all of the water that could possibly be contaminated by oil is run through these oil water separators before it is discharged to the Housatonic River, so this consolidation was done to control that kind of ubiquitous contamination which is much,

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much larger in terms of quantity than the PCBs.

Q Let me see if I understand you correctly.

When the pipes are run together into the separator, you must be able to identify which pipes go where and is it my understanding -- is my understanding correct that you have not gone back up to these pipes to measure the PCB levels in each?

A You have to visualize, Mr. Eckert, the way this is. You have had a whole network of pipes all underground. These are drainage pipes; they're not -- all the pipes by which Pyranol or PCBs are transported around the plant are now above ground, so that any leaks that occur are immediately detectable and repairable, but these are drainage pipes for cooling waste water, for storm runoff, for everything that we don't need anymore, and these are all underground.

Now, what was done some years back-- And this predates the concern for PCBs as an environmental contaminant. What was done was to say, Look, we had all these outfalls going to the river. So they were clearly identified. What they did was to dig up and put connectors there and send them all to consolidated outfalls and then bury the whole thing again because this is all underground.

Now we see nothing to be gained by digging all that up and putting individual sample stations on all these, because we would not even know where these originated from

in the plant. Remember, this is just down where they would terminate at the river we have consolidated them into a common manifold. But even identifying those individual pipes would not identify the sources. We know where the current production is located and our philosophy has been, "Let's stop losses to the best of our ability from those." Anything else that gets in could come from anyplace in the plant, because for 70 years we've moved around production underground facilities and everything else and nobody has detailed records of where everything is in all 70 years of operation.

Do you know, you have referred to an incinerator, and the only incinerator GE operates is at Pittsfield; is that correct?

A The only incinerator that is capable of destroying PCBs, yes.

Q Yes.

Now, have the emissions from the stack of that incinerator been monitored to determine precisely what they contain?

A The emissions from this incinerator have been tested. They are acceptable both to the state and to the EPA. Indeed, we are now just concluding negotiations for a program that was initiated by Region One, headquartered in Boston.

They have come and inspected our incinerator

facility. They are satisfied that it is an environmentally compatible way of destroying PCBs without adding air pollutants. And they've said:"Look, we havein Hingham, Massachusetts I don't know how many pounds or tons of DDT that has been pulled off the market as a result of EPA's ban on DDT, and we want to get rid of that, and we are convinced that your incinerator provides an environmentally sound way of doing that."

It was just last week that representatives from Region One and from the state visited our Pittsfield plant for the final negotiations. We have agreed to accept on a test basis a certain number of pounds and we will carry out that incineration; if it is satisfactory, we will destroy more.

So they are convinced, too, that this is a sound way of disposing of DDT without providing environmental contamination.

Q Well as I recall, my question was as to the levels that were measured in the emissions.

A I don't have any data on that specifically. I've been told by the plant people that the emissions do meet the requirements and I am also inclined to believe that when I see that EPA has come and said, "Look --" we did not go out to solicit this business; we're not in the business of incinerating DDT. We have been asked specifically by EPA to perform this as a service for them.

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In fact, I believe in my testimony I quote from the

initial visit on page 3, in which Dennis Huebner, the Chief of the Solid Waste Program for EPA Region One, sent an unsolicited letter indicating his approval of the process: "The great strides forward in solving the processing of disposal problems of PCB. I'm very pleased with your willingness to assist Massachusetts in solving some of their hazardous waste disposal problems, particularly the DDT stored in Hingham, Massachusetts."

We did not ask for that letter.

Q On page 10 of your testimony, you refer to the rapid metabolism of the lower chlorinated homologs and you give a quotation and a Reference 19.

In my copy of the testimony, there is no Reference 19. I wonder if you could tell me what the reference is that you intended to cite there.

A That's what happens when documents are put together against a deadline.

I'm afraid I can't answer unequivocally now. I would have to go back and look at my earlier draft and see that, so I cannot answer that at this sitting. It was obviously a direct quotation and it was from some published paper, but without going back to the original draft I could not identify it here.

Q Has GE done any work to determine the biodegradability of PCBs?

A No.

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Q Has GE done any independent work to determine whether or not PCBs are metabolized?

A We have relied entirely on the data which others have published and, upon reading it, we have found that it seemed to be data which were properly obtained and reported and we have relied on the scientific ability and integrity of those who have reported it. We have not done any independent work of our own.

Q If all of the PCBs which were discharged from the two plants on the Hudson River were mixed with Hudson River water, have you calculated what the concentration in the Hudson River would be after such mixing?

A I have not. I have done it for the Housatonic River, because there we had actual measurements and these calculations and measurements were -- I mentioned we had one at three parts per billion; that's what the calculations would have indicated. Since we didn't have any measurement of the Hudson, I didn't have the same immediate incentive to do the calculation. I don't know whether Dr. Pozefsky may have done that, but I have not. It can be done, based on the 1600 cfs as the flow rate.

Q Thank you, very much.

MR. ECKERT: I don't have any further questions.

MR. RICHEL: I have just a few questions.

REDIRECT EXAMINATION

BY MR. RICHEL:

Q A while back, you referred to certain initial limitations for the Hudson Falls facility. I take it those limitations were not the proposed final limitations as well?

A These were not. These were for an initial period as defined in the permit.

Q And the final limitations proposed were?

A Zero discharge.

Q A while back you also referred to -- what was the duration of the permit? Do you recall offhand?

A The initial limitations were for a period of 21 months following which the condition was changed to zero discharge for chlorinated hydrocarbons.

Q And the duration of the permit entirely was five years?

A I would have to check that point.

Yes. The initial period was 21 months, the total five years, yes.

Q Now you also referred at one point a while ago to the concept of zero containment. I just want to make sure there that it reads properly.

Am I correct in assuming that zero containment is the equivalent of a hundred percent containment?

A Thank you for correcting that. I mean containment

from which the losses are directed as low as possible toward zero.

Q Just one other point.

Mr. Eckert touched upon the company's manufacture of transformers for railroad applications. Where is that done?

A Pittsfield.

Q Is it also done at Erie?

A Erie manufactures the cars and they purchase transformers from Pittsfield and install them on the cars that they manufacture at Erie.

Q And has Erie received any inquiries from representatives of operating railroads and representatives of the Department of Transportation and the Department of Commerce concerning the application of this proposed standard?

A The Department of Transportation and the Department of Commerce and major railroads, particularly in the Northeast, have expressed great concern over the continued availability of PCB-filled transformers for mass transit operation.

Q Very simply, without a long dissertation, what's the problem?

A With them getting it? Or why they use it?

Q What's the problem if they can't get it any further?

A Flammability. These are mounted underneath the cars on which passengers ride. If there should be any malfunction of the transformer or any rupture of the transformer,

allowing liquid to leave it, as through an accident, if that liquid is oil there is immediately a fire hazard endangering the safety of lives of the passengers.

Q To your knowledge, has this problem been considered by EPA?

A I've seen no evidence that EPA has considered this.

MR. RICHEL: I don't have any other questions.

XXXXX

RECROSS EXAMINATION

BY MR. ECKERT:

Q Does GE intend to attain zero discharge at the two plants on the Hudson River?

A Zero discharge as it appears in the Federal Water Pollution Control Act is a national goal. And --

Q Well, I'm referring to the proposed permit condition which Mr. Richel questioned you about.

A Oh. We have filed a formal objection on grounds that I'm sure Mr. Richel, who wrote the letter, could explain in more legal terms than I. Whom of us do you wish to answer that, because we feel there was an improper imposition of a condition in the permit which was not justified either in terms of timing, or certainly even in terms of the proposed regulations? The proposed regulations would not set zero discharge into a river flowing at 1600 cubic feet per second.

MR. RICHEL: Let me just say that in this instance, as with one other recent instance, we felt regional

EPAs were attempting to prematurely impose toxic pollutant standards for the sake of administrative convenience. That principle was acknowledged by Region Four recently, and we're hoping that that same principle will be acknowledged by Region Two; and therefore will not impose zero discharge limitation as being representative of best practicable technology.

BY MR. ECKERT:

Q Are there alternative dielectrics for PCBs in transformers for railroad use?

A The use of PCBs in transformers is dictated exclusively by the safety factor that it imparts to the equipment. From an electrical point of view, mineral oil would do just as well. It would be cheaper for us and for the customer. It would provide a transformer that was lighter in weight. It would provide a transformer which would not require some of the special insulation that is required inside of PCB-filled transformers.

There has therefore been ever since we got into this business all of the traditional economic incentives for us to find a substitute material. And over the last 30 years, more than a hundred possible substitutes for PCBs have been looked at in the laboratory for use in transformers.

That effort has been accelerated within the past year, since the first indication that these regulations might

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appear as stringent as they have been published. And to date we see nothing that would combine the electrical and safety characteristics of PCBs.

Q Thank you, Dr. Simons.

MR. ECKERT: I don't have any further questions.

JUDGE SWEENEY: You're excused, sir.

(Witness excused.)

JUDGE SWEENEY: We'll take a 15-minute recess.

End 3A (Recess.)

AROCLOR® 1254 IN EGGS OF SHEEPSHEAD MINNOWS: EFFECT ON FERTILIZATION SUCCESS AND SURVIVAL OF EMBRYOS AND FRY[1]

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[1] Contribution No. 177, Gulf Breeze Environmental Research Laboratory

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MONS 065813

ABSTRACT

The effect of the polychlorinated biphenyl (PCB), Aroclor 1254, in eggs of the sheepshead minnow, Cyprinodon variegatus, on fertilization success and survival of embryos and fry was investigated. Adult fish were exposed for four weeks to 0.1, 0.32, 1.0, 3.2 or 10.0 µg/l of PCB, then injected twice with 50 IU of human chorionic gonadotrophin to stimulate egg production. The eggs were fertilized, placed in PCB-free flowing seawater and observed for mortality. Fertilization success was unimpaired by concentrations in eggs as high as 201 µg/g but survival of embryos and fry was reduced. Usually, fry from eggs containing 7.0 µg/g or more began dying 24-48 hours after hatching. If this PCB affects other species similarly, then populations of fish that presently have comparable concentrations in their eggs may be endangered.

INTRODUCTION

Polychlorinated biphenyls (PCB's) have been found frequently in estuarine organisms from many states (Butler, 1973) and in an estuary near the Gulf Breeze Laboratory (Duke et al., 1970). PCB's in seawater are toxic to and accumulated by juvenile shrimp, crabs, oysters and fishes (Nimmo, et al., 1971; Lowe, et al., 1972 and Hansen, et al., 1971). The relationship between the amount accumulated by fish and subsequent effects is poorly understood. However, PCB's in eggs may decrease fertility and survival in early stages of embryonic development in Atlantic salmon, Salmo salar (Johannsson et al., 1970), and PCB's have been implicated in poor reproductive success of striped bass, Morone saxatilis (Anonymous, 1971). Because

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reproductive success with both fishes varied, the exact relationship of success to concentration of PCB in eggs remains unclear.

Our study was conducted to determine the effect of one PCB, Aroclor 1254, on fertilization success of eggs of sheepshead minnows, Cyprinodon variegatus, and on survival of embryos and fry. Aroclor 1254 was selected because we found eggs from striped bass that exhibited decreased reproductive success contained a PCB whose chromatograms closely resembled Aroclor 1254. Sheepshead minnows were selected because they can be readily exposed in the laboratory and reproductive success is excellent.

MATERIALS AND METHODS

Test fish

Adult sheepshead minnows were seined from ponds on laboratory grounds and acclimated to laboratory conditions for four days before exposure. During acclimation, mortality was less than 1% and no abnormal behavior was observed. Females averaged 42.5 mm standard length, range 35-52 mm, and males averaged 42.8 mm, range 35-52 mm. During acclimation and exposure, fish were fed commercial fish food that contained no detectable PCB (<0.01 µg/g).

Adult exposure

We exposed 20 female and 10 male fish in aquaria containing none, 0.1, 0.32, 1.0, or 3.2 µg/ℓ of Aroclor 1254 and exposed 25 females and 15 males to 10 µg/ℓ for four weeks in an intermittent-flow bioassay. The apparatus used was a modification of that of Brungs and Mount (1970). In our modification, Aroclor 1254 and carrier, polyethylene glycol 200, were injected into seawater each time the apparatus cycled. Each cycle

siphoned water to six 80ℓ test aquaria. The injection device was operated by a solenoid that raised a lever each cycle turning gears on six injectors and pushing the plungers of six 50cc syringes. Each of the approximately 150 daily cycles delivered 1.5ℓ of filtered 30C seawater, 11 µg of carrier and appropriate amounts of PCB to each aquarium. Water and carrier without PCB were delivered to the control aquarium. Salinity of water averaged 17 o/oo, range 5 to 28 o/oo.

Egg fertilization, embryo and fry survival

The effect of Aroclor 1254 in eggs was determined by enhancing egg production in exposed fish by hormonal injection, fertilizing the eggs artificially and monitoring their development in flowing PCB-free seawater. Female sheepshead minnows were injected intraperitoneally with a 50 I.U. human chorionic gonadotrophic hormone on exposure-days 25 and 27. On day 28, eggs were stripped manually from five females from each aquarium and those from each female placed in individual beakers containing 40 ml of filtered 30C seawater. Ninety-three of 96 females that survived produced eggs. Eggs from a female were fertilized with excised macerated testes from a male from the same aquarium. In addition, eggs from five control fish and two fish surviving exposure to 10 µg/ℓ PCB were fertilized by males exposed to 1.0 µg/ℓ. Twenty-five eggs from each fish were placed in Petri dishes to which a nine cm high collar of 500µ nitex mesh was glued. Dishes were submerged 7 cm in the 80ℓ aquarium which received approximately 225ℓ of filtered PCB-free seawater per day;

[2]Manufactured by George Frazer, 4528 Pitt Street, Duluth, Minn. 55804

average salinity was 18 o/oo, range 10 - 27 o/oo. Success of fertilization was confirmed by checking microscopically for cleavage 1.5 hours after fertilization. Thereafter, dishes were checked daily to determine survival of embryos and fry. Dishes remained in the aquarium for 34 days. Fry were fed brine shrimp nauplii or dry commercial fish food daily.

Chemical analyses

Concentrations of Aroclor 1254 in water, eggs and fish were determined by electron capture gas-chromatography. Unfiltered water samples from each aquarium were analyzed weekly during the four-week exposures of adults. At the end of the adult exposure, concentrations were determined in the fertilized eggs from each fish and in surviving adult males and females. Also, fry that hatched from these eggs and survived for four weeks in PCB-free water were analyzed for Aroclor 1254 content. Analytical methods for water, eggs and fish were the same as those of Mimmo et al. (1971), except that an OV-101 column was used and all peak heights were summed for PCB quantification. Recovery efficiency of Aroclor 1254 exceeded 80%. Measured concentrations were not corrected for percentage recovery.

Statistical analysis

Probit analysis was used to determine whether increasing concentration of PCB in eggs increased the effect on fertilization success and on survival of embryos and fry. The χ^2 test for independent samples was used to compare data for eggs from individual unexposed and exposed fish. Differences were considered real at $\alpha = 0.05$ for probit analysis and $\alpha = 0.01$ for χ^2 tests.

RESULTS AND DISCUSSION

Aroclor 1254 in water was toxic to and accumulated by adult sheepshead minnows exposed for four weeks (Table 1). Mortality of fish was negligible, except in the aquarium receiving 10 µg/ℓ. Dying fish in this aquarium typically became lethargic, ceased feeding, and some developed fin rot. Fish accumulated the PCB in direct proportion to the concentration in the water and concentrations in fish ranged from 15,000 to 30,000 X the nominal concentration in the water. Concentrations in males and females were similar. Concentrations of the chemical in eggs from exposed adult fish were proportional to the concentrations in the fish and concentrations in female fish were 1.8 to 2.3 times greater than the concentrations in their eggs. The PCB exposure apparently did not alter the percentage of females producing eggs or their fecundity.

Fewer embryos and fry from eggs of exposed fish survived than did embryos and fry from eggs of control fish (Table 2). The percentage of the eggs fertilized was not affected, but survival of embryos to hatching was less in eggs from fish exposed to 10 µg/ℓ. Survival rate of fry in the first week following hatching was less in eggs from fish exposed to 0.32 to 10.0 µg/ℓ than in eggs from unexposed fish. The estimated LC50 was 6.1 µg/g; 95 percent confidence limit equals 3.5 to 11.8 µg/g. Fry typically began to die one or two days after hatching, about the time they started feeding. If fry survived the first week, there seemed to be no additional mortalities

related to PCB during three weeks of additional observation. Concentrations of Aroclor 1254 in surviving fry were similar, 0.26 - 0.56 µg/g, and not proportional to concentrations in eggs.

Embryo survival decreased at the highest concentration of PCB in eggs and fry survival decreased with increasing concentration of PCB in eggs. The amount in eggs was critical because it was the sole source of PCB for the embryos and fry reared in PCB-free water. PCB in milt was probably not critical to fertility and survival because when eggs from control fish were fertilized with milt from either control or 1.0 µg/ℓ exposed males, survival rate of embryos and fry was not altered (Table 2). Survival rate of fry hatched from eggs containing 7.0 µg/g or more of PCB was significantly less than the lowest survival rate of eggs from any of the five control fish (Table 3).

If the effect of PCB in eggs of other fishes is similar to that found with sheepshead minnows — and we have no data to support this view — then variations in published information concerning the chemicals relation to spawning success could be explained. Atlantic salmon eggs containing up to 1.9 µg/g of PCB had decreased fertility and survival of early embryos, but survival of late embryos and sac fry was unimpaired (Johannsson et al., 1970). Chesapeake Bay striped bass eggs containing PCB's had decreased fertility and survival of newly hatched fry (Anonymous, 1971). Our analysis of eggs from eleven striped bass from the Eastern shore of Chesapeake Bay showed that the eggs contained about 2.5 to 8.7 µg/g of a PCB resembling Aroclor 1254. Because concentrations of

PCB in eggs of sheepshead minnows as high as 201 µg/g were not accompanied by decreased fertility and only minimal embryo mortality, it seems unlikely that decreased fertility and embryo survival in Atlantic salmon and striped bass could be related solely to PCB in their eggs. Diminished survival of newly hatched striped bass fry, however, could be PCB-related since concentrations in their eggs were similar to those in sheepshead minnow eggs which produced fry whose survival was poor.

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Table 1. Toxicity and uptake of Aroclor® 1254 by adult sheepshead minnows (Cyprinodon variegatus) exposed for 28 days in an intermittent-flow bioassay. Thirty fish were tested per concentration. Residue analyses are for a minimum of 7 male and 17 female fish and eggs from 5 fish.

TEST CONCENTRATION (µg/l)		MORTALITY %	CONCENTRATION IN FISH (µg/g, wet weight)			FEMALES GRAVID %	AVERAGE FECUNDITY No.
Nominal	Measured		Males	Females	Eggs		
Control	ND*	7	0.64	0.47	0.52	100	97
0.1	0.09	13	2.5	1.9	0.88	89	121
0.32	0.14	7	9.7	9.3	5.1	100	110
1.0	0.39	10	—	25.	11.	100	127
3.2	1.1	3	49.	49.	27.	94	152
10.0	5.6	95	—	—	170**	100	138

* ND = not detectable, < 0.03 µg/l.

** Eggs from two fish.

Table 2. Success of fertilization of eggs from sheepshead minnows exposed to Aroclor® 1254 for four weeks, survival of embryos from fertile eggs until hatching and survival of hatched fry. Eggs are from five fish per concentration (except two fish from 10 µg/l). Percentages are in parentheses.

CONCENTRATION		EGGS			FRY	
Adult	Eggs	Tested	Fertile	Hatched	Survival	
Exposure Average					Week 1	Weeks 2,3,4
(µg/l)	(µg/g)					
Control	0.52	125	125 (100)	116 (93)	111 (95)	106 (96)
0.1	0.88	125	120 (96)	106 (88)	103 (97)	98 (95)
0.32	5.1	126	120 (95)	107 (80)	82 (77)*	76 (93)
1.0	11.	126	121 (96)	118 (98)	31 (26)*	26 (96)
3.2	27.	126	118 (94)	100 (85)	23 (23)*	19 (83)
10.0	170.	50	46 (92)	33 (72)*	0 (0)*	0 —
Control ♀ and 1.0 µg/l ♂	—	128	119 (93)	113 (95)	112 (99)	111 (99)

* Significantly less than control hatching or one week fry survivals (χ^2; $\alpha = 0.01$).

Table 3. Comparison of concentration of Aroclor® 1254 in eggs (wet weight) from sheepshead minnows exposed to the PCB for four weeks and success of fertilization of eggs and survival of embryos and fry.

Concentration	EGGS			FRY		Adults
in Eggs	Tested	Fertile	Hatched	Week 1	Weeks 2,3,4	from Aquaria
(µg/g)						(µg/ℓ)
0.41	25	25	23	23	22	Control
0.44	25	25	24	19	19	"
0.45	25	25	25	25	24	"
0.53	25	25	24	24	23	"
0.57	25	24	19	18	18	0.1
0.76	25	25	20	20	18	Control
0.84	25	23	21	21	19	0.1
0.91	25	25	25	23	23	"
0.98	25	23	17	17	15	"
1.1	25	25	24	24	23	"
3.7	25	23	22	21	20	0.32
4.1	26	26	23	22	21	"
5.4	25	24	19	13	12	"
5.4	25	24	22	21	19	"
7.0	25	23	21	5	4	"
7.1	26	23	22	2	2	1.0
9.5	25	24	23	7	7	"
10.8	25	25	25	8	5	"

Table 3. (Continued)

Concentration in Eggs	EGGS			FRY		Adults from Aquaria
	Tested	Fertile	Hatched	Week 1	Weeks 2,3,4	
(µg/g)						(µg/l)
13.2	25	25	25	9	7	1.0
13.3	25	24	23	5	5	"
23.6	25	23	23	4	4	3.2
25.7	25	24	16	6	6	"
27.9	25	25	23	0	0	"
28.6	25	25	25	5	3	"
28.7	26	21	13	8	6	"
145.	25	23	15	0	0	10.0
201.	25	23	18	0	0	"

MONS 065825

AROCLOR® 1254: EFFECT ON COMPOSITION OF DEVELOPING ESTUARINE ANIMAL COMMUNITIES IN THE LABORATORY*

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Running page head: PCB Affects Estuarine Communities

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ABSTRACT

Aroclor® 1254, a polychlorinated biphenyl, affected the composition of communities of estuarine animals that developed from planktonic larvae in salt water that flowed through 10 control aquaria and 10 aquaria contaminated with 0.1, 1 or 10 µg/ℓ of this PCB. Communities that developed in control aquaria and aquaria that received 0.1 µg/ℓ of PCB in water for four months were dominated (>75%) by arthropods, primarily the amphipod Corophium volutator. In aquaria receiving 1 and 10 µg/ℓ, the number of arthropods decreased and the number of chordates, primarily the tunicate Molgula manhattensis, increased; over 75% of the animals in 10 µg/ℓ aquaria were tunicates. Numbers of phyla, species, and individuals (particularly amphipods, bryozoans, crabs, and molluska) were decreased in this PCB, but there was no apparent effect on the abundance of annelids, brachipods, coelenterates, echinoderms or nemerteans. The Shannon-Weaver index of species diversity was not altered by Aroclor 1254.

MONS 065827

INTRODUCTION

Polychlorinated biphenyls (PCBs) have been manufactured for various uses (Broadhurst, 1972) for over 40 years, but their occurrence in aquatic ecosystems was not confirmed until 1966 (Anonymous, 1965). Since then, PCBs have been detected in estuarine organisms from 5 of 15 of the coastal United States (P. A. Butler, 1973). One PCB, Aroclor 1254, was discovered in the water, sediment and biota of Escambia Bay, Florida (Duke et al., 1970).

Chronic and acute toxicity experiments conducted at the Gulf Breeze Laboratory have established that Aroclor 1254 is toxic to some estuarine organisms. A concentration of 100 µg/l of Aroclor was acutely toxic (48 to 96 hours) to pink shrimp, Penaeus duorarum, and oysters, Crassostrea virginica, but not to pinfish, Lagodon rhomboides (Duke et al., 1970). Chronic toxicity was up to 100 times greater than acute toxicity. In exposures lasting more than two weeks, 1 µg/l of Aroclor 1254 killed pink shrimp (Nimmo et al., 1971a), whereas 5 µg/l killed pinfish and spot, Leiostomus xanthurus (Hansen et al., 1971) and significantly reduced oyster growth rate (Parrish et al., 1972), but it was not lethal to blue crabs, Callinectes sapidus (Duke et al., 1970). Aroclor 1254 is, therefore, toxic to certain estuarine species exposed separately. However, its effect on communities of estuarine animals is not known. This study reports experiments that determined the effect of this chemical on development of estuarine animal communities in the laboratory.

MATERIALS AND METHODS

I investigated the effect of Aroclor 1254 on development of estuarine communities by comparing the number, species, and diversity of animals that grew from planktonic larvae in apparatuses continuously contaminated with 0.1, 1 or 10 $\mu g/\ell$ of PCB for four months, 18 May to 25 September 1970, with animals from an identical apparatus that was not contaminated.

The apparatus used in this investigation is illustrated in Fig. 1 (only one of four identical apparatuses is shown). Sea water with its natural component of plankton was pumped from the estuary adjacent to the laboratory into the primary constant head box. Salinity of the water ranged from 10 to 34 °/oo (average, 29.7 °/oo) and temperature ranged from 22 to 33 C (average, 28.5 C). In contaminated apparatuses Aroclor 1254 was added to water after it was siphoned, at the rate of 2,300 ml/min, from the primary into the secondary constant head box; the control apparatus received the same flow of water. Water then flowed from the secondary constant head box to each of 10 adjacent aquaria--10 replicates for each treatment. (Treatment includes control and contaminated apparatuses). Flow rate through each aquarium was maintained at 200 ml/min each by adjusting the height of a 2.7 mm diameter hole in each of the 10 standpipes in the secondary constant head box. Each aquarium was 44 cm long, 9 cm wide and 14 cm high. Water depth in each aquarium was maintained at 8 cm. PCB-free sand was placed in each aquarium to a depth of 6 cm.

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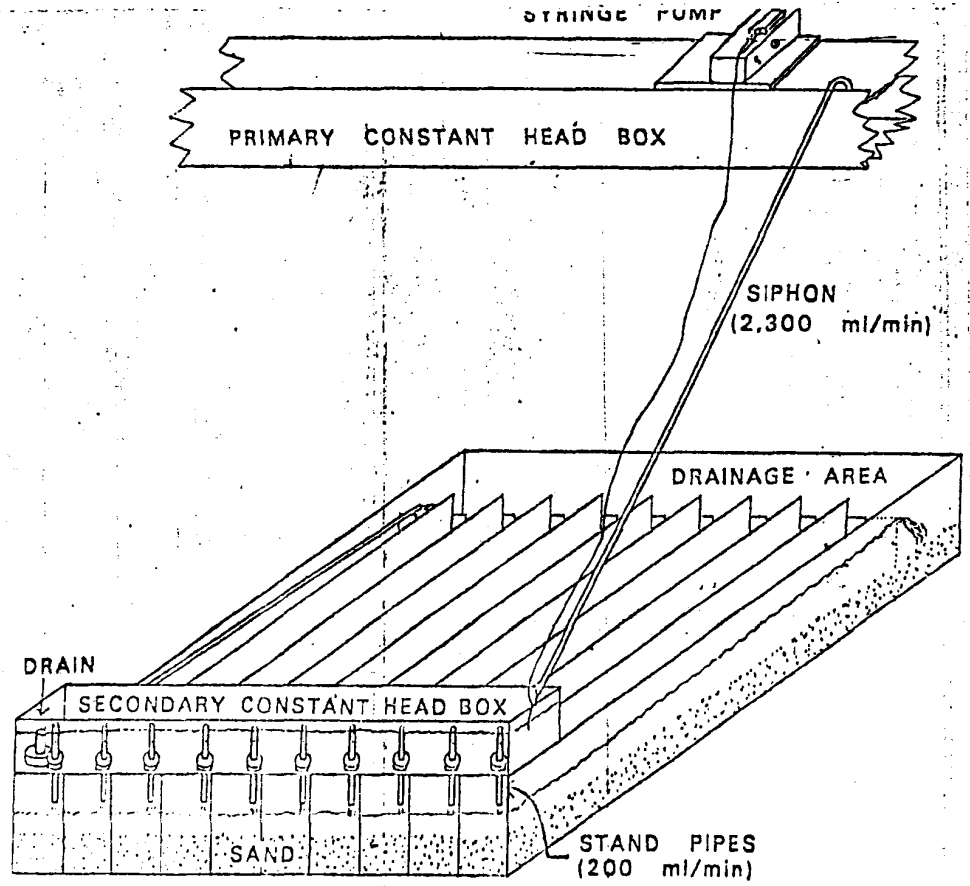
SYRINGE PUMP
PRIMARY CONSTANT HEAD BOX
SIPHON
(2,300 ml/min)
DRAINAGE AREA
DRAIN
SECONDARY CONSTANT HEAD BOX
SAND
STAND PIPES
(200 ml/min)

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Figure 1 -- Apparatus used to test the effect of Aroclor 1254 on composition of estuarine animal communities.

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Planktonic larvae colonized this sand and the walls of the aquaria. The siphon and constant head boxes were cleaned weekly so that all aquaria received planktonic larvae from a common source--the incoming water. Water leaving each aquarium flowed through a V-shaped opening and into a common drain for the apparatus.

Aroclor 1254, dissolved in polyethylene glycol 200, was metered by a syringe pump into the water as it entered the secondary constant head box of each experimental apparatus. The same amount of polyethylene glycol (2 ml/day, 0.68 mg/ℓ) was metered into the control apparatus. Solvent-induced effect was not expected because: (1) polyethylene glycol 200 did not affect development of two species of crabs at this concentration (Epifanio, 1971) (2) concentrations up to 1% ($v/_v$) were not lethal to grass shrimp, Palaemonates pugio, or sheepshead minnows, Cyprinodon variegatus, in 96 hours in static tests (Hansen, unpublished data) and (3) the toxicity of 5 mg/ℓ of Aroclor 1254 to brown shrimp, Penaeus aztecus, and pinfish was not increased by increasing the concentration of solvent up to 100 times (0.1 to 10.0 mg/ℓ) (Hansen, unpublished data).

Concentrations of Aroclor in test water and sediment were determined by gas chromatography. Methods of analysis for water are described by Nimmo et al. (1971a) and for sediment by Nimmo et al. (1971b), except that an OV-101 column was used. Recovery rates were above 70%, but data in this report do not include a correction factor for recovery. Water from the secondary constant head box of each

apparatus was analyzed twice a month (Table 1). Concentrations throughout this box were uniform; water from each standpipe, analyzed once during the 10 $\mu g/\ell$ exposure, averaged 7.9 $\mu g/\ell$ (range 6.8 – 8.7). Sediment cores from 4 of 10 aquaria from each apparatus were analyzed at the end of the exposure (Table 1).

At the end of the four-month exposure, animals were scraped from the sides of the aquaria and the contents of the aquaria siphoned into a 1 mm mesh sieve. During the last three months of the experiment, animals that left or were lost from the aquaria or were cleaned from the secondary constant head box and the drainage area were also collected in a 1 mm mesh sieve. Animals retained by the sieve were placed in fingerbowls of seawater relaxed with $MgCl_2$, preserved in 50% isopropanol and identified.

To determine effect of Aroclor 1254 in each treatment, an index of species diversity as well as the number and percent occurence of various species in each treatment (contaminated and control aquaria) were compared. A species diversity index provides a numerical means of assessing community structure that is independent of sample size, expresses the relative importance of each species and is dimensionless. Modifications of the Shannon-Weaver (1963) formula, $H' = -\sum_{i=1}^{s} p_i \log p_i$, where p_i is the proportion of the ith species in the collection and s = the number of species, have been used in freshwater (Wilhm and Dorris, 1968) and saltwater (Bechtel and Copeland, 1970) to assess effects of pollution on natural communities. In unpolluted

areas, many species of animals are abundant and diversity is high, but pollution can decrease diversity by making a few species very abundant and all others rare. In this study, the Shannon-Weaver formula ($\log_2$) was used to determine the usefulness of the species diversity index in assessing the effect of Aroclor 1254 on community structure in laboratory experiments.

Pooled data from each Aroclor concentration and control were compared statistically using the χ^2 test for independent samples. Data from each of the 10 aquaria receiving one treatment were compared with data from 10 aquaria receiving a different treatment using the Mann-Whitney "U" test (Siegal, 1956). Differences were considered real at $\alpha = 0.01$.

RESULTS

A large number and variety of animals were found in all aquaria (Tables 2 & 3). Of the 67 species from nine phyla, 27 were mollusks (15 pelecypods and 12 gastropods), 23 annelids, 6 arthropods, 3 chordates, 2 coelenterates, 2 echinoderms, 2 nemerteans, 1 brachiopod and 1 bryozoan. Arthropods were most abundant (3,842) of the 5,897 animals followed by chordates (1,302), annelids (448), mollusks (219) and animals from other phyla (86). The two most abundant animals were the amphipod, Corophium volutator (3,770), and the tunicate, Molgula manhattensis, (1,164).

Species composition and abundance of individual species varied

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among the 40 aquaria. The number of species in each aquarium ranged from 5 to 23 (average 13). Annelids and mollusks were present in all aquaria. Animals from other phyla were present in from 1 to 36 aquaria (Table 3). Seventeen species were found in all treatments and 26 were in only one.

Aroclor 1254 prevented animals of certain phyla from colonizing (Table 3). Although nine phyla were found, the number of phyla represented in any aquarium ranged from three to seven. The number of phyla in the control, 0.1 and 1 $\mu g/\ell$ aquaria averaged 5.7, 5.4 and 5.7, respectively. Fewer phyla, average 4.1, were in aquaria contaminated with 10 $\mu g/\ell$ of Aroclor because fewer aquaria contained arthropods, and none contained bryozoans.

The total number of species found in each apparatus ranged from 25 to 52 but the percentage of species in each phylum was similar in all four treatments (Table 4). In each apparatus, more species of mollusks were found than species from any other phylum. The relative numbers of molluscan species were similar for all treatments (40 - 44 percent). The number of annelid species was only slightly less (29 - 35 percent). Although fewer arthropods and chordates were found, the relative numbers of each were similar in all treatments.

The number of species in each aquarium of an apparatus was altered by Aroclor 1254 (Tables 2 & 5). The total number of species and the number of species from each phylum in the ten

control, 0.1 and 1 µg/ℓ contaminated aquaria were similar. However, there were significantly fewer species and the species composition differed in the ten aquaria contaminated by 10 µg/ℓ of the PCB. The greatest shifts in species composition were found in arthropods, bryozoans, and molluska. Although there were significant reductions in the number of molluscan species in the 10 µg/ℓ aquaria, there was no difference in the gastropod - pelecypod ratio.

The total number of animals in each aquarium did not differ significantly among the four treatments; whereas the number and percentage occurrence of species was markedly different (Tables 2 & 6). Arthropods (primarily the tube-dwelling amphipod, Corophium volutator) were the dominant animals in the control (76 percent) and 0.1 µg/ℓ PCB (84 percent) aquaria. In these aquaria, chordates (primarily Molgula manhattensis) were secondarily abundant. Arthropods were also abundant (55 percent) in aquaria that received 1 µg/ℓ but a significant decrease in their abundance and an increase in abundance (31 percent) of chordates occurred. Dominance was different in aquaria contaminated by 10 µg/ℓ; 80 percent of the animals were chordates. This difference from communities dominated by arthropods in control aquaria and in aquaria contaminated by 0.1 µg/ℓ of Aroclor 1254 to communities dominated by chordates in aquaria receiving the highest concentration of this PCB was the most striking PCB-

induced effect in this experiment.

The abundance of animals of other phyla, although less striking, was also altered by PCB. There were more mollusks in the control aquaria than in treated aquaria, but the percentage of their occurrence was not different in the PCB environments. Colonies of the encrusting bryozoan, Membranipora tenuis, were not counted, and therefore their numbers are not adequately represented in Table 6. However, their exclusion from the ten aquaria contaminated with 10 µg/ℓ was significant. Abundance of polychaetes was not altered by any of the three concentrations of PCB.

The Shannon-Weaver (1963) index of species diversity calculated for each aquarium did not differ among the control and three contaminated apparatuses (Table 7). Species diversity is a function of two components, richness (numbers of species (Table 5) and equitability or relative number of each species (Table 7) (Lloyd and Ghelardi, 1964). In my study, species diversity is not correlated ($r = 0.094$) with richness of species, but is correlated ($r = 0.882$) with relative abundance of each species: $J' =$ calculated diversity ÷ maximum diversity (Pielou, 1966). (Maximum diversity is defined as species diversity where all species are equally abundant.) Equitability did not differ between treatments because communities in this study were usually dominated by one species and were not rich in species. Therefore, the effect of Aroclor was not on species diversity but on species composition.

Conclusions based on abundance and diversity of animals collected at the end of the four-month exposure were corroborated by the abundance and diversity of animals that migrated from and were washed from each apparatus during the exposure (Table 8). The total number of animals and species from aquaria with 10 µg/ℓ was markedly lower than those from the other aquaria. Arthropods were abundant in collections from the effluents of control aquaria and aquaria with 0.1 and 1 µg/ℓ but rare from the aquaria with 10 µg/ℓ. The effect of Aroclor on crabs collected from the aquaria could not be assessed at the end of the exposure because only two were found in all aquaria. However, presence of exoskeltons in seven of 10 control, six of 10 0.1 µg/ℓ and eight of 10 1µg/ℓ aquaria and absence of exoskeltons in the 10 µg/ℓ aquaria strongly suggests that crabs were sensitive to highest concentration of Aroclor 1254. This sensitivity was substantiated by collections of crabs from the effluents of the aquaria. Eurypanopeus sp., Neopanope sp., Pinnixa sp., and portunids were abundant in effluents of control, 0.1 and 1 µg/ℓ aquaria but absent from the effluent of the 10 µg/ℓ aquaria. The bryozoan, M. tenuis, was absent in the effluent from the 10 µg/ℓ aquaria, but present in the effluent from the other aquaria. Mollusks were most abundant in effluent from the 10 control aquaria.

DISCUSSION AND CONCLUSIONS

The polychlorinated biphenyl, Aroclor 1254, influenced the composition of animal communities that developed from planktonic larvae in sea water which entered the test aquaria. The primary influence was that the dominant species in the control aquaria was the amphipod, C. volutator, and the dominant species in aquaria receiving 10 µg/ℓ PCB was the tunicate, M. manhattensis. Also, there were fewer species and the number of animals was markedly but not significantly fewer in the 10 µg/ℓ aquaria. The abundance of arthropods, chordates, bryozoans and mollusks differed significantly but abundance of annelids, brachiopods, coelenterates, echinoderms or nemerteans apparently did not differ.

Differences in community structure that were apparent at the lowest concentration (0.1 µg/ℓ) became more pronounced as the concentration of Aroclor 1254 increased to 10 µg/ℓ. Control aquaria were dominated by arthropods (76 percent), with lesser numbers of animals from eight other phyla. Aquaria contaminated by 0.1, 1 or 10 µg/ℓ contained fewer mollusks than did control aquaria; however, the percentage occurrence of mollusks was not altered by the PCB. Aquaria receiving 1 µg/ℓ or 10 µg/ℓ had more tunicates and fewer arthropods than did control aquaria. Aquaria receiving 10 µg/ℓ were dominated by tunicates (80 percent) with lesser numbers of five other phyla; only 1% of the animals were arthropods. Animals most reduced in numbers at the highest PCB concentration included

the amphipod, C. volutator; the xanthid crabs, Eurypanopeus depressus and Neopanope texana; the bryozoan, M. tenuis; the gastropod, Bittium varium; and the pelecypods, Abra aequalis and Tellina alternata.

Few of these changes could have been predicted from information from current literature, because only one species in this study had been challenged previously with PCB and only a few are phylogentically related to previously challenged species. Arthropods, particularly amphipods and crabs, were sensitive to Aroclor 1254 in this experiment and in the experiments by Nimmo et al. (1971a) in which pink shrimp were killed by 1 µg/ℓ. Juvenile blue crabs appeared resistant to 5 µg/ℓ (Duke et al., 1970). In my experiment, the numbers of xanthid crabs was reduced by 10 µg/ℓ indicating that larval stages may be particularly sensitive to PCBs. Sensivity of crab larvae has been shown with the insecticides dieldrin (Epifanio, 1971) and mirex (Bookhout et. al., 1972). Aroclor 1254 was lethal to two estuarine fishes at 5 µg/ℓ (Hansen et. al., 1971) but in this study lower chordates (tunicates) seemed unaffected and were most abundant in the PCB-stressed communities. Lethal effects of PCBs on mollusks are not known. However, growth of oysters was reduced significantly without mortality by 5 µg/ℓ of Aroclor 1254 (Farrish et al., 1972). In my experiment fewer mollusks occurred in all exposure concentrations possibly because the larval stages are sensitive or because

of factors other than the presence of Aroclor. Studies on protozoans (Cooley, Keltner, and Forester, 1972) provided the only other data I am aware of on the sensitivity of estuarine animals of other phyla to PCBs.

The Shannon-Weaver species diversity index has been used as an indicator of the effects of some types of pollution on animal communities in estuaries, but in this experiment, the index was not decreased even though composition of the communities were greatly altered. This species diversity index did not decrease as the concentration of PCB increased because the index was proportional to the relative number of each species present in the aquaria, and communities that developed at each treatment concentration were dominated by one species of animal. If Aroclor 1254 effected the composition of established communities in an estuary as it did the developing communities in this experiment, this species diversity index could not be used to estimate effects of this pollutant in the environment.

One purpose of this experiment was to determine whether the effect of a toxicant on developing estuarine animal communities can be investigated in the laboratory. Preliminary experiments at this laboratory indicated that the structure of communities of organisms setting in aquaria was altered by presence of the insecticide Dursban® (J. I. Lowe, personal communication[2]). My analysis of his data indicated that replicate aquaria were necessary to separate the effects of a toxicant from the effects

of an efficient predator or from the effects of an animal with great reproductive capacity. The use of ten replicate aquaria for each treatment in my experiment readily separated the effect of Aroclor 1254 from other factors that might influence community structure. My experiment also showed that small aquaria can be used, provided that larger animals can emigrate before they drestically affect community structure and thus mask effects of the toxicant. Emigrating animals must be caught and enumerated so the effects on them can be assessed.

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Table 1. Range and average concentration of Aroclor® 1254 in water and sediment from experimental and control apparatuses. Water was analyzed twice monthly and sediment was analyzed at the end of the four month experiment. Limit of quantification was 0.1 µg/ℓ in water and 0.015 mg/kg (dry weight) in sediment. Correction for recovery (>70%) is not included.

Concentration in water, µg/ℓ			Concentration in sediment, µg/g	
Nominal	Measured		Measured	
	Average	Range	Average	Range
Control	None		None	
0.1	<0.1	<0.1 – 0.1	0.1	0.05 – 0.18
1.0	0.6	0.48 – 0.72	0.36	0.25 – 0.42
10.0	6.7	5.2 – 7.8	2.0	1.5 – 2.5

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Table 3. Animals collected from control aquaria and from aquaria contaminated for four months with Aroclor® 1254. Ten aquaria were used for each treatment. Number of animals and number of aquaria from which they were collected are listed.

Taxon	Control		Aroclor 1254						Total Animals
			0.1 µg/l		1 µg/l		10 µg/l		
	Animals	Aquaria	Animals	Aquaria	Animals	Aquaria	Animals	Aquaria	
Annelida									
Ammotrypane aulogaster	8	5	11	4	3	2	0	0	22
Capitella capitata	34	10	30	8	34	9	23	8	121
Cirratulus sp.	1	1	0	0	1	1	0	0	2
Dasybranchus sp.	0	0	0	0	1	1	0	0	1
Exogone dienthus	6	5	8	6	11	6	9	6	34
E. protulicola	8	4	13	9	5	4	17	9	43
Heteromastus filiformis	0	0	0	0	2	1	0	0	2
Laeonereis culveri	1	1	0	0	0	0	0	0	1
Lumbrineris parvapedata	1	1	0	0	0	0	0	0	1
Mediomastus californiensis	0	0	0	0	0	0	1	1	1
Nephtys caecoides	8	6	11	7	12	6	9	7	40
Paraprionospio pinnata	0	0	0	0	1	1	0	0	1
Podarke, near guanica	1	1	1	1	0	0	0	0	2
Polydora websteri	28	10	35	10	51	8	22	4	136
Polygora sp.	2	2	1	1	1	1	0	0	4
Prionospio sp.	1	1	2	1	0	0	0	0	3
Spiochaetopterus bombyx	1	1	0	0	0	0	0	0	1
Streblospio benedicti	6	4	7	4	3	3	0	0	16
Capitellidae sp.	0	0	0	0	0	0	3	1	3
Spionidae sp.	6	1	0	0	0	0	0	0	6
Unidentified sp. #1	2	2	0	0	2	1	1	1	5
Unidentified sp. #2	1	1	0	0	1	1	0	0	2

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Table 2. (Continued)

TAXON	Control		Aroclor 1254						Total Animals
			0.1 µg/l		1 µg/l		10 µg/l		
	Animals	Aquaria	Animals	Aquaria	Animals	Aquaria	Animals	Aquaria	
Arthropoda									
Balanus sp.	6	4	2	2	9	6	2	1	19
Caprella sp.	0	0	11	1	3	3	0	0	14
Corophium volutator	1338	10	1693	10	736	10	3	3	3770
Neozanopa texana	2	2	0	0	0	0	0	0	2
Uporebia	0	0	0	0	0	0	1	1	1
Decapod larvae, unident. sp.	0	0	0	0	4	3	0	0	4
Pycnogonidae, unident. sp.	0	0	3	1	28	4	1	1	32
Brachiopoda									
Glottidia pyramidata	1	1	0	0	0	0	0	0	1
Chordata									
Boetrichobranchus pilularis	100	1	2	2	3	1	29	5	134
Branchiostoma caribaeum	2	1	1	1	0	0	0	0	3
Molgula manhattensis	91	7	141	10	436	9	499	10	1164
Coelenterata									
Leptomedusae, unident. sp.	5	5	4	4	8	8	7	7	24
Zoantharia, unident. sp.	0	0	0	0	3	3	0	0	5

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Table 2. (Continued)

TAXON	Control		Aroclor 1254						Total Animals
			0.1 µg/l		1 µg/l		10 µg/l		
	Animal	Aquaria	Animal	Aquaria	Animal	Aquaria	Animal	Aquaria	
Echinodermata									
Hemipholis elongata	4	2	17	4	15	6	0	0	1
? Amphioplus sp.	1	1	0	0	0	0	0	0	36
Ectoprocta									
Membranipora tenuis*	6	6	6	6	4	4	0	0	16
Mollusca									
Abra aequalis	15	8	11	6	5	5	0	0	31
Amygdalum papyria	10	6	4	3	0	0	6	6	20
Arachis translirata	2	2	0	0	0	0	0	0	2
Ardara transversa	6	4	4	4	3	3	6	5	19
Barnea costata	5	4	1	1	1	1	1	1	8
Bittium varium	16	7	4	4	7	4	1	1	28
Crassostrea virginica	0	0	2	2	0	0	0	0	2
Crepidula fornicata	4	3	5	4	4	3	4	4	17
Ericentrum humphreysi	0	0	0	0	0	0	3	3	3
Laevicardium mortoni	0	0	0	0	1	1	0	0	1
Lyonsia hyalina	9	5	3	3	2	2	4	3	18
Macoma fragilis	2	1	1	1	1	1	0	0	4
Mitrella lunata	0	0	1	1	1/	1	0	0	2
Modiolus americanus	2	2	0	0	1	1	0	0	3
M. demissus	1	1	0	0	1	1	1	1	3
	1	1	1	1	2	1	0	0	4

Table 2. (Continued)

TAXON	Control Animal	Control Aquaria	Aroclor 1254 0.1 µg/l Animal	0.1 µg/l Aquaria	1 µg/l Animal	1 µg/l Aquaria	10 µg/l Animal	10 µg/l Aquaria	Total Animals
Mollusca (Continued)									
Mulinia lateralis	5	3	0	0	1	1	0	0	6
Musculus lateralis	7	4	3	2	2	1	3	2	15
Nassarius albus	1	1	0	0	2	2	0	0	3
N. vibex	0	0	0	0	1	1	0	0	1
Ostrea equestris	1	1	0	0	1	1	0	0	2
Retusa canaliculata	1	1	0	0	0	0	0	0	1
Rissoina catesbyana	1	1	0	0	0	0	0	0	1
Tagelus divisus	0	0	1	1	1	1	0	0	2
Tellina alternata	9	7	3	3	7	7	1	1	20
Eolidacea, unident. sp.	1	1	0	0	0	0	0	0	1
Gastropoda, unident. sp.	2	1	0	0	0	0	0	0	2
Nemertinea									
Carinella dorsalis	2	2	0	0	0	0	0	0	2
Unidentified sp.	1	1	0	0	0	0	0	0	1

*Colonies: Counted as one animal.

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Table 3. Number of control and experimental aquaria that contained animals, by phylum. Ten aquaria were used for each control and contaminated apparatus. Experimental aquaria were contaminated continuously with Aroclor 1254 for four months.

Phylum	Control Aquaria	Aroclor 1254 Aquaria		
		0.1 ppb	1.0 ppb	10.0 ppb
Annelida	10	10	10	10
Arthropoda	10	10	10	4
Branchiopoda	1	0	0	0
Chordata	7	10	9	10
Coelenterata	5	4	9	7
Echinodermata	3	4	6	0
Ectoprocta	6	6	4	0
Molluscs	10	10	10	10
Nemertea	3	0	0	0
Total phyla in apparatus	8	7	7	6
Average number of phyla per aquarium	5.7	5.4	5.7	4.1

Table 5. Number of species, by phylum, that developed from planktonic larvae in 10 control aquaria and 10 aquaria in each apparatus contaminated continuously for four months with 0.1, 1 or 10 µg/l of Aroclor 1254.

Taxon	Control		Aroclor 1254					
			0.1 µg/l		1.0 µg/l		10.0 µg/l	
	Average number per aquarium	Range	Average number per aquarium	Range	Average number per aquarium	Range	Average number per aquarium	Range
Annelida	5.7	2-10	5.1	3-7	4.5	2-6	3.9	3-5
Arthropoda	1.6	1-2	1.4	1-3	2.8	2-4	0.6	0-3
Chordata	0.9	0-3	1.3	1-2	1.0	0-2	1.5	1-2
Mollusca	6.3	2-10	3.6	1-7	3.9	1-6	2.7	1-5
Other phyla	1.8	0-3	1.4	0-3	2.1	1-4	0.7	0-1
TOTAL	16.3	7-33	12.8	9-18	14.3	7-18	9.4	3-13

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Table 4. Number of species, by phylum, that developed from planktonic larvae in control apparatus and in apparatuses contaminated continuously for four months with 0.1, 1 or 10 µg/ℓ of Aroclor 1254. Each apparatus consisted of 10 aquaria.

Taxon	Control		Aroclor 1254					
			0.1 µg/ℓ		1 µg/ℓ		10 µg/ℓ	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Annelida	18	34.6	10	29.4	14	32.6	8	32.0
Arthropoda	3	5.8	4	11.8	4	9.3	4	16.0
Chordata	3	5.8	3	8.8	2	4.6	2	8.0
Mollusca	21	40.4	14	41.2	19	44.2	10	40.0
Other phyla	7	13.4	3	8.8	4	9.3	1	4.0
TOTAL	52	100.0	34	100.0	43	100.0	25	100.0

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Table 6. Average number per aquarium and average percent frequency per aquarium of animals, by phylum (range in parentheses), that developed from planktonic larvae in 10 control aquaria and 10 aquaria that for four months received 0.1, 1 or 10 µg/l of Aroclor 1254.

Phylum	Control		Aroclor 1254					
			0.1 µg/l		1 µg/l		10 µg/l	
	Number	Percentage	Number	Percentage	Number	Percentage	Number	Percentage
Annelida	11.6 (3-23)	6.5 (1.8-21.4)	11.9 (4-21)	5.8 (1.3-42.8)	12.8 (7-22)	9.0 (3.9-38.5)	8.5 (5-16)	12.9 (5.3-66.7)
Arthropoda	134.6 (6-406)	75.8 (12.7-94.8)	170.9 (14-528)	83.6 (28.6-96.2)	78.0 (8-199)	54.9 (20.5-86.9)	0.7 (0-4)	1.1 (0-2.8)
Chordata	19.3 (0-112)	10.9 (0-64.7)	14.4 (1-52)	7.0 (0.6-19.4)	43.7 (0-130)	30.8 (0-59.1)	52.8 (3-160)	80.4 (25.0-88.6)
Mollusca	10.1 (3-18)	5.7 (0.7-28.6)	4.4 (1-10)	2.2 (0.8-12.2)	4.4 (1-9)	3.1 (1.3-33.3)	3.0 (1-6)	4.6 (1.9-9.0)
Other phyla	2.0 (0-4)	1.1 (0-7.1)	1.7 (0-11)	1.4 (0-6.5)	3.2 (1-7)	2.2 (0.9-7.7)	0.7 (0-1)	1.0 (0-3.6)
TOTAL	177.6 (14-432)	100.0	204.3 (49-589)	100.0	142.1 (24-239)	100.0	65.7 (12-186)	100.0

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Table 7. Shannon-Weaver index of species diversity and index of species richness in the ten control aquaria and ten aquaria contaminated with 0.1, 1 or 10 µg/l of Aroclor 1254.

	Control			Aroclor 1254								
				0.1 µg/l			1.0 µg/l			10.0 µg/l		
	Mean	Range	Std. Error	Mean	Range	Std. Error	Mean	Range	Std. Error	Mean	Range	Std. Error
Species diversity	1.80	0.57-2.83	0.24	1.42	0.56-3.17	0.26	2.07	0.94-3.26	0.20	1.62	1.03-2.19	0.13
Equitability (J)	0.47	0.14-0.89	0.07	0.38	0.10-0.81	0.07	0.55	0.25-0.86	0.06	0.53	0.26-0.94	0.06

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Table 8. Species and total number of animals collected from the effluents of 10 control aquaria and 10 aquaria contaminated for four months with 0.1, 1 or 10 µg/l Aroclor 1254.

Taxon	Control	0.1 µg/l	1 µg/l	10 µg/l
Annelida				
Eupomatus dianthus	1	1	0	0
E. protulicola	0	1	1	0
Neanthes succinea	1	2	2	0
Total	2	4	3	0
Arthropoda				
Balanus sp.	10	2	2	1
Caprella sp.	0	8	4	0
Cilibanaria tricolor	0	1	0	0
Corophium volutator	7	15	32	1
Eurypanopeus depressus	5	2	5	0
Neopanope texana	10	6	3	0
Pagurus longicarpus	1	0	0	0
Pinnixa chaetopterа	1	0	0	0
Upogebia affinis	1	1	0	0
Decapod zoea, unident. sp.	0	0	1	0
Portunidae, unident. sp.	2	1	0	0
Pycnogonidae, unident. sp.	0	0	3	0
Total	37	36	50	2
Chordata				
Bostrichobranchus pilularis	3	0	0	0
Branchiostoma caribaeum	1	0	1	0
Molgula manhattanensis	72	103	304	35
Total	76	103	305	35
Coelenterata				
Leptomedusae*, unident. sp.	1	1	1	1
Echinodermata				
Hemipholis elongata	1	0	3	0
Ectoprocta				
Membranipora tenuis*	1	1	1	0
Mollusca				
Anadara ovalis	1	0	0	0
A. transversa	12	0	4	1
Bittium alternata	0	1	0	0
B. varium	3	0	1	0
Crassostrea virginica	2	0	1	1
Doridella obscura	17	1	2	1
Laevicardium mortoni	1	0	0	0
Mitrella lunata	2	0	2	2

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Table 8. (Continued)

Taxon	Control	0.1 µg/ℓ	1 µg/ℓ	10 µg/ℓ
Mollusca (Continued)				
Musculus lateralis	1	0	1	0
Nassarius albus	2	0	0	0
Tagelus divisus	1	2	0	0
Eolidacea, unident. sp.	1	1	1	1
Total	38	5	12	8
TOTALS: Animals	156	150	375	47
Species	27	18	20	10

*Colonies: Counted as one animal.

MONS 065857

MAY 28 1974

CHLORINATED HYDROCARBONS IN FISH FROM LAKE MICHIGAN

by

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Project 16020 PBE

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ABSTRACT.

Lake Michigan fish representing 13 species from 11 regions were captured in the fall of 1971 and analyzed for chlorobiphenyls (PCBs) and DDT and analogs. The presence of the major chlorinated hydrocarbons was confirmed by GC/MS, and additional confirmations of PCBs were obtained through perchlorination. The major PCBs in Lake Michigan fish are the tetra-, penta-, hexa- and heptachlorobiphenyls although lesser chlorinated PCBs were present in fish from nearshore waters. Mean concentrations of PCBs in the fish expressed as Aroclor 1254 (wet weight) ranged from 2.7 μg/gm in smelt to 15 μg/gm in lake trout. Essentially all trout and salmon greater than 12 inches in length contained PCBs at concentrations greater than the FDA tolerance level of 5 μg/gm. The concentrations of DDT (sum of analogs) ranged from less than 1 μg/gm in suckers to approximately 16 μg/gm in large lake trout.

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SECTION I

CONCLUSIONS

1. The predominant chlorinated hydrocarbons in Lake Michigan fish on a weight basis are chlorobiphenyls (PCBs) and DDT and its analogs.

2. The PCB mixtures are comprised primarily of the tetra-, penta-, and hexachlorobiphenyls, although fish from the nearshore waters often contain appreciable quantities of di- and trichlorobiphenyls.

3. The data reported as total DDT is comprised of approximately 50 to 60 percent p,p'DDE, 20 to 30 percent p,p'DDT, and lesser amounts of o,p'DDT and pp'TDE.

4. Mean concentrations of PCBs in the 1971 populations of fish averaged over the entire lake range from 2.7 µg/gm in smelt to 15 µg/gm in salmon. In general, trout and salmon greater than 12 inches in length contain PCBs at concentrations greater than the FDA action level of 5 µg/gm in food for human consumption.

5. Large variations in the concentration of PCBs were observed and were dependent on species, lipid content, length, and season of sampling. All of these factors must be recognized in the design of future monitoring work on Lake Michigan fish.

6. The concentration of DDT ranged from less than 1 µg/gm in suckers to approximately 16 µg/gm in large lake trout. In general, large trout and salmon contained from 7 to 12 µg/gm DDT, also exceeding the FDA tolerance level of 5 µg/gm DDT in human food.

7. Although the mobility of fish precludes the possibility of explicitly determining the variation of chlorinated hydrocarbons with region of Lake Michigan, the trend of higher concentrations of the PCBs in the southern end of the lake was observed in most of the species analyzed. This trend was more pronounced in the analysis of bottom fauna as presented in Appendix B in which the concentrations of PCBs varied from 0.06 µg/gm in

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Pontiporeia captured in 100 feet of water near Sturgeon Bay, Wisconsin, to 0.45 ug/gm in those from Waukegan, Illinois. Decreasing concentrations of PCBs were also observed in fauna from greater depths along each transect.

8. The present methodology for the analysis of PCBs in tissue is adequate for the determination of PCBs containing four or more chlorine atoms per molecule. However, the silicic acid separation procedure does not allow explicit determination of PCBs with fewer numbers of chlorines due to their greater polarity.

9. The use of perchlorination as an analytical method for PCBs provides rapid confirmation and data similar to direct GLC analyses when the predominant PCB mixture is known.

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SECTION II

RECOMMENDATIONS

1. Luecshow (1972) recommended that the concentrations of PCBs in Lake Michigan fish should be determined. This study has satisfied this recommendation for the 1971 fish populations and has provided "baseline" data for future work aimed at detecting trends in the PCB and DDT concentrations. Because of the recent restrictions on PCB and DDT uses, the Lake Michigan system provides a unique opportunity to demonstrate the effect legislative and other regulatory actions may have on a large body of water. It is recommended that comprehensive sampling of selected fish species be conducted at two-year intervals and that these fish be analyzed for PCBs and DDT. Such studies should be modeled after the limited studies presently underway at the Great Lakes Fishery Laboratory in Ann Arbor, Michigan.

2. Detailed information is needed regarding the quantities of PCBs in use after the restrictions Monsanto Company has voluntarily imposed. It is recommended that the Environmental Protection Agency initiate appropriate investigations to assure that the "open system" use of PCBs is, in fact, curtailed and that significant quantities of PCBs are not being imported.

3. Further studies concerning the impact of PCBs and DDT on the biological resources of Lake Michigan are needed and should be stimulated by Federal funding.

4. Detailed searches for potentially hazardous chemicals heretofore unidentified should be conducted on Lake Michigan fish in order that the significance of such chemicals can be evaluated as early as possible and appropriate regulatory action be considered before the concentrations become sufficient to further jeopardize the usefulness of the Lake Michigan resources.

SECTION III

INTRODUCTION

The literature is replete with data concerning the occurrence of chlorinated hydrocarbons in the environment and the effects of these synthetic chemicals on test animals. Concomitant with such studies are attempts to correlate the composition of organochlorine chemicals in organisms (or their environment) to observed effects in the biological communities and to formulate regulatory policies in accordance with existing evidence. However, the complex nature of ecosystems and of the mixtures of potentially hazardous chemicals found in the ecosystems often preclude explicit interpretation of data, as has been exhibited in the numerous hearings before the U.S. Senate and state agencies concerning DDT and related compounds. Thus, from the outset, large-scale field studies such as this effort which provide data on a few variables run the risk of producing data of limited value and adding to an already superfluous literature.

The purpose of this study is to identify and quantitate the major organochlorine compounds in the 1971 populations of fish from different regions of Lake Michigan. The study was recommended by the four states surrounding Lake Michigan in the Lake Michigan pesticide report which was requested by the Lake Michigan Interstate Pesticide Committee and prepared by L. A. Lueschow of the Wisconsin Department of Natural Resources. The forthcoming results are put in perspective by the following brief review of factors which produced the need for this study.

It has been established that Lake Michigan is unique in that it contains much higher concentrations of agricultural pesticides than the other Great Lakes due, in part, to the large useage in the watershed in comparison to the flushing period for the lake and to the relatively low biomass density. Previous studies have shown that the fish from Lake Michigan approached the FDA action levels for dieldrin in 1969 and that a major fraction exceeded the action levels for DDT (Reinert, 1970). More recent data (Reinert, 1972) from carefully designed monitoring (Reinert, 1971)

indicates that the average DDT concentration in Lake Michigan fish remained essentially the same between 1967 to 1970 and suggested that the levels have begun to decrease.

Although not realized in the early analyses by Reinert, other work (Veith, 1970) has shown that the concentration of PCBs (similar to Aroclor 1254) were greater than 15 µg/gm in large fish collected from Lake Michigan in 1969. Thus, it is apparently in Lake Michigan rather than the other Great Lakes that the potentially hazardous and persistant chemicals from our industrialized technology are most concentrated. It follows, then, that consideration must be given to the effect these chemicals have on the biological communities sustained by Lake Michigan and the possibility of stemming or even reversing the trend of increasing levels of organochlorine compounds in the Lake Michigan system.

Despite the comparatively high levels of DDT, dieldrin and PCBs in Lake Michigan, there is no direct evidence that the chemicals are endangering the aquatic life in the lake. The concentration of each of the chemicals appears to be below 10 ng/l in the pelagic waters and less than 100 ng/l in the nearshore waters, all of which are below the "no effect" level for the respective chemicals for most aquatic organisms. However, the lack of direct evidence of damage may simply reflect the difficulty in adequately measuring such effects in this environment.

There is considerable indirect evidence which suggests that the build-up of organochlorine compounds may be a threat to the future of the biological resources of the lake. It is beyond the scope of this introduction to review the literature concerning the pesticides and PCBs, and the reader is referred to existing comprehensive reviews (Zitko and Choi, 1971; NIH, 1972; Quinby, 1972; Task Force, 1972).

Consider first the major effort of the states surrounding Lake Michigan to stock the lake with brown, lake and rainbow trout and with coho and chinook salmon. Between the years of 1963 and 1970, over 600,000 rainbow trout have been released by Wisconsin alone (Kornon, 1970). In 1971, the State of Michigan stocked 3.2 million coho, 2.1 million chinook, 2.1 million lake trout and 200,000 rainbow trout. The first widespread spawning of lake trout in Lake Michigan since 1940 occurred in 1971 (GLFL, 1972). This

massive stocking program has produced an unparalleled sport fishery and provides a valuable protein source for human food as well as animal feeds. Essential to the establishment and maintenance of this fishery is the successful reproduction of the adult fish. However, Reinert (1970) has previously pointed out that DDT and dieldrin levels in eggs are similar to those which inhibited reproduction in the studies of Burdick et al. (1964) and Macek (1968). In addition, Jensen et al. (1970) have shown that 15 µg/gm of PCBs (lipid basis) in salmon eggs produced 50 percent mortality and complete mortality can be expected when the eggs contain 25 µg/gm PCBs (lipid basis). All of these data concerning the effects of organochlorine compounds on reproduction were obtained individually, and little is known of possible combined effects when the tissues contain mixtures of the toxicants.

Even though the continued stocking of fish may maintain a food resource in spite of possible adverse effects of the residues on reproduction in Lake Michigan fish, many fish contain body burdens which make the fish unfit as a food resource for humans. The U.S. Food and Drug Administration has established a tolerance level of 5 µg/gm, 5 µg/gm and 0.3 µg/gm for DDT, PCBs and dieldrin, respectively, in food to be sold for human consumption. Since the lake supports a sizeable commercial fishery in addition to the sport fishery, the presence of these chemicals below the "no effect" level in water may still endanger these industries due to the large partition coefficient for lipid/water systems. Indeed, numerous catches of commercial fish being shipped to markets have been seized, and tons of large salmon have been withdrawn from state give-away programs in Michigan because the DDT and PCB residues exceeded the 5 µg/gm concentration.

Concern has also arisen with respect to the impact the organochlorine compounds in the Lake Michigan biota (principally fish) is having on other animals which use this food supply. Most notably is the effect of Lake Michigan fish on mink reproduction in the North Central states. Before DDT and dieldrin levels in these fish were well documented, Hartsough (1965) indicated that Lake Michigan fish were suspected as the factor leading to poor mink reproduction. Aulerich et al. (1970) clearly demonstrated the fish had been the cause of the reproductive failure. Aulerich

and Ringer (1970) found that DDT and DDD did not have significant adverse effects on mink. Furthermore, dieldrin was lethal at 2.5 μg/gm in the food for extended periods but did not appear to effect reproduction at twice this level during the gestation period. Aulerich et al. (1971) concluded that coho salmon per se did not cause reproduction problems but that the disorder is associated with other species of fish and "appears to be dependent upon the species of fish and its environment." Finally, after the earlier reports that PCBs were present in Lake Michigan fish, Ringer et al. (1972) demonstrated that 10 μg/gm of Aroclor 1254 in coho salmon produced 71 percent mortality in mink and that a mixture of 10 μg/gm PCBs and 0.5 μg/gm dieldrin in coho feed produced 100 percent mortality. No kits were born alive when the diet contained 5 μg/gm or greater Aroclor 1254 alone. This evidence clearly indicates that the biological resources of Lake Michigan may seriously endanger other species even though the levels of toxicants are not sufficiently great to produce a dramatic effect within the aquatic communities.

Equally important is the coincidence of high levels of chlorinated hydrocarbon in herring gull and other bird populations with reproductive failures and subsequent population decline. Ratcliffe (1970) and Anderson (1970) have clearly shown that major changes in eggshell thickness have occurred since 1945 and that the phenomenon may be a major factor in the decline, if not extinction, of many species of birds. The effect is found in predators and most notably in fish-eating birds. In general, egg shell thinning of 10 to 15 percent (relative to pre-1940 eggs) may produce an effect in the population, 15 to 20 percent is associated with readily observable egg breakage, and 50 percent thinning has been associated with virtually total reproductive failure (Risebrough et al., 1970; Keith et al., 1970).

Anderson (1970) found the Great Lakes Herring Gulls contained the highest chlorinated hydrocarbon levels in eggs ever reported for that species. He also found that the Lake Michigan gull, which declined drastically in the early 1960's but recovered in the late 1960's, had egg shell thinning which varied from nine percent in 1953-1956 to 18 percent in 1965. However, since 1965, the degree of thinning has decreased to eight percent in 1969. In comparison, gulls on Lake Huron and Lake Superior have

exhibited thinning of seven and eight percent, respectively, and those from the east coast have remained essentially unchanged from earlier eggs.

Anderson (1970) also showed that double-crested cormorants from Wisconsin had 20 percent thinner eggs and produced eggs with the highest DDE concentrations of this species from interior North America. Golden eagles which primarily feed on mammals do not show as dramatic egg shell thinning as do the Bald Eagles which feed on fish. Despite the lack of detailed data in the literature, it is not unreasonable to suggest that the disappearance of Bald Eagles from the shores of Lake Michigan may also be linked by correlation to the chlorinated hydrocarbons in the food resources of the lake.

The Lake Michigan system is also unique in that the use of the major persistent chemicals have been curtailed in the watershed by a variety of actions. Although it is likely the use of the chlorinated pesticides in agriculture was diminishing in the late 1960's, the Lake Michigan Enforcement Conference recommended regulatory actions on many uses in 1968. This recommendation led to restrictions on DDT in Illinois, Michigan and Wisconsin, including the sale of this compound. A more detailed summary is presented by Luecshow (1972).

The realization that the widespread use of PCBs has resulted in the widespread occurrence of these potentially hazardous chemicals in the environment moved Monsanto Company, the sole producer of PCBs in the United States, to restrict the sales of PCBs in 1970 and by April, 1971, only "close system" uses were able to purchase PCBs from Monsanto. However, there is no data to confirm the fact that PCB useages are significantly reduced.

As previously discussed, the FDA has placed a 5 µg/gm action level on PCBs in food for human consumption. Moreover, on March 18, 1972, this restriction was extended to food packaging materials. On May 2, 1972, the Environmental Protection Agency announced that all discharges to the aquatic environment involving PCBs will be restricted to the lowest possible level and that the desired limit will be 0.01 µg/l PCBs. These restrictions were re-enforced by the recommendation of the joint task

force headed by the Council on Environmental Quality and the Office of Science and Technology (Task Force, 1972) which called for all current uses of PCBs, except capacitors and transformers, to be discontinued.

In summary, the use of chlorinated hydrocarbons in the agriculture and industry in the Lake Michigan watershed over the last few decades has resulted in the contamination of this valuable, mesotrophic body of water. Indirect evidence exists that these chemicals are having subtle detrimental effects on the species near the top of the food chain, and some of the food resources have been deemed unfit for human consumption. However, the Lake Michigan watershed has also realized unparalleled legislative action regarding the use of these hazardous, persistent chemicals in the last two years. At the recommendation of the Lake Michigan Interstate Pesticide Committee, this study was funded to establish detailed data on PCBs and DDT in Lake Michigan fish which will serve as a 1971 baseline in determining future trends of the levels of these chemicals in the lake and the impact cooperative legislative actions have had in managing the quality of large lakes.

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SECTION IV

MATERIALS AND METHODS

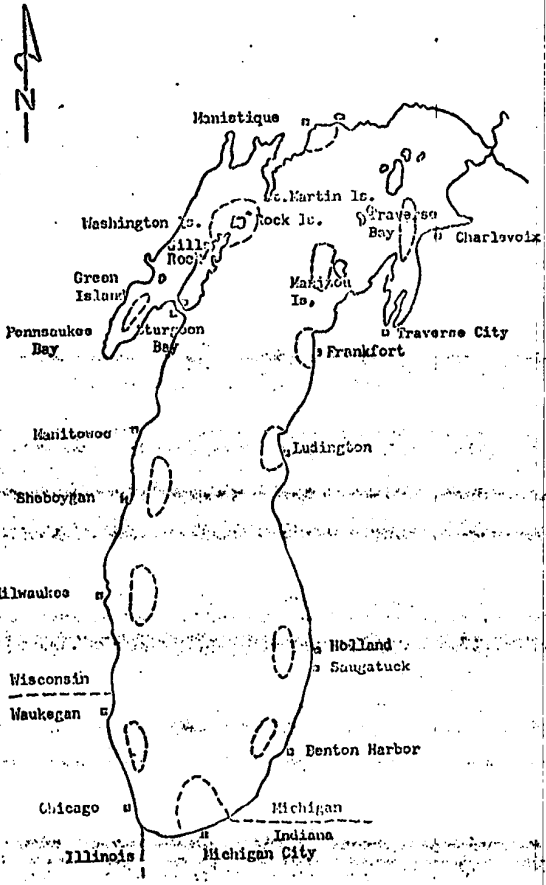
This section describes the procedures used in collecting samples for the study and in analyzing the tissue for major chlorinated hydrocarbons. Special emphasis has been placed on preparation of reagent chemicals used in the study.

A. Sample Collection

The intent of the field sampling phase of this study was to collect 20 samples of yellow perch (10-12 inches), white sucker (10-12), carp (12-25), chub (8-10), lake trout (20-25), coho salmon (20-25) and alewife (6-8) from each of the following regions of Lake Michigan: central basin--north, central basin--south, Green Bay, Sheboygan - Manitowoc, Milwaukee - Racine, Chicago - Indiana Harbor, Benton Harbor, Saugatuck, Grand Haven, Muskegon and Grand Traverse Bay. The above field objectives suggested by the Lake Michigan Interstate Pesticide Committee were not explicitly attainable due, in part, to the availability of each species in the regions of interest and to the availability of fishing vessels in the respective regions of the lake. Thus, the majority of the fish were captured as available during September and October of 1971 through the use of gill nets, pond nets and trawls. To minimize variations in the concentration of chlorinated materials with size of fish, the length of the fish taken for analysis was limited as much as possible to the size ranges suggested by the Committee. Figure 1 is an illustration of Lake Michigan in which the sampling areas are indicated by dashed lines.

Where possible, the samples were transferred directly from the ship to insulated boxes lined with acetone-rinsed aluminum foil which contained dry ice. However, many of the samples which were collected by research biologists from state agencies were placed in cardboard cartons or polyethylene bags and frozen immediately. When grinding these samples, the containers were sampled to determine whether significant amounts of

FIGURE 1, SAMPLING REGIONS OF LAKE MICHIGAN



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contaminants were present in the materials in contact with the frozen fish. All samples were transported directly to the University of Wisconsin at Madison.

B. Reagents

Spurious gas chromatograph peaks which arise from the contamination of the sample in the laboratory are not an uncommon problem in trace analyses. These contaminants not only add to the anonymity of the GLC interpretation but also often make true quantitative analyses an impossibility. Previous work by the author has indicated that most reagents used in pesticide analysis contain contaminants which may interfere with the analysis. Moreover, contamination of the sample may arise from objects worn or brought into the laboratory by personnel such as adhesive bandages, order forms, etc. and the laboratory is regulated accordingly. Also, the following reagent cleaning procedures were established to minimize the possibility of sample contamination during the analyses.

1. The Na_2SO_4 (Fischer Scientific Co.) was washed with three volumes of 1:1 hexane/acetone and dried at 130° C. To prevent further contamination from cap liners or containers, the Na_2SO_4 was stored in large glass bottles with Al foil liners in the cap.

2. The Florisil media (Kensington Chemical, Fisher Scientific) was extracted in an all-glass Soxhlet extractor for 24 hours with the azeotrope of hexane and acetone in an effort to remove traces of organic impurities. The solvent was evaporated from the Florisil at 100° C, and the solid was heated at 650° C for 2.5 hours for activation. If not used immediately after heating, the Florisil was warmed to 105° C prior to its use.

3. The silicic acid (Mallinckrodt Chemical, AR grade, Ramsey and Patterson) was used directly from the reagent bottle.

4. The hexane (Skelly B) was redistilled in glass from Dri-Sodium (Fisher Scientific).

5. The acetone (Fisher Scientific, ACS) was redistilled in glass from Dri-Sodium.

6. The ethyl ether and methylene chloride (Mallinckrodt Chemical) were pesticide quality solvents and were used directly out of the reagent bottle after periodic checks showed that interferences were not present for the experimental conditions of this study.

7. Glass wool was soaked in acetone and then rinsed with an acetone in hexane mixture (1:1).

8. Glassware was washed thoroughly with hot detergent and rinsed with hot water, twice with distilled water and with a mixture of acetone and hexane (1:1).

C. Sample Preparation

The fish were stored frozen at -20° C until analysis. The storage period for the majority of the fish was restricted to several weeks but did not exceed two months in order to minimize dessication and possible chemical changes in the tissue during storage. The frozen fish were fragmented with a cleaver and homogenized while frozen using a Hobart meat grinder. The frozen tissue was first passed through the grinder to obtain a free-flowing, granular product in which bone, fat and muscle tissue could be recognized. The entire sample was thoroughly mixed and passed through the grinder twice more to yield a uniform light pink sample. The homogenate was sampled by quartering several times and removing aliquots for immediate analysis and for bulk samples which have been stored for possible future work.

During the homogenizing operation, considerable effort was expended to assure that the tissue came in contact only with metal surfaces which were rinsed with acetone. The grinder was cleaned with hot water after each fish was ground. The bearing and seal of the grinder was inspected periodically to make certain no lubricants could enter the grinding chamber. Since several of the assistants on this project worked only part-time between classes, care was taken to clean hands thoroughly to assure that contaminants were not introduced from outside sources of PCBs such as carbon papers, inks, etc.

D. Extraction

Because of the large number of samples which were to be extracted for this study, the 12 extractor unit in Figure 2 was built at the Water Chemistry Laboratory. The unit featured two rows of six extractors, each heating mantle independently spring-loaded such that the extractors could be set up or removed individually by pressing down on the mantle and lifting the extractor off. Since many of the organic solvents require less than 115 volts on the heater for refluxing, pairs of the heaters were connected in series, thus dropping approximately 60 volts across each heater. This arrangement precluded the need for voltage transformers and provided enough power to maintain about eight extractions each hour in the extractors. The main power cord was connected to a timed relay, allowing the extraction to be carried out unattended.

Approximately 10 gm of frozen tissue was weighed into a tared beaker and then ground with 50 gm anhydrous Na_2SO_4 until the mixture appeared dry. The mixture was tamped into a glass extraction thimble fitted with an extra course glass frit and placed into the Soxhlet extraction apparatus. The receiver flasks were filled with 170 ml of hexane/ethyl ether (1:1), and the samples were extracted for three to four hours.

E. Column Cleanup

Sample cleanup was conducted as indicated in Figure 3. Briefly, the extracts were concentrated to 20 ml and 2 ml were withdrawn for the non-volatile residue analysis. After further concentration of the extract, the bulk of the oil and fat was removed through liquid chromatography on Florisil as shown in Figure 4.

The Florisil column consisted of a 25 mm O.D. glass column which was filled with 19 gm of Florisil (Reynolds, 1969). The column was fitted with a glass frit and Teflon stopcock at the bottom and was topped with 10 gm anhydrous Na_2SO_4 to prevent deactivation from water in the extract. The extracts (15 ml) were placed on the dry column and eluted with six percent ethyl ether in hexane (200 ml) at 3 to 5 ml/min to obtain PCBs, DDE, DDD, DDT, heptachlor, aldrin and toxaphene, if present. The receiving flask was changed, and the column was eluted with 15 percent ethyl ether

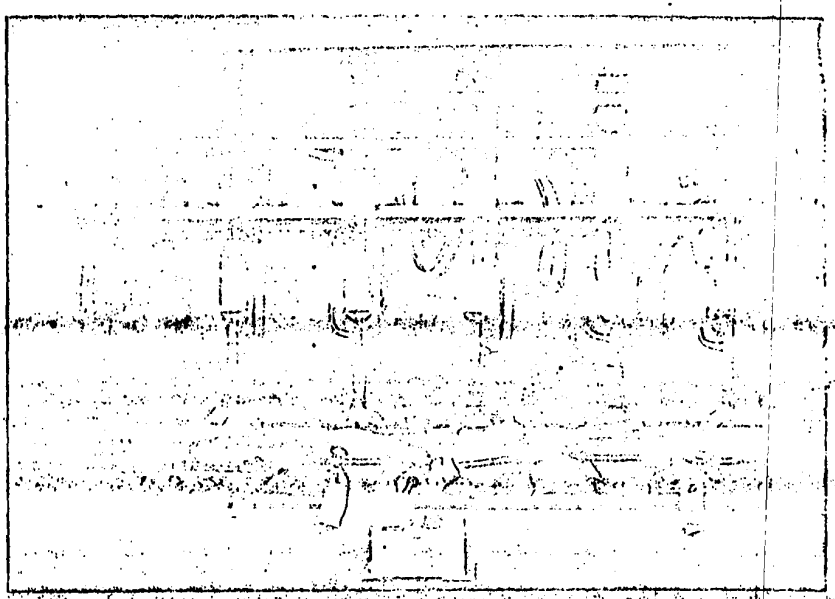
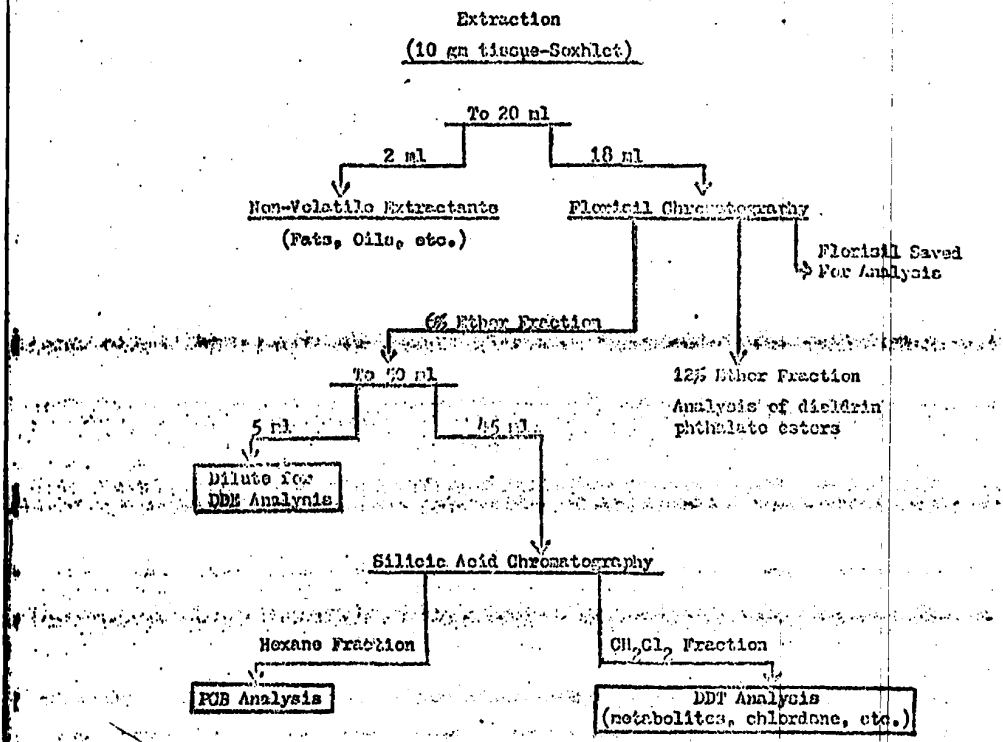


Figure 2. Apparatus for Multiple Extraction Fish Tissue Using Soxhlet Extractors

Each unit is held in place by spring tension on the heating mantles. Samples are added or removed by pressing down on the individual mantles.

Figure 3. Analysis Scheme for Lake Michigan Fish



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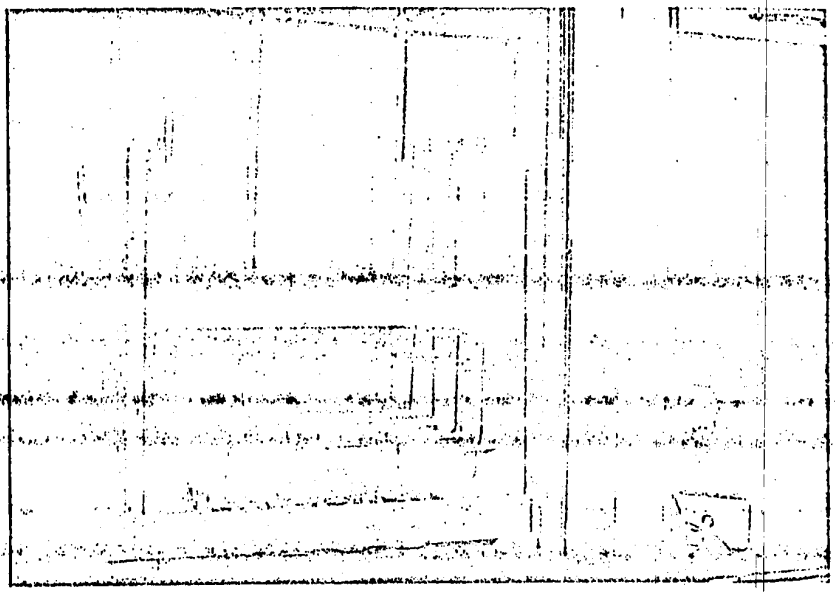


Figure 4. Apparatus for Multiple Cleanup of Extracts by Florisil Chromatography.

Approximately 32 extracts were passed through this primary fractionation step each day.

in hexane (200 ml) to obtain dieldrin, heptachlor epoxide, lindane and some of the phthalate esters, if present. The samples were concentrated to appropriate volumes for GLC analysis. In general, the 19 gm Florisil column was suitable only for removing the bulk of the co-extracted non-volatile materials, dieldrin and related compounds from the chlorobiphenyls and DDT family of pesticides.

F. Liquid Chromatography on Silicic Acid

The six percent (ether in hexane) fraction from the Florisil column contained primarily PCBs and DDT and derivatives thereof (Veith, 1970). Because a mutual interference exists in GLC analyses of samples containing residues of both these groups of compounds, separation of the PCBs from DDT was necessary prior to analyses.

Although PCBs can be separated from DDT on alumina, silicic acid (Armour and Burke, 1970) and charcoal (Berg et al., 1972), previous work by the author has demonstrated that the separation of DDE from the PCBs, particularly those with three or less chlorine atoms per molecule, cannot be consistently attained in routine analyses. However, due to the comparatively large concentration of p,p'DDE with respect to other chlorinated hydrocarbons in Lake Michigan fish, the extracts can be diluted and analyzed for DDE without significant error (see example in Figure 5). Therefore, prior to the fractionation of the six percent ether eluate from the Florisil column, an aliquot (nine percent of sample) was diluted approximately tenfold and analyzed directly for DDE. The remainder of the sample was subjected to further separation on silicic acid.

The silicic acid separation was conducted according to the procedure of Armour and Burke (1970) with minor modifications. Because more than 20 samples were passed through silicic acid each day, large quantities of silicic acid of uniform deactivation were necessary to assure consistent separations. To accomplish this, 500 grams of silicic acid (Mallinckrodt, 100 mesh, AR) were weighed into flasks in five 100 gram portions after the powder was dried at 130° C overnight. Water (2.1 to 2.7 percent) was added by buret to deactivate the media, and the individual flasks were sealed and shaken vigorously in a wrist-action shaker for four hours. The media in the flasks were then combined and blended in a sealed bottle and

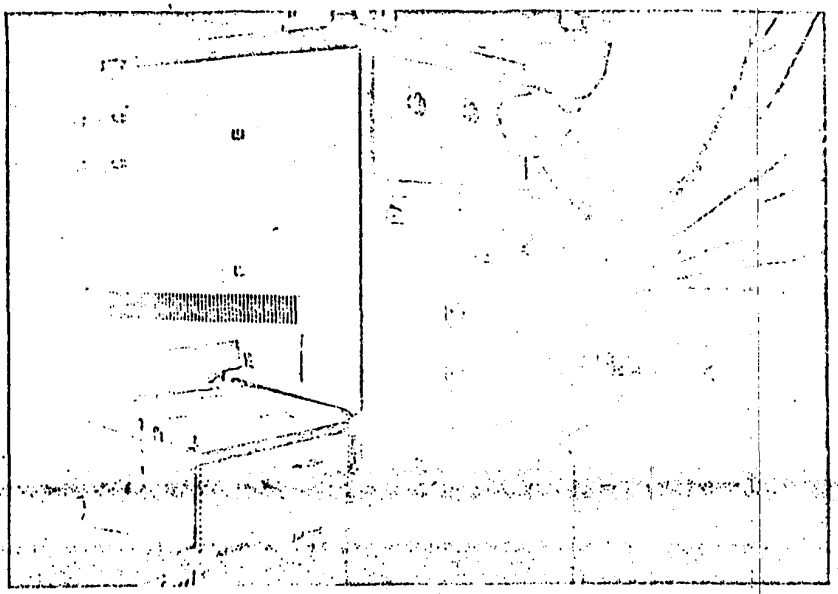
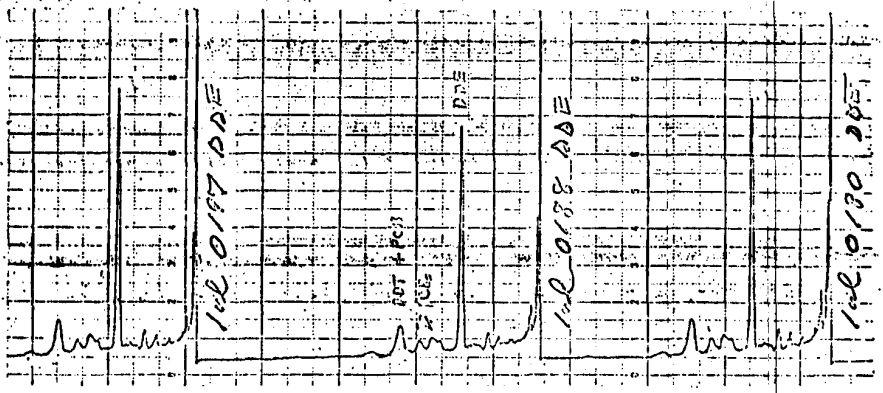


Figure 5. GLC Analysis of DDE on a Varian 1745 Gas Chromatograph. Below-A typical chromatogram for Lake Michigan fish with interference-free response of DDE in the presence of PCBs.



allowed to equilibrate approximately 18 hours in a desiccator. Colito 545 was not used in the procedure because of the impurities present in the commercially available material.

The chromatography columns were prepared by pouring a slurry of 20 grams of the deactivated silicic acid and hexane into a 22 mm (I.D.) shell column fitted with pressure fittings on top. After the sample was placed on the column, it was eluted first with 250 ml of hexane and then with 250 ml of a 1:1 mixture of hexane and methylene chloride. Since the samples were analyzed immediately by GLC, it was generally possible to adjust the water content daily in order that the DDT and DDD remain in the methylene chloride fraction but the trichlorobiphenyl isomers remain in the pure hexane fraction.

C. Instrumentation

Quantitative gas chromatographic analyses were conducted on an Aerograph 1745-20 gas chromatograph equipped with dual concentric-tube electron capture detectors (^3H, 250 mc) and illustrated in Figure 5. The columns were 2.0m x 1.8 mm (I.D.) glass coils packed with ov-101 (three percent) on 120/140 mesh Gas Chrom Q. The carrier gas (purified N_2) was maintained at 20 ml per minute and the injector, column and detector temperatures were 240° C, 180° C and 220° C, respectively. The chromatograms were recorded on a Varian Model A-25 dual pen recorder.

H. Quantitative Analysis

Previous work (Veith, 1971) has shown that the fish from Lake Michigan contain mixtures of PCBs which closely resemble Aroclor 1254 produced by Monsanto Company, although PCBs both heavier and lighter than those most abundant in Aroclor 1254 were also present. Figures 6a and 6b compare chromatograms of Aroclor 1254 and a typical Lake Michigan fish extract, respectively. The fish extract contains predominantly those PCBs which elute at 70, 84, a doublet near 100, 125, 145 and 176 (relative to pp'DDE). In addition, the chromatogram shows several of the lighter PCBs and the 203, 232 and 280 PCBs (relative to DDE).

Because the majority of the fish from Lake Michigan contain apparent Aroclor 1254 primarily and a large number of samples were to be analyzed

Figure 6. Comparison of PCB Mixtures in Fish and Commercial Mixtures (Standard)

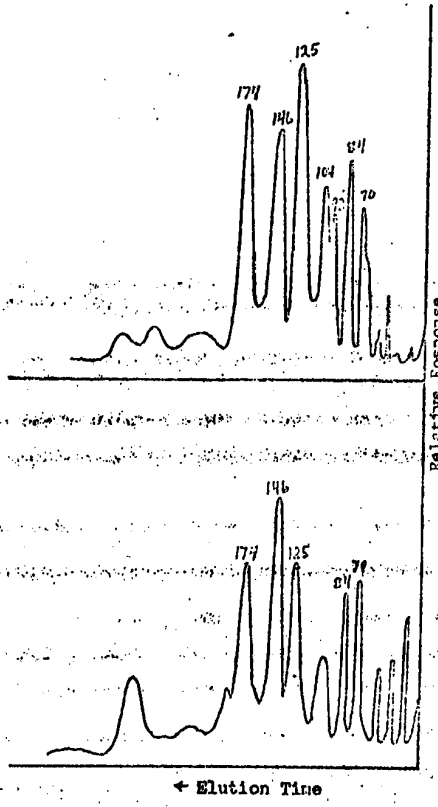


Figure 6a. Chromatogram of Aroclor 1254. Peak Number Relative to p,p'-DDE = 100.

Figure 6b. SA Chromatogram of Lake Michigan Fish.

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in this study, all of the fish were analyzed for Aroclor 1254 only. Thus, in the absence of evidence of other major, unknown contaminants in the PCB (hexane) fraction from the silicic acid separation, the data is likely to be conservative; and those fish from nearshore regions which have some Aroclor 1242 and/or 1246 present may have more PCBs in the tissue than is reported by this study.

As stated previously, pp'DDE cannot be consistently removed from the PCBs and was analyzed separately. The interference of pp'DDE to the quantitation of the PCBs was overcome by excluding the doublet at 98 and 104 from the calculations. The heights of peaks at 70, 84, 125, 146 and 174 were summed to give a number which, when compared to a standard curve prepared similarly, produced the mass estimation. With this method, the amount of pp'DDE in the sample could vary considerably without effecting the PCB analysis. Figure 7 illustrates a standard curve prepared from the peak height data.

I. Evaluation of Analytical Methods

The methods used throughout this study are well proven (with the possible exception of work on the silicic acid column). In general, the methods will account for greater than 85 percent of the residues in the tissue and exhibit less than 10 percent variability. Thus, when analyzing a sample from the environment where the sample history is largely unknown, there may be more significant error in interpreting chromatograms than in the manipulation of the extract.

The extraction of hydrophobic chlorinated hydrocarbons from tissue using ethyl ether and hexane is quantitative, even under mild conditions. For example, Stalling (1971) found that 97 ± 3 percent of the chlorinated pesticides added to fish tissue was extracted by rinsing the tissue with 200 ml of cold solvent. The exhaustive extraction with Soxhlet extractors as used in this study is essentially 100 percent. Previous work by the author (Veith, 1970) has shown that the recovery of PCBs for extraction and clean-up was 87 ± 3 percent. Thus, approximately 10 percent of the residues are lost on the clean-up columns or in the transferring of samples between vessels. Both of these losses can be minimized by rinsing with sufficient amounts of solvents.

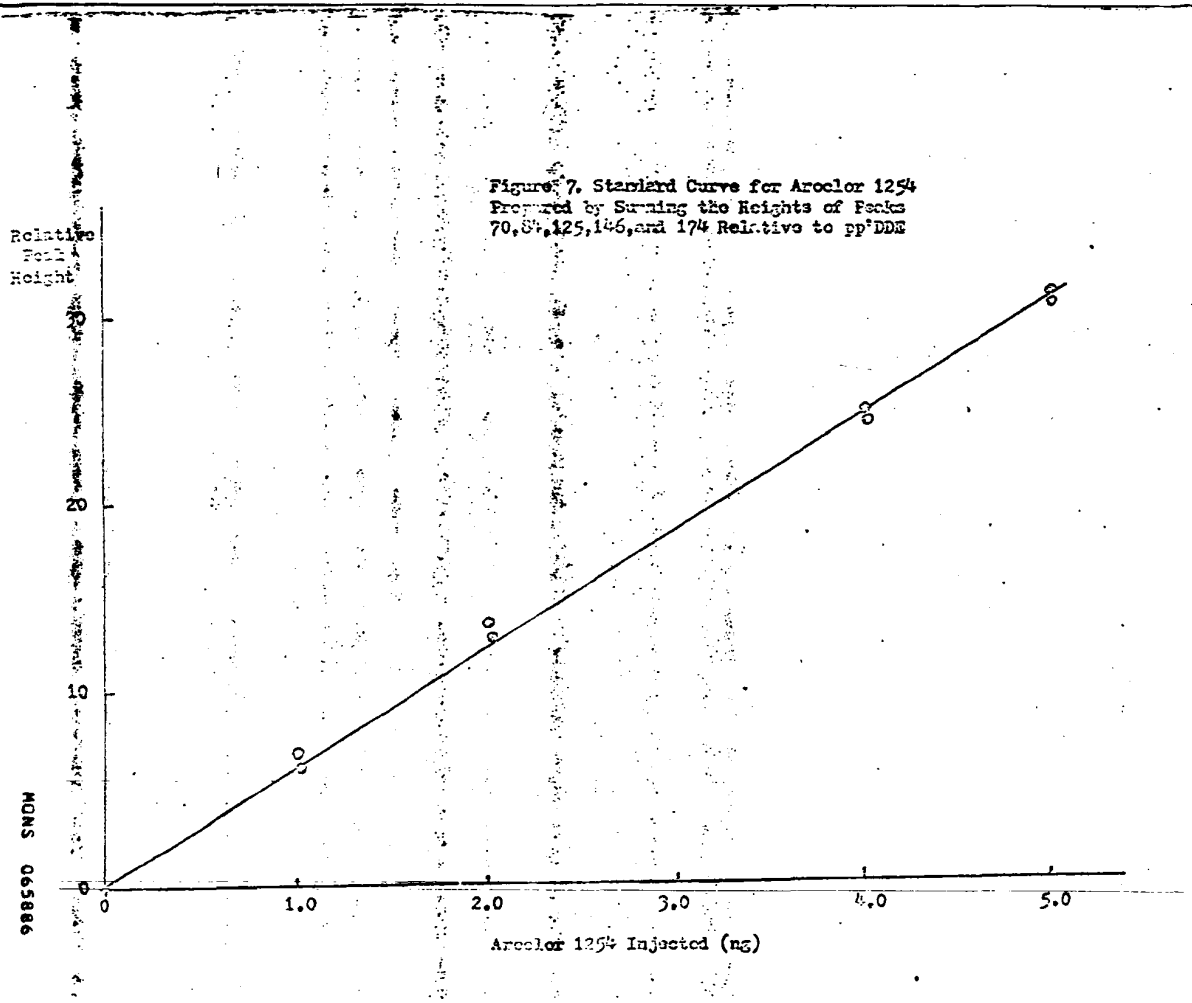

Figure 7. Standard Curve for Aroclor 1254 Prepared by Summing the Heights of Peaks 70,84,125,146,and 174 Relative to pp'DDE

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The analysis of PCBs in spiked tissues of six fish from northern Wisconsin (contain negligible quantities of PCBs) indicated that the present method permitted recovery of 85.1 $\pm$ 4.3 percent. The recovery of DDT was likely the same as PCBs while that of DDE was near 90 percent.

More important than what can be recovered under spiking conditions is the reproducibility with which a sample can be prepared, cleaned up and analyzed. Of particular concern in this study is the sampling of a large fish which, because of the large quantity of tissue to be homogenized, may give rise to considerable variability. Table 1 presents the results of multiple analyses of selected fish during this study. The data indicate that the relative standard deviation for the PCB analyses ranged from five percent in the smaller fish to 14 percent in the large coho salmon. It is likely that the decrease in precision in the coho is due to the difficulty of homogenizing the larger fish in addition to the inherent variability of interpreting the chromatograms of the hexane fractions from the silicic acid columns. The analyses with the poorest precision was that of the DDT analyses where the relative standard deviation ranged from eight percent to 23 percent and appeared to average approximately 14 percent. It is likely that this reduced precision results from losses during silicic acid chromatography which is necessary to quantitate the DDD and DDT isomers. The precision of the DDE analyses were lower than that of DDT which would be anticipated because of the fewer manipulations of the extracts. The relative standard deviation ranged from seven percent to 18 percent, but the average deviation was approximately 10 percent. The fat analyses, due to the relatively simple procedure, were the most precise and exhibited relative standard deviations ranging from five to seven percent.

To further evaluate the quantitative analysis of PCBs, replicate samples were sent to Analytical Bio Chemistry Laboratories, Inc. in Columbia, Missouri, for analysis. Table 2 presents the results of this collaborative study. In general, the concentrations of PCBs in the fish as determined by the two laboratories were in close agreement, although several of the concentrations determined by ABC Labs were a factor of two lower than that determined by this study. Of particular interest, however, is the fact that the analyses of total PCBs (ABC Labs) did not

Table 1. Precision of Chlorinated Hydrocarbon Determinations for PCBs, DDE, DDT and Fat in Selected Lake Michigan Fish.

Species	Replicates	Aroclor 1254 (µg/gm)	p,p'-DDE (µg/gm)	p,p'-DDT (µg/gm)	Fat (percent)
Coho Salmon (25 inches)	6	15.2 (2.2)[a]	7.5 (0.6)	3.2 (0.6)	4.2 (0.2)
Coho Salmon (27 inches)	6	13.1 (1.3)	5.5 (0.4)	1.8 (0.4)	10.0 (0.6)
Whitefish (13 inches)	6	4.1 (0.2)	0.35 (0.04)	0.56 (0.04)	16.2 (0.9)
Chub (10 inches)	6	5.7 (0.4)	3.4 (0.3)	2.2 (0.3)	18.2 (1.3)
Alewife (8 inches, composite)	6	4.0 (0.2)	1.1 (0.2)	1.0 (0.2)	5.7 (0.3)

[a] standard deviation in parentheses

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Table 2. Collaborative Determination of PCBs in Lake Michigan Fish

Species	This Study Aroclor 1254 (ng/gm)	ABC Labs.[a] Total PCBs (ng/gm)
Chub	3.7	3.9
Chub	6.1	1.6
Chub	5.7(6)	2.9
Chinook Salmon	11.5	11.3
Coho Salmon	12.3	6.5
Coho Salmon	11.8	10.2
Lake Trout	7.0	7.8
Perch	5.2	5.0

[a] Analytical Bio Chemistry Laboratories, Inc. Columbia, Missouri

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result in concentrations significantly greater than that determined in the analysis of Aroclor 1254 alone. This observation will be discussed further in the next Section V of the report.

J. Confirmation of the PCBs

In addition to preliminary analysis of the extracts with a Varian Mat CH-5 mass spectrometer, the presence of PCBs in selected samples from each sampling area were confirmed by the perchlorination of the PCBs to decachlorobiphenyl and the subsequent analysis of the product by GLC (Borg et al., 1972). Briefly, the aliquots of the hexane fraction of the silicic acid columns were evaporated to dryness in a 5 ml vial fitted with a Teflon-lined screw cap. Antimony pentachloride (0.2 ml) was added to the residue, and the vial was sealed and held at 180° C for six hours. Approximately 1 ml of 6N HCl was added to the products to destroy the $SbCl_5$, and the solution was extracted with five 1 ml portions of hexane. The hexane was passed through a disposable pipet containing anhydrous Na_2SO_4 to remove traces of the aqueous solution. The sample was collected in a graduated centrifuge tube and was diluted to the proper volume for GLC analysis. The GLC analyses were conducted on a Micro-Tec MT-220 gas chromatograph equipped with a ^{63}Ni electron capture detector. The column was 1/4 in. x 3 ft. and was packed with three percent Dexsil 300 on Gas Chrom Q. The column, injector and detector were held at 225° C, 250° C and 285° C, respectively.

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SECTION V

QUALITATIVE ANALYSIS OF LAKE MICHIGAN FISH

A substantial effort has been made in this study to examine the extracts of Lake Michigan fish on a qualitative basis. The purpose of this effort is to confirm the presence of the PCBs and DDT (and metabolites) and to determine whether significant quantities of unrelated materials are present and interferring with the quantitative analyses. The presence of PCBs in the extracts were confirmed by perchlorinating the extracts and subsequently analyzing the decachlorobiphenyl formed by GC/MS analyses of selected extracts.

A. Perchlorination

Perchlorination is a particularly useful technique because it gives both qualitative and quantitative information concerning the extract. A group of fish extracts comprising approximately five percent of the total number of samples and representing all regions of Lake Michigan were perchlorinated according to the procedure in Section IV. Without exception, the perchlorination of the extracts produced decachlorobiphenyl, and the quantity of PCBs indicated by the decachlorobiphenyl formed (after correcting to 54 percent chlorine) was generally within 25 percent of that found by the direct analysis of the extract by GLC. Figure 8 illustrates a series of chromatograms of the perchlorination products of the extracts. The large peak eluting at approximately ten minutes is the decachlorobiphenyl and the unreacted PCBs (if present) elute as a small peak on the tail of the solvent.

Although it is often difficult to determine the amount of the various PCB mixtures present in the extract from the amount of the decachlorobiphenyl formed during perchlorinating, good agreement is expected between the estimates from GLC and perchlorination when the fish extract contains predominantly one PCB mixture. Figure 9 presents data obtained from the perchlorination corrected to 54 percent chlorine and plotted against that

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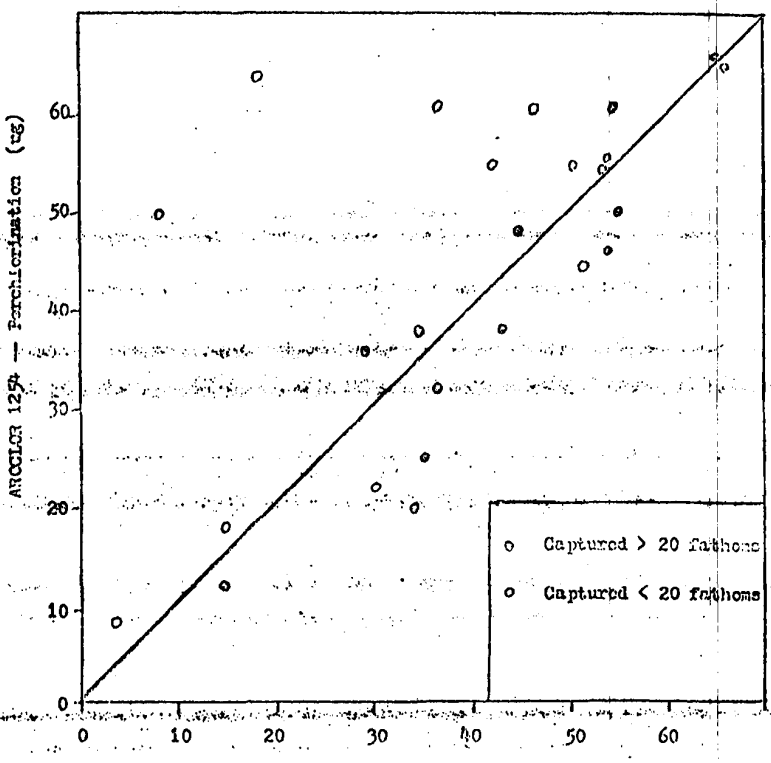
Figure 8. GLC Analyses of $C_{12}Cl_{10}$ from the Perchlorination of Lake Michigan Fish Extracts

Figure 9. Comparison of PCB Analysis via Direct GLC and Perchlorination-GLC



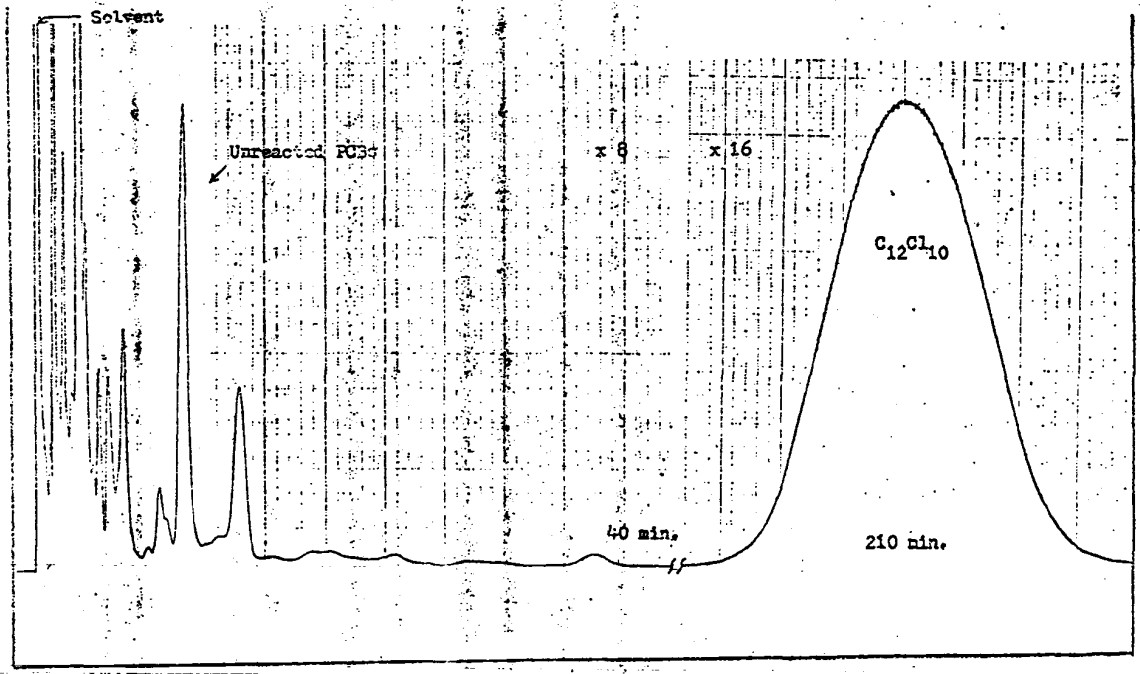
MONS 065893

obtained from the gas chromatograph prior to perchlorination. The data are expressed as total micrograms in the aliquots of the sample extracts. Figure 9 indicates that much of the data from the two methods agree well but that a number of the perchlorination estimates differ widely from the GC analysis.

These data were examined more closely to determine the cause of the discrepancy. For the majority of points in Figure 9 where the PCBs determined by perchlorination was much lower than that by GLC, it was generally found that the perchlorination products contain small amounts of unreacted PCBs as illustrated in Figure 10. Thus, it is likely that the data below the line in Figure 9 resulted from incomplete chlorination, presumably due to varying amounts of residual oil in the extract which consumed some of the $SbCl_5$. This difficulty could be overcome by increasing the quantity of $SbCl_5$ and by perchlorinating replicates.

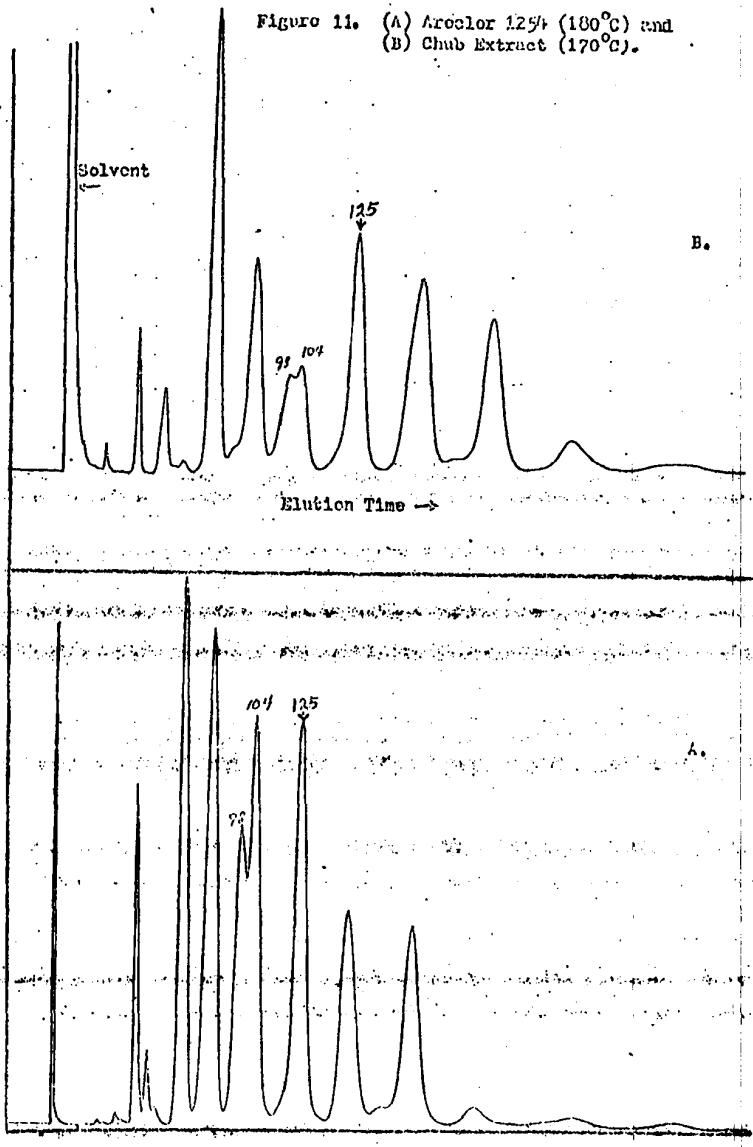
The points above the line represent fish which generally contained appreciable quantities of PCBs other than Aroclor 1254. For example, Figures 11a and 11b compare chromatograms of Aroclor 1254 and a chub captured from 50 fathoms of water off Saugatuck, Michigan. It can be seen that the fish extract resembles Aroclor 1254 closely. The results of the perchlorination indicated that 40 µg PCBs were present in the extract whereas the direct analysis indicated 45 µg (as Aroclor 1254). However, the data from the smelt caught in nearshore waters off Door County, Wisconsin, contained a substantial amount of the early-eluting PCBs as shown in Figure 12. Accordingly, the GLC estimate of PCBs was lower than that of the perchlorination method as evidenced by the two points in the upper left corner of Figure 9. It must be pointed out, however, that the apparent error in the analysis of the smelt is not as great as indicated in Figure 9 if the decachlorobiphenyl formed is expressed as Aroclor 1221 (the early peaks) rather than as Aroclor 1254. For example, the smelt contained some apparent Aroclor 1221 and 19 µg Aroclor 1254 but produced approximately 84 µg $C_{12}Cl_{10}$ (64 µg as Aroclor 1254). If the 45 µg of $C_{12}Cl_{10}$ (as Aroclor 1254) not accounted for by the GLC determination is expressed as Aroclor 1221, the GLC analysis was low by 17 µg (approximately 1.7 µg/gm on a whole fish basis). Thus, the perchlorination of the extracts has confirmed without exception the

Figure 10. Chromatogram of Products from an Incomplete Perchlorination of Fish Extracts on a 6 ft. Column at 180° C



MONS 065895

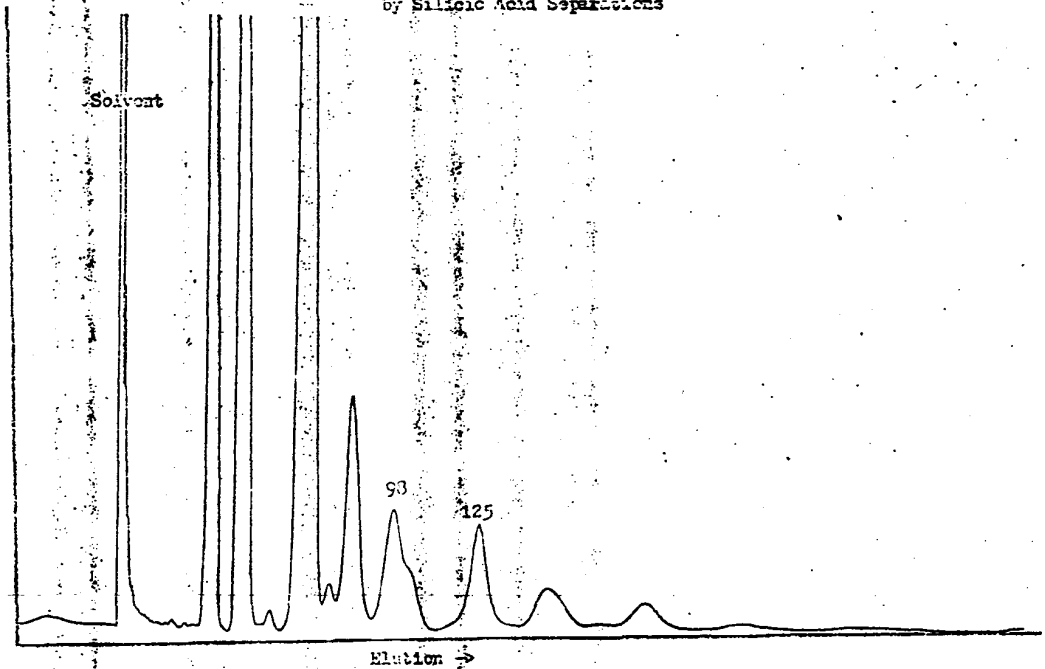
Figure 11. (A) Aroclor 1254 (180°C) and
(B) Chub Extract (170°C).



MONS 065896

MONS 065897

Figure 12. Chromatogram of Smelt (Door County) Showing Early-Eluting PCBs. Note: Some Trichlorobiphenyls are Removed by Silicic Acid Separations



presence of PCBs in all samples examined and substantiated the estimates of total PCBs for the fish captured in deep water. Those fish taken from the near-shore environment are more likely to have the lighter PCBs present due to the runoff from the watershed (Veith; 1970, 1971). Therefore, the data presented in this report may be considered conservative estimates of the total PCBs present.

B. Mass Spectrometry

To further examine the extracts on a qualitative basis, composites of five extracts of trout and salmon from Green Island, Manitowoc, Milwaukee, Michigan City, Saugatuck, Ludington, and Grand Traverse Bay were prepared, and the composites were examined by GLC/mass spectrometry at the National Water Quality Laboratory in Duluth.

Figure 13 presents a chromatogram of the fish extract from Michigan City, Indiana. After each sample was introduced into the gas chromatograph, the solvent was vented for 45 seconds, and the mass spectrometer was set to the repetitive span mode. The data system acquired 50 to 600 a.m.u. spectra approximately every seven seconds, providing 300 to 500 spectra per sample. The mass-converted spectra were examined by several methods for PCBs, DDE and related materials. The first was using the data system to compile ion intensity data for a specific m/e to form a mass chromatogram. For example, in the search for PCBs, the typical mass chromatograms included those of m/e = 256, 290, 324, 358, 392 which represent molecular ions for the tri-, tetra-, penta-, hexa- and hepta-chlorobiphenyl, respectively. In addition, searches for the molecular ions from the ^{37}Cl isotopes such as m/e = 325, 360, etc. were plotted.

Figure 14 compares mass chromatograms for m/e 292, 326 and 360 for the sample from Michigan City. The data show the composition of PCBs in the mixture in that the early peaks contain tetrachlorobiphenyl, and the 5-4 and 6Cl peaks elute later in the mixture. All of the trout and salmon composite samples gave similar results, thus substantiating that the PCBs present were those found predominantly in Aroclor 1254.

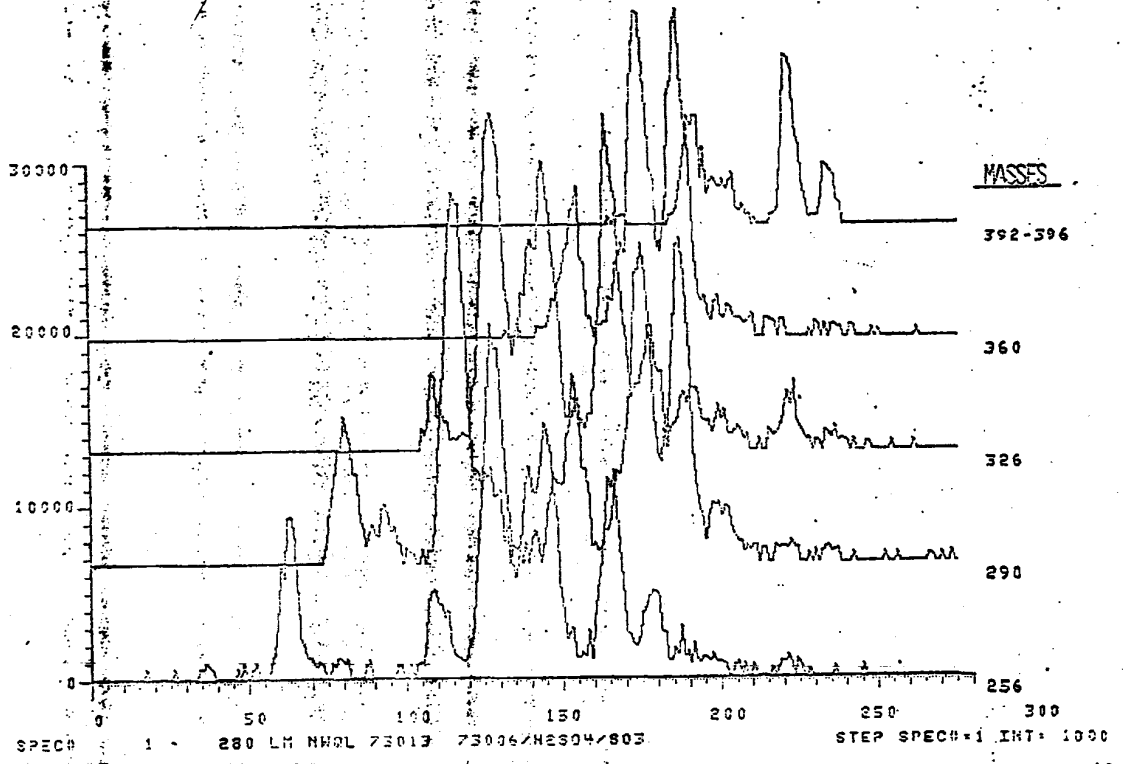
Mass chromatograms for molecular ions of other pesticides and related materials produced no evidence for compounds which were present in

MONS 065898

Figure 13. Chromatogram of Composite Sample of Lake Trout From Michigan City, Indiana, on GC/MS System

MDNS 065899

Figure 14a. Mass Chromatogram of PCB Components of Michigan City Trout Extract



MONS 065900

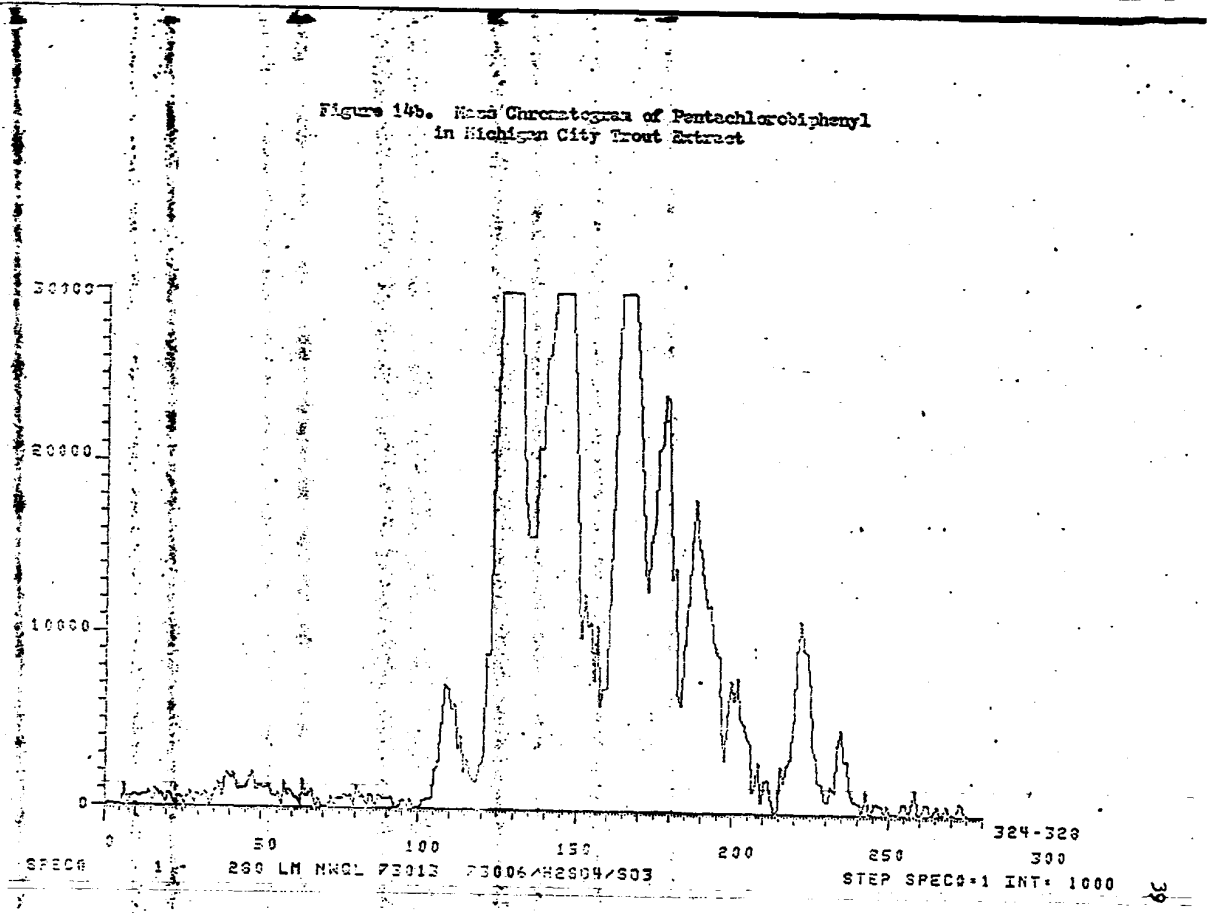


Figure 14b. Mass Chromatogram of Pentachlorobiphenyl in Michigan City Trout Extract

MONS 065901

quantities sufficiently great to cause errors in the quantitative analyses.

Locating the major components of the PCBs in the mixture also allowed for the selection of spectra which were obtained when the greatest quantity of material was eluting from the gas chromatograph. These spectra were plotted for numerous points throughout each run, and the spectra were analyzed to make certain the data arose from PCBs. A summary of the data is presented in Figures I through VI in Appendix B for the major regions of Lake Michigan. Figure Ia is a spectrum of an early-eluting peak which has a molecular ion at m/e = 256. This corresponds to a trichlorobiphenyl, and the characteristic isotope effect between m/e = 256 to 262 as well as the presence of an M - 35 peak at 221 indicates the presence of chlorine. Similarly, Figure Ib shows the presence of a M = 290 for a tetrachlorobiphenyl, and figures Ic and d show the presence of M = 392 indicating heptachlorobiphenyls. Figures II through VI further substantiate the presence of the PCBs common to Aroclor 1254 through Lake Michigan.

In addition to examining many of the spectra obtained in the GC/MS, the spectra were put in a format suitable for a library search in the computer facilities at Battel Memorial Institute in Columbus, Ohio. Tables 3 and 4 present the results of a typical library search in which the spectra of interest was found to best resemble spectra of the various components of the Aroclor mixtures. Table 3 shows that spectrum 150 in the analysis of trout from Milwaukee (LM-1) produced 24 "hits" and, although only five were called for, all five have similarity indexes between 0.48 and 0.52 (generally considered a close match), and all are pentachlorobiphenyls. Table 4 shows that spectrum 230 of the Milwaukee trout extract matched (similarity indexes of 0.24 to 0.53) the spectra of the pentachlorobiphenyls also.

Table 3. MS Library Search for
SCI - PCBs in the Milwaukee
Lake Trout Composite Sample

```
SAMPLE ID?
      150
PAPER TAPE?Y
FN= DWK:LM-1,150/LM;%
TT=LAKE MICH-1;%
134,8;145,8;146,16;149,43;162,7;171,7;184,80;186,22;193,6;72;%
194,4;205,7;219,22;220,22;254,100;256,100;258,22;289,22;291,38;77;%
324,52;326,87;328,60;330,21;34;%
END
OPTIONS? N
DATA FOR TOP OF GC PEAK?Y
 21 HITS
PRINT SIM. INDEX?Y
POLYCHLORINATED BIPHENYL (AROCLOR 1254-6) (SEWL) 324 C12-H5-CL5 BSR 01
66
FILE KEY= 10766
SI=0.5241

POLYCHLORINATED BIPHENYL (AROCLOR 1254-9) (SEWL) 324 C12-H5-CL5 BSR 01
69
FILE KEY= 10769
SI=0.5187

POLYCHLORINATED BIPHENYL (AROCLOR 1254-7) (SEWL) 324 C12-H5-CL5 BSR 01
67
FILE KEY= 10767
SI=0.5125

PCB (JA04C,53,251,1970,1254111,PK6) 324 C12-H5-CL5 BSR 0069
FILE KEY= 10669
SI=0.5099

POLYCHLORINATED BIPHENYL (AROCLOR 1254-8) (SEWL) 324 C12-H5-CL5 BSR 01
68
FILE KEY= 10768
SI=0.4785
```

Table 4. MS Library Search for 6 Cl - PCBs in the Milwaukee Lake Trout Composite Sample

```
SAMPLE ID?
      230
PAPER TAPE?Y
FN= DWK:LM-1,230/LM:%
TT= LAKE MICH-1:%
144,50;145,81;146,42;147,28;162,10;169,10;183,27;184,30;193,7;76:%
206,8;218,85;220,60;254,43;256,41;256,13;288,84;290,100;324,30;77:%
326,78;328,30;329,14;360,95;362,80;43:%
END
OPTIONS? N
DATA FOR TOP OF GC PEAK?Y
 10 HITS
PRINT SIM. INDEX?Y
POLYCHLORINATED BIPHENYL (AROCLOR 1254-15) (SEWL) 358 C12·H4·CL6 HSR O
172
FILE KEY= 10772
SI=0.5394

POLYCHLORINATED BIPHENYL (AROCLOR 1254-13) (SEWL) 324 C12·H5·CL5 HSR O
171
FILE KEY= 10771
SI=0.3698

POLYCHLORINATED BIPHENYL (AROCLOR 1254-17) (SEWL) 358 C12·H4·CL6 HSR O
173
FILE KEY= 10773
SI=0.2792

POLYCHLORINATED BIPHENYL (AROCLOR 1254-5) (SEWL) 324 C12·H5·CL5 HSR 01
65
FILE KEY= 10765
SI=0.2365

5,8-DITHIAINDENO(2,1-C)FLUORENE 290 C16·H10·S2 APM 0139
FILE KEY=  6143
SI=0.0726
```

The use of computer library searches, however, should be used only to assist the analyst and cannot be regarded as a strict confirmation of a particular chemical. Not only may the computer library searches produce misleading information, but also useful data may be lost. For example, Table 5 represents searches for spectra 167 and 208 in the sample from Manitoba (the search for spectrum 147 was aborted due to a lack of a base peak.) Neither of these searches produced useful results due to the fact that the spectra are abbreviated to eliminate interfering peaks from hydrocarbons. However, inspection of the data in Table 5 or in Figure 15 reveals the presence of 5-Cl and 6-Cl PCBs by respective molecular ions.

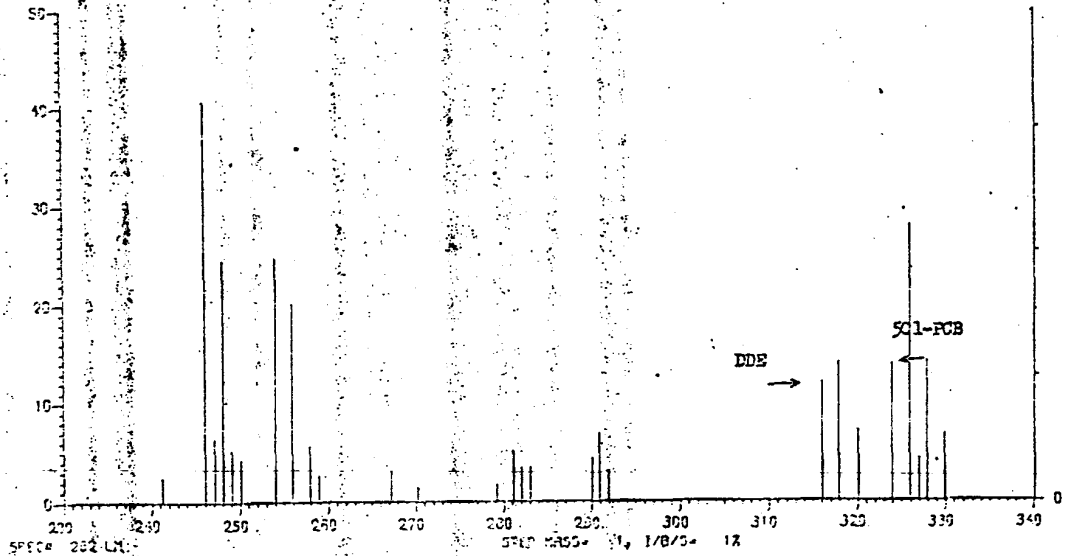
Moreover, computer library searches are of limited value in detecting minor components evident in mixed spectra obtained when several compounds elute simultaneously from the GLC. Figure 15 is a spectrum of a pentachlorobiphenyl (M^+ = 324) in which the molecular ion for DDE at m/e = 316 is observed. This is expected since the PCBs which elute with DDE contain five chlorines and are commonly found as evidenced by Figures IIIB and VIB. As discussed previously, however, the presence of DDE in some of the pentachlorobiphenyl components did not introduce an error in the quantitative analysis because the doublet (5-Cl PCBs) eluting at 98 and 104 relative to DDE were omitted from the calculations.

Table 5 MS Library Search for Spectra 167 and 208 of the Manitowoc Lake Trout Composite Sample.

```
SAMPLE ID?
      167
PAPER TAPE?Y
FN= DWK:LM-4,167/LM:%
TT= LAKE MICH-4:%
148,3:149,8:163,4:185,16:207,4:218,4:219,5:254,19:256,18:71:%
258,7:289,4:291,8:324,13:326,22:328,13:330,4:55:%
END
OPTIONS? N
NO HITS
S, E, OR P?S
SAMPLE ID?

167
PAPER TAPE?Y
FN= DWK:LM-4,146/LM:%
TT= LAKE MICH-5:%
149,10:150,15:184,5:185,5:220,30:222,19:256,2:257,2:290,25:73:%
292,35:7:%
END
UNREC. INPT. CHAR- ABORT
S, E, OR P?S
SAMPLE ID?
      167
PAPER TAPE?Y
FN= DWK:LM-4,167/LM:%
TT= LAKE MICH-4:%
148,3:149,8:163,4:185,16:207,4:218,4:219,5:254,19:256,18:71:%
258,7:289,4:291,8:324,13:326,22:328,13:330,4:55:%
END
OPTIONS? N
NO HITS
S, E, OR P?S
SAMPLE ID?
      208
PAPER TAPE?Y
FN= DWK:LM-4,208/LM:%
TT= LAKE MICH-4:%
183,3:184,6:218,5:220,31:254,9:256,6:258,3:288,5:290,6:66:%
324,7:326,12:328,6:330,3:360,6:362,5:45:%
END
OPTIONS? N
NO HITS
```

Figure 15 Mass Spectrum 282 of the Manitowoc Lake Trout Sample Illustrating the Presence of Both DDE and a Pentachlorobiphenyl in the Peak



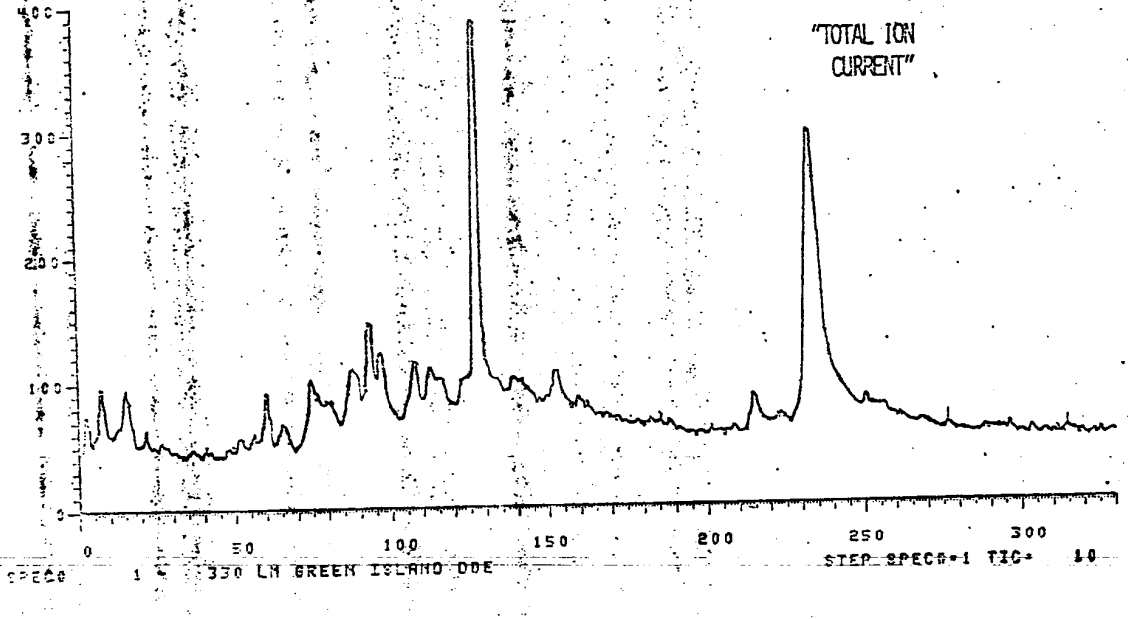
MCNS 065907

C. Other Confirmations

Several composite samples were prepared from the methylene chloride fractions of the silicic acid separation, and the samples were examined by GC/MS. Figure 16 shows the "total"-ion-current chromatograph for the extract of trout from Michigan City, Indiana. The detection of components of this mixture is enhanced by plotting the sum of ion intensities for each spectrum as illustrated in Figure 17. Many of the components appear to be materials with considerable hydrocarbon characteristics--presumably triglycerides. The contribution of these components to the mass chromatogram is removed by considering only the sum of ion intensities within the range of m/e 150 to 400 as plotted in Figure 18. All of the components which eluted prior to spectrum 115 are trichlorobiphenyls which are separated from the heavier PCBs on silicic acid and appear in the fraction with DDT. The retention volume of DDE, DDD, and DDT isomers in the temperature program used corresponds to the region between spectrum 120 and 160. The presence of these chlorinated hydrocarbons in the extract is seen in Figure 19 which are mass chromatograms of m/e 246 and 235. The large peak at spectrum 126 is DDE, op'DDD appears at 130, DDT appears at 152, and pp'DDD and op'DDT elute as a partially resolved doublet near spectrum 159.

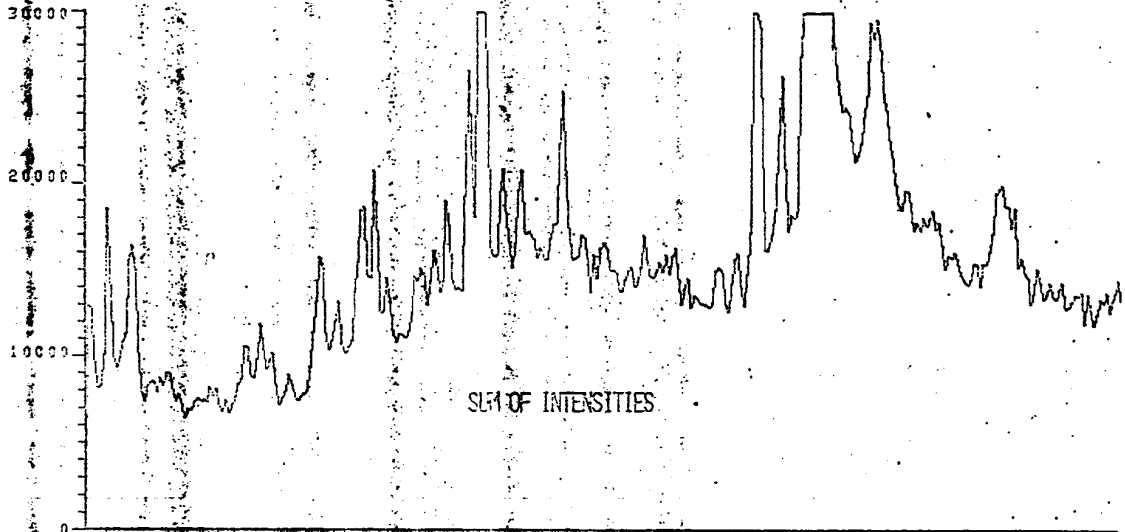
One of the major concerns in determining the quantity of DDD or DDT in the samples has been the possibility that the PCBs interfere with the analyses, giving high results. Although the routine checks of the silicic acid separation procedure indicated the DDT and DDD isomers were completely separated from the interfering PCBs, the composite of the methylene chloride fractions were also analyzed for molecular ions of the PCBs. In general, ions which arise from the 5, -6- and 7-Cl PCBs were low and insignificant. For example, Figures 20a and b are mass chromatograms which have been plotted as absolute intensities with no scale expansion. Figure 20c is the mass chromatogram for pentachlorobiphenyls which has been expanded tenfold. Even though the ion intensities cannot be compared in the strict sense to give relative masses of the two compounds in the mixture, the data indicates that PCB interference in the DDT analysis is less than 10 percent and likely insignificant after silicic acid separation in these composite samples.

Figure 16. Total Ion Current Chromatogram of the Polar Eluant Fraction (Silicic Acid) of a Green Bay Trout Extract



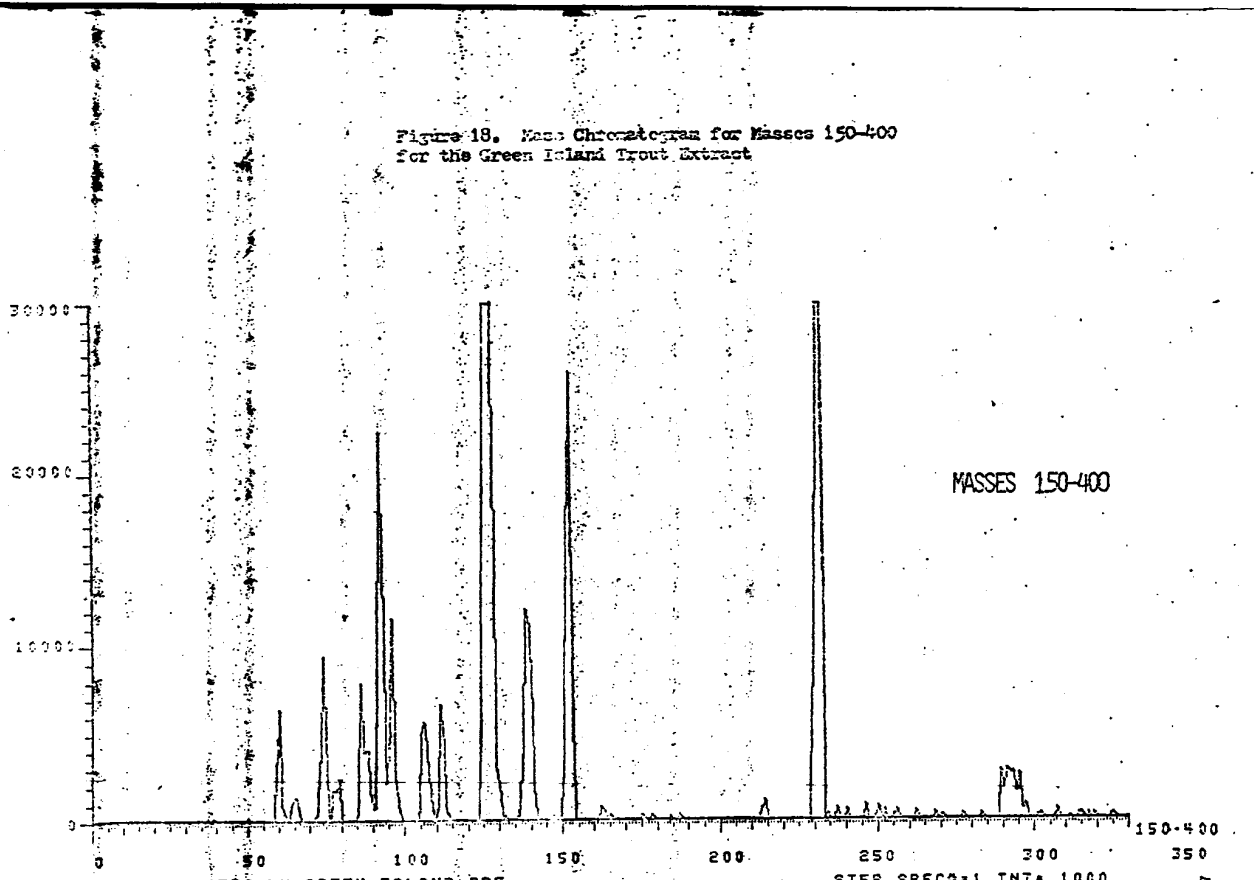
MONS 065909

Figure 17. Sum of Ion Intensity Mass Chromatogram for Green Bay Trout Extract



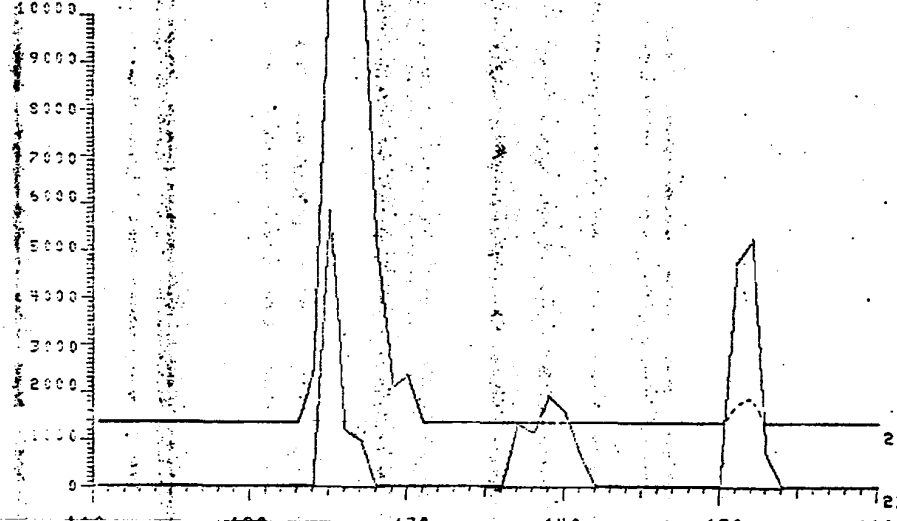
MONS 069910

Figure 18. Mass Chromatogram for Masses 150-400 for the Green Island Trout Extract



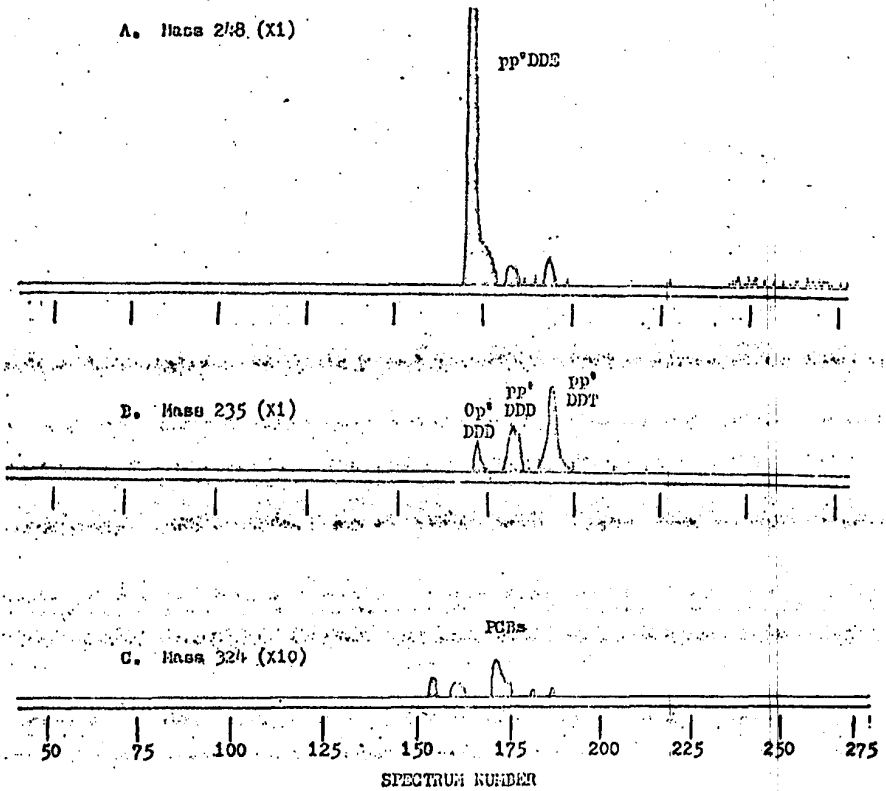
MONS 065911

Figure 19. Mass Chromatogram for Masses 246 and 235 for the Green Island Trout Extract



MONS 065912

Figure 20 Selected Mass Chromatograms of the GC/MS Analysis of the DDE Fraction



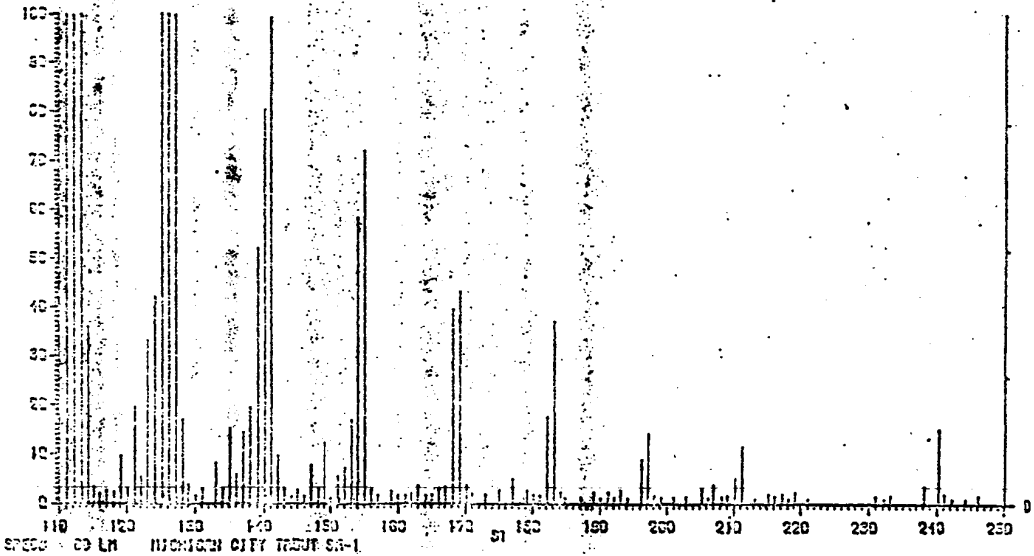
The major component eluting in spectrum 230 in Figure 18 has not been identified as yet. However, it contains no chlorine and appears to arise from the lipids. Figure 13 has indicated that a number of major components elute early in the chromatogram and that they have been identified as saturated, linear hydrocarbons. The predominant component eluting in spectrum 47 in Figure 13 has been identified as n-heptadecane with the substantiating data including mass spectra as in Figure 21, retention time, and bromination and related chemical reactivity studies. The presence of the C_{12}, C_{13}, and C_{17} hydrocarbons at comparatively high concentrations without the presence of C_{14}, C_{15}, and C_{16} hydrocarbons suggest that the hydrocarbons may be due to metabolic activities within the food chain rather than contamination of the waters by petroleum products. Considerable more research is needed to determine the source of these hydrocarbons.

The qualitative analysis also indicated the presence of several phthalate esters in the fish from Lake Michigan. In general, the di-n-butyl, a di hexyl, and a dioctyl (presumably di-2-ethylhexyl) phthalate were found, although some fish had lesser or undetectable quantities of the dihexylphthalate. The presence of these chemicals are readily detected by plotting the mass chromatogram for m/e 149, since m/e 149 is a predominant ion in the phthalate ester fragmentation. However, the low abundance of ions above 149 precludes explicit identification of the phthalate and GLC retention volume data were used to make the assignments presented here. The dihexyl-phthalate was not detected by electron capture GLC.

Also detected in some extracts was a dioctyl adipate. Figure 23a illustrates a m/e 147 mass chromatogram which is somewhat specific for the adipate esters. Although the adipate was found in the Green Bay trout extract and several others, no evidence was found for adipates in the trout from Michigan City and Saugatuck regions as evidenced by Figure 23b. A spectrum of the dioctyl-adipate from the Sheboygan trout extract is presented in Figure 24. The abundant m/e 147 ion is apparent; however, like the phthalates, the ion abundances in the parent ion region are low in electron impact spectra. The base peak at m/e 129 as well as the other major ions are often obscured by interference co-eluting from the column.

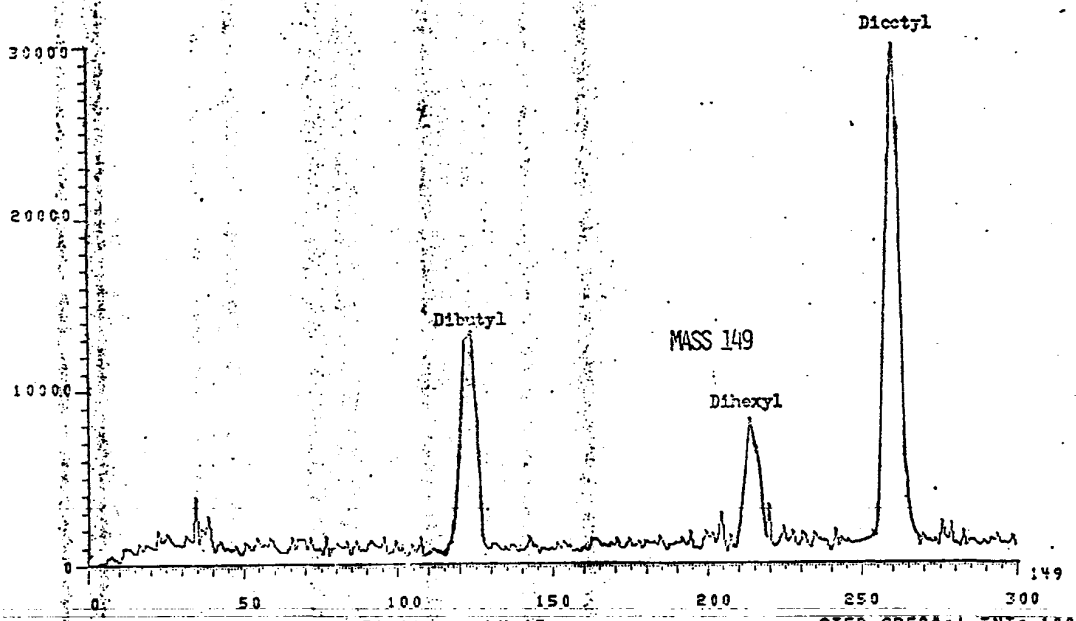
MONS 065914

Figure 21. Mass Spectrum of Heptadecane in Michigan City Trout Extract



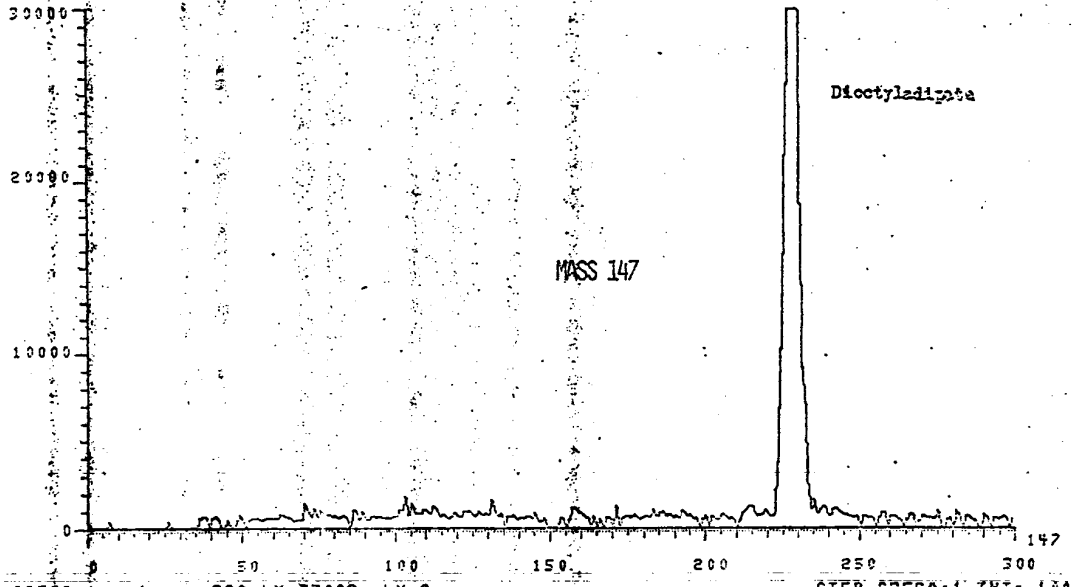
MONS 069515

Figure 22. Mass Chromatogram M/Z 149 of Grand Traverse Bay Trout Extract



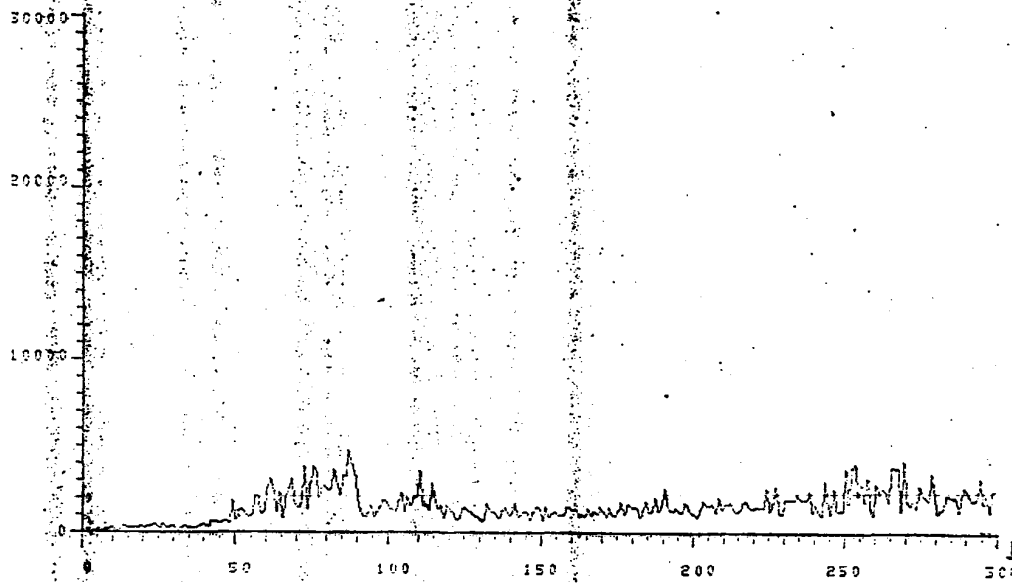
MONS 069516

Figure 23a. Mass Chromatogram M/E 147
for Adipates in Green Bay Trout



MONS SNOW 065917

Figure 23b. Mass Chromatogram M/Z 147
for Adipates in Michigan City Trout



MONS 069018

Figure 24. Mass Spectrum of Dioctyladipate Isolated from Trout Captured Near Sheboygan

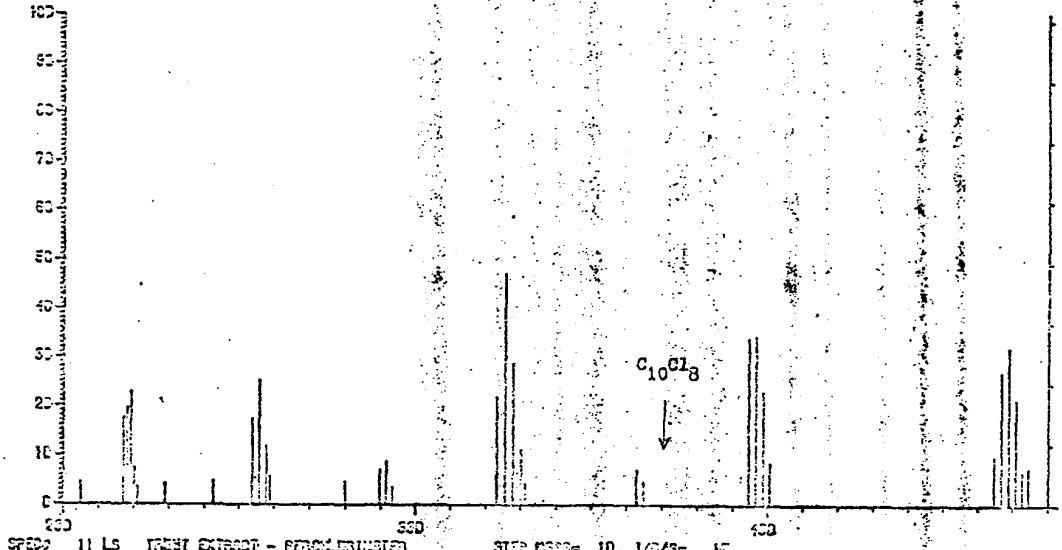
MONS 065919

It must be emphasized that the elution behavior for pthalate esters and related esters do not behave as the pesticides on column chromatography and "quantitation" of these compounds must be considered estimates only.

The search for other potentially toxic chemicals in Lake Michigan fish is inherently open-ended. No evidence of lindane, hexachlorobenzene, chlordane, or other chlorinated pesticides has been found. However, the difficulty of obtaining explicit confirmation for dieldrin which is likely and often reported at concentrations of 0.3 ug/gm in the larger fish as well as spiked samples indicates that the GC/MS techniques employed may have to be refined for confirmations of minor components which may be present below approximately 0.1 ug/gm.

Of particular interest is the search for the chlorinated napthhalenes which may interfere with the PCB determination, if present. In all of the extracts analyzed by GLC and GC/MS, there was no evidence of the chlorinated naphthalenes. To further examine the extracts, the extracts were perchlorinated, and the products were analyzed by direct probe mass spectrometry. Figure 25 presents a spectrum in which the ions arising from decachlorobiphenyl are readily apparent. However, there is no evidence of ions at m/e 400 which is the parent ion region for octachloronaphthalene which results from the perchlorination. Sensitivities studies with this technique leads to an estimated detection limit of approximately 0.01 ug/gm.

Figure 25. Direct-Probe MS Analysis of the Perchlorination Products of a Lake Michigan Trout Extract



MONS 065921

SECTION VI

RESULTS AND DISCUSSION

This section of the report presents data regarding the concentrations of PCBs and DDT (and metabolites) in the Lake Michigan fish collected in this study. Also presented are preliminary data regarding concentrations of two of the phthalate esters in the Lake Michigan fish.

A. Polychlorinated Biphenyl

Approximately 850 of the fish collected from Lake Michigan were analyzed for PCB mixtures resembling that of Aroclor 1254. A generalized summary of these results is presented in Table 6 in which the range and average concentrations of PCBs (as Aroclor 1254) is reported for 13 species of fish. The mean concentrations ranged from 2.7 µg/gm in smelt to 15 µg/gm in lake trout. The data show that the larger fish such as brown, lake and splake trout and chinook and coho salmon contained PCBs at concentrations two to three times the 5 µg/gm action level established by the FDA. The mean PCB concentrations in suckers, smelt and whitefish were considerably less than 5 µg/gm and the mean concentrations in the alewife, carp, chub and perch were approximately 5 µg/gm, ranging from 4.2 to 6.0 µg/gm. As is expected, the larger fish with greater percentage fat contain greater concentrations of PCBs.

Table 6 also indicates that the mean concentration of DDT (total DDT defined as the sum of p,p'DDT, o,p'DDT, p,p'TDE, and p,p'DDE) in Lake Michigan fish ranged from 1.2 ug/gm in carp and smelt to 7.1 ug/gm in lake trout. As was found in the analyses of PCBs in these fish, the fish containing higher lipid concentrations contained greater concentrations of DDT.

Table 7 summarizes more detailed data collected for the 13 species of fish captured in Lake Michigan. The data show that the ratio of PCB/TotalDDT (a ratio often calculated and cited but not often explicable) ranged from 1.3 in red suckers which were caught primarily in the northern waters to 7.6 in carp. Of particular interest are the facts that the ratio of PCB/DDT in the majority of the fish was between 1.7

Table 6. Summary of PCB and Total DDT Concentrations in 1971 Lake Michigan Fish

Species	Numbers of Fish Analyzed	PCB's Mean	PCB's S.D.	Total Mean	Total S.D.
Alewife	85	4.6	2.1	2.2	1.1
Brown Trout	17	7.3	2.8	4.2	1.6
Carp	42	4.2	3.6	1.2	0.9
Chub	287	6.0	2.2	3.8	2.0
Chinook Salmon	21	11.4	4.0	6.8	2.5
Coho Salmon	56	11.5	5.7	6.3	2.8
Lake Trout	134	15.5	3.2	7.1	3.7
Perch	44	5.8	3.5	1.6	1.1
Rainbow Trout	11	9.3	4.1	4.2	1.8
Red Sucker	16	3.0	0.7	2.6	0.7
Smelt	38	2.7	1.3	1.2	0.6
White Sucker	51	3.9	3.6	1.6	1.2
Whitefish	43	3.0	1.9	1.4	0.6

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TABLE 7

GROSS MEAN CONCENTRATIONS OF MAJOR CHLORINATED HYDROCARBONS FOR LAKE MICHIGAN FISH CAUGHT IN FALL, 1971.

SPECIES: Alewife

VARIABLE	NUMBER PRESENT	MEAN	STANDARD DEVIATION
FISH WEIGHT (KG)	1:1	.100	.735
PERCENT FAT	65	6.5	3.9
PP'DDE	65	1.7	.4
PCB	74	9.6	4.1
OP'DDT	53	.08	.04
PP'DDT	53	.6	.3
PP'DDD	53	.40	.18
TOTAL DDT	65	2.2	1.1
PCB/TOTAL DDT	74	3.9	1.9
PP'DDE/PP'DDT	53	3.6	2.5
OP'DDT/PP'DDT	53	.2	.1
PP'DDE/TOTAL DDT	65	.8	.2
OP'DDT/TOTAL DDT	53	.0	.0
PP'DDT/TOTAL DDT	53	.2	.1
PP'DDD/TOTAL DDT	53	.1	.0

GROSS MEAN CONCENTRATIONS OF MAJOR CHLORINATED HYDROCARBONS FOR LAKE MICHIGAN FISH CAUGHT IN FALL, 1971.

SPECIES: Brown Trout

VARIABLE	NUMBER PRESENT	MEAN	STANDARD DEVIATION
FISH WEIGHT (KG)	13	3.476	1.06
PERCENT FAT	17	15.5	9.1
PP'DDE	17	2.7	1.0
PCB	17	2.1	2.8
OP'DDT	17	.16	.05
PP'DDT	17	1.1	.3
PP'DDD	17	.49	.11
TOTAL DDT	18	4.2	1.6
PCB/TOTAL DDT	17	1.8	.9
PP'DDE/PP'DDT	16	2.6	1.0
OP'DDT/PP'DDT	17	.1	.0
PP'DDE/TOTAL DDT	17	.6	.2
OP'DDT/TOTAL DDT	17	.0	.0
PP'DDT/TOTAL DDT	17	.3	.1
PP'DDD/TOTAL DDT	17	.1	.0

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TABLE 7

GROSS MEAN CONCENTRATIONS OF MAJOR CHLORINATED HYDROCARBONS FOR LAKE-MICHIGAN FISH CAUGHT IN FALL,1971.

SPECIES: CARP

VARIABLE	NUMBER PRESENT	MEAN	STANDARD DEVIATION
FISH WEIGHT (KG)	51	2.163	1.998
PERCENT FAT	51	10.0	7.0
PP'DDE	49	.7	.9
PCB	42	9.2	3.6
OP'DDT	19	.05	.04
PP'DDT	12	.2	.2
PP'DDD	30	.20	.27
TOTAL DDT	49	.9	1.2
PCB/TOTAL DDT	40	7.4	4.7
PP'DDE/PP'DDT	12	6.5	9.0
OP'DDT/PP'DDT	12	.1	.1
PP'DDE/TOTAL DDT	49	.6	.2
OP'DDT/TOTAL DDT	19	.0	.0
PP'DDT/TOTAL DDT	12	.1	.1
PP'DDD/TOTAL DDT	30	.3	.1

GROSS MEAN CONCENTRATIONS OF MAJOR CHLORINATED HYDROCARBONS FOR LAKE-MICHIGAN FISH CAUGHT IN FALL,1971.

SPECIES: Chinook Salmon

VARIABLE	NUMBER PRESENT	MEAN	STANDARD DEVIATION
FISH WEIGHT (KG)	22	3.137	.826
PERCENT FAT	21	5.9	3.9
PP'DDE	22	5.2	1.5
PCB	21	11.9	9.0
OP'DDT	18	.21	.11
PP'DDT	18	1.3	.9
PP'DDD	18	.52	.35
TOTAL DDT	22	6.8	2.5
PCB/TOTAL DDT	21	1.7	.6
PP'DDE/PP'DDT	18	5.3	3.7
OP'DDT/PP'DDT	18	.2	.0
PP'DDE/TOTAL DDT	22	.8	.1
OP'DDT/TOTAL DDT	18	.0	.0
PP'DDT/TOTAL DDT	18	.2	.1
PP'DDD/TOTAL DDT	18	.1	.0

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TABLE 7

GROSS MEAN CONCENTRATIONS OF MAJOR CHLORINATED HYDROCARBONS FOR LAKE MICHIGAN FISH CAUGHT IN FALL, 1971.

SPECIES: CHUB

VARIABLE	NUMBER PRESENT	MEAN	STANDARD DEVIATION
FISH WEIGHT (KG)	175	.299	.276
PERCENT FAT	249	20.0	5.9
PP'DDE	277	2.5	1.1
PCB	231	6.0	2.2
OP'DDT	155	.22	.09
PP'DDT	154	1.6	.9
PP'DDD	154	.43	.20
TOTAL DDT	287	3.6	2.0
PCB/TOTAL DDT	223	2.2	2.2
PP'DDE/PP'DDT	148	1.9	3.3
OP'DDT/PP'DDT	155	.2	1.3
PP'DDE/TOTAL DDT	277	.7	.3
OP'DDT/TOTAL DDT	155	.0	.0
PP'DDT/TOTAL DDT	154	.4	.1
PP'DDD/TOTAL DDT	154	.1	.0

GROSS MEAN CONCENTRATIONS OF MAJOR CHLORINATED HYDROCARBONS FOR LAKE MICHIGAN FISH CAUGHT IN FALL, 1971.

SPECIES: COHO Salmon

VARIABLE	NUMBER PRESENT	MEAN	STANDARD DEVIATION
FISH WEIGHT (KG)	50	2.721	1.235
PERCENT FAT	62	6.5	2.1
PP'DDE	62	4.8	2.3
PCB	54	11.5	5.7
OP'DDT	51	.20	.08
PP'DDT	51	1.3	.7
PP'DDD	51	.44	.16
TOTAL DDT	63	6.3	2.8
PCB/TOTAL DDT	56	2.1	1.3
PP'DDE/PP'DDT	50	4.1	2.1
OP'DDT/PP'DDT	51	.2	.1
PP'DDE/TOTAL DDT	62	.7	.2
OP'DDT/TOTAL DDT	51	.0	.0
PP'DDT/TOTAL DDT	51	.2	.1
PP'DDD/TOTAL DDT	51	.1	.0

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TABLE 7

GROSS MEAN CONCENTRATIONS OF MAJOR CHLORINATED HYDROCARBONS FOR LAKE MICHIGAN FISH CAUGHT IN FALL, 1971.

SPECIES: Fourhorn Sculpin

VARIABLE	NUMBER PRESENT	MEAN	STANDARD DEVIATION
FISH WEIGHT (KG)	13	.020	.007
PERCENT FAT	13	5.9	.9
PP'DDE	13	1.9	.4
PCB	12	2.7	1.1
OP'DDT	9	.06	.05
PP'DDT	9	.2	1.0
PP'DDD	9	.15	.09
TOTAL DDT	13	2.9	1.7
PCB/TOTAL DDT	12	1.4	.9
PP'DDE/PP'DDT	9	1.5	.4
OP'DDT/PP'DDT	9	.1	.0
PP'DDE/TOTAL DDT	13	.7	.2
OP'DDT/TOTAL DDT	9	.0	.0
PP'DDT/TOTAL DDT	9	.4	.1
PP'DDD/TOTAL DDT	9	.1	.0

GROSS MEAN CONCENTRATIONS OF MAJOR CHLORINATED HYDROCARBONS FOR LAKE MICHIGAN FISH CAUGHT IN FALL, 1971.

SPECIES: Lake Trout

VARIABLE	NUMBER PRESENT	MEAN	STANDARD DEVIATION
FISH WEIGHT (KG)	56	1.617	1.336
PERCENT FAT	153	14.4	4.3
PP'DDE	142	4.0	2.8
PCB	134	15.5	12.3
OP'DDT	122	.26	.19
PP'DDT	122	2.9	1.0
PP'DDD	122	.63	.26
TOTAL DDT	149	7.1	3.7
PCB/TOTAL DDT	133	2.5	5.9
PP'DDE/PP'DDT	115	2.1	3.9
OP'DDT/PP'DDT	122	.2	.1
PP'DDE/TOTAL DDT	142	.7	.2
OP'DDT/TOTAL DDT	122	.0	.0
PP'DDT/TOTAL DDT	122	.3	.1
PP'DDD/TOTAL DDT	122	.1	.0

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TABLE 7

GROSS MEAN CONCENTRATIONS OF MAJOR CHLORINATED HYDROCARBONS FOR LAKE MICHIGAN FISH CAUGHT IN FALL, 1971.

SPECIES: Perch

VARIABLE	NUMBER PRESENT	MEAN	STANDARD DEVIATION
FISH WEIGHT (KG)	57	.196	.046
PERCENT FAT	56	6.1	1.7
PP'DDE	49	1.0	.4
PCB	49	5.6	3.5
OP'DDT	27	.08	.04
PP'DDT	27	.7	.7
PP'DDD	29	.29	.14
TOTAL DDT	47	1.6	1.1
PCB/TOTAL DDT	49	4.6	3.7
PP'DDE/PP'DDT	24	3.0	3.8
OP'DDT/PP'DDT	26	.1	.0
PP'DDE/TOTAL DDT	49	.4	.2
OP'DDT/TOTAL DDT	27	.0	.0
PP'DDT/TOTAL DDT	27	.3	.2
PP'DDD/TOTAL DDT	29	.1	.1

GROSS MEAN CONCENTRATIONS OF MAJOR CHLORINATED HYDROCARBONS FOR LAKE MICHIGAN FISH CAUGHT IN FALL, 1971.

SPECIES: Rainbow Trout

VARIABLE	NUMBER PRESENT	MEAN	STANDARD DEVIATION
FISH WEIGHT (KG)	11	1.149	1.344
PERCENT FAT	10	14.4	3.3
PP'DDE	11	3.4	1.3
PCB	11	14.3	4.1
OP'DDT	6	.16	.06
PP'DDT	6	1.2	.3
PP'DDD	6	.35	.11
TOTAL DDT	11	4.2	1.6
PCB/TOTAL DDT	11	2.1	1.0
PP'DDE/PP'DDT	6	3.6	1.9
OP'DDT/PP'DDT	6	.2	.0
PP'DDE/TOTAL DDT	11	.4	.2
OP'DDT/TOTAL DDT	6	.0	.0
PP'DDT/TOTAL DDT	6	.2	.1
PP'DDD/TOTAL DDT	6	.1	.0

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TABLE 7

GROSS MEAN CONCENTRATIONS OF MAJOR CHLORINATED HYDROCARBONS FOR LAKE-MICHIGAN FISH CAUGHT IN FALL,1971.

SPECIES: Red Sucker

VARIABLE	NUMBER PRESENT	MEAN	STANDARD DEVIATION
FISH WEIGHT (KG)	16	.902	.227
PERCENT FAT	16	4.6	1.2
PP'DDE	16	1.6	.5
PCB	16	3.0	.7
DP'DDT	16	.09	.03
PP'DDT	16	.7	.3
PP'DDD	16	.33	.10
TOTAL DDT	16	2.6	.7
PCB/TOTAL DDT	16	1.3	.5
PP'DDE/PP'DDT	16	3.1	2.9
DP'DDT/PP'DDT	16	.2	.1
PP'DDE/TOTAL DDT	16	.6	.2
DP'DDT/TOTAL DDT	16	.0	.0
PP'DDT/TOTAL DDT	16	.3	.1
PP'DDD/TOTAL DDT	16	.1	.0

GROSS MEAN CONCENTRATIONS OF MAJOR CHLORINATED HYDROCARBONS FOR LAKE-MICHIGAN FISH CAUGHT IN FALL,1971.

SPECIES: Smelt

VARIABLE	NUMBER PRESENT	MEAN	STANDARD DEVIATION
FISH WEIGHT (KG)	36	.051	.026
PERCENT FAT	39	5.8	1.3
PP'DDE	41	.8	.4
PCB	38	2.7	1.3
DP'DDT	39	.09	.02
PP'DDT	39	.3	.2
PP'DDD	39	.12	.06
TOTAL DDT	42	1.2	.6
PCB/TOTAL DDT	38	2.6	1.3
PP'DDE/PP'DDT	33	2.8	1.3
DP'DDT/PP'DDT	39	.1	.0
PP'DDE/TOTAL DDT	41	.7	.2
DP'DDT/TOTAL DDT	39	.0	.0
PP'DDT/TOTAL DDT	39	.3	.1
PP'DDD/TOTAL DDT	39	.1	.0

TABLE 7

GROSS MEAN CONCENTRATIONS OF MAJOR CHLORINATED HYDROCARBONS FOR LAKE-MICHIGAN FISH CAUGHT IN FALL,1971.

SPECIES: Whitefish

VARIABLE	NUMBER PRESENT	MEAN	STANDARD DEVIATION
FISH WEIGHT (KG)	37	1.109	.432
PERCENT FAT	47	17.6	9.9
PP'DDE	49	.8	.3
PCB	43	3.0	1.9
OP'DDT	34	.07	.04
PP'DDT	39	.5	.2
PP'DDD	39	.25	.11
TOTAL DDT	47	1.4	.6
PCB/TOTAL DDT	43	2.8	2.5
PP'DDE/PP'DDT	31	2.1	1.4
OP'DDT/PP'DDT	34	.2	.3
PP'DDE/TOTAL DDT	49	.7	.2
OP'DDT/TOTAL DDT	34	.0	.0
PP'DDT/TOTAL DDT	39	.3	.1
PP'DDD/TOTAL DDT	39	.2	.1

GROSS MEAN CONCENTRATIONS OF MAJOR CHLORINATED HYDROCARBONS FOR LAKE-MICHIGAN FISH CAUGHT IN FALL,1971.

SPECIES: White Sucker

VARIABLE	NUMBER PRESENT	MEAN	STANDARD DEVIATION
FISH WEIGHT (KG)	37	1.131	1.405
PERCENT FAT	53	5.9	2.3
PP'DDE	54	1.0	.5
PCB	51	1.9	3.6
OP'DDT	37	.05	.04
PP'DDT	42	.5	.6
PP'DDD	45	.24	.21
TOTAL DDT	54	1.6	1.2
PCB/TOTAL DDT	51	3.4	3.5
PP'DDE/PP'DDT	42	3.8	2.5
OP'DDT/PP'DDT	37	.1	.1
PP'DDE/TOTAL DDT	54	.7	.2
OP'DDT/TOTAL DDT	37	.0	.0
PP'DDT/TOTAL DDT	42	.2	.1
PP'DDD/TOTAL DDT	45	.2	.0

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and 2.8, and that only the carp, red suckers, and perch contained ratios outside this range. This ratio may become important in future studies to determine the relative rates of elimination of the chemicals from the Lake Michigan system now that the inputs to the Lake have been decreased.

The mean ratios of o,p'DDT/p,p'DDT ranged from 0.1 to 0.3 with the ratio in the majority of the fish being 0.2. Since technical DDT generally contains about 30 percent of the o,p'DDT isomer (ratio of 0.4), the data from Lake Michigan fish suggest that the degradation and/or other removal mechanisms in the lake are slightly greater for the o,p' isomer than for the p,p' isomer.

The data also show that greater than 80 percent of the "total DDT" residue is accounted for by p,p'DDE and p,p'DDT.

Not only does the PCB concentration vary considerably among the 13 species captured, but also the range of concentrations in a single species in the lake was generally greater than 100 percent (the range in red suckers was less; however, all were captured in the same region). Although some variation in concentration is expected because of the normal analytical precision, Table 7 reveals much larger ranges which are undoubtedly due to other factors which limit the usefulness of mean concentrations presented. Previous research has shown (Reinert, 1970) that the lipid content, size of fish, season of capture and concentration in the water may affect the observed concentration of chlorinated hydrocarbons in tissue considerably. Accordingly, the data in Table 7 must be considered in more detail.

The above summary data for PCBs is presented in Table 8 where the regional variations and variations due to lipid content are expressed. The concentration of PCBs in alewives (on a fresh weight basis) were greater in southern Lake Michigan than in the northern regions, although anomolies are apparent. It is apparent that most of the alewives captured south of a line between Saugatuck and Sheboygan contained between 4.4 and 5.5 µg/gm PCBs whereas those caught north of the line contained between 3.5 and 4.4 µg/gm. An interesting exception is the high concentration, 8.9 µg/gm, in the alewives from Rock Island just off the Door County Peninsula in Wisconsin.

The analyses of brown trout suggested similar trends in that those from Michigan City at the southern end of the lake contained 11.9 µg/gm while those from Sheboygan and Gills Rock contained 7.9 and 6.7 µg/gm, respectively.

The carp from Michigan City also had higher levels of PCBs than did those from the northern region. In contrast to the 11.0 µg/gm found in the Michigan City carp, those from Saugatuck and Sheboygan contained 4.6 and 1.7 µg/gm, respectively.

The PCBs in chubs in southern Lake Michigan ranged from 4.9 µg/gm near Milwaukee to 8.1 µg/gm near Saugatuck. In general, the chubs from the northern regions were below 5 µg/gm. The concentration of PCBs in the five groups of chubs collected over three months near Sheboygan varied without trend between 3.7 and 6.1 µg/gm, although the mean was below 5 µg/gm. The variation is somewhat less when the data is expressed on a lipid basis. For example, the PCBs in the 8/27 and 10/15 chubs was 5.0 and 3.7 µg/gm--wet weight, respectively. In contrast, the concentration of PCBs in the lipids was 23 µg/gm and 21 µg/gm, respectively. Thus, much of the observed variability is due to lipid content of the fish analyzed.

One hundred percent of the chinook salmon captured in Wisconsin contained greater than 5 µg/gm PCBs and mean concentrations ranged from 24 µg/gm in Milwaukee to 9.9 µg/gm in Strawberry Creek.

Little trend in the concentration of PCBs in coho salmon was observed with sampling region. With the exception of coho caught early in 1971

Table 8. PCB Concentrations
1971 Lake Michigan Fish

Number	Species	Location	Date (1971)	% Over 5 µg/gm	PCB(µg/gm as Aroclor 1254) Wet Weight	S.D.	Lipid Basis	S.D.
10	ALWF	MICHIGAN CITY	1015	40	4.4	2.0	164	172
10	ALWF	BENTON HARB	902	40	4.8	1.1	60	31
2	ALWF	WAUKEGAN	823		2.5	.1	47	11
12	ALWF	SAUGATUCK	911	91	5.3	2.2	51	21
4	ALWF	SHEBOYGAN	1015	50	5.5	1.4	79	50
14	ALWF	LUDINGTON	703	18	4.4	1.4	207	154
10	ALWF	FRANKFORT	1005	20	3.7	1.2	62	35
3	ALWF	MANITOU IS	910	33	3.8	2.2	51	47
5	ALWF	ROCK IS	914	60	8.9	12.0	182	256
8	ALWF	ST MARTINS I	911	16	3.5	1.3	82	17
1	BRTR	MICHIGAN CITY	1015	100	11.9	.0	51	
5	BRTR	SHEBOYGAN	713	100	7.9	3.0	92	16
10	BRTR	GILLS ROCK	916	70	6.7	2.5	64	22
7	CARP	MICHIGAN CITY	1129	100	11.0	7.2	72	27
15	CARP	SAUGATUCK	1015	26	4.6	4.8	71	24
11	CARP	SHEBOYGAN	723		1.7	.8	30	14
9	CARP	PENSAUKEE BR	1101	33	4.2	1.4	30	10
5	CARP	MANITOU IS	916	80	5.8	.9	30	9
10	CHUB	BENTON HARB	902	60	5.8	1.2	24	5
20	CHUB	SAUGATUCK	916	80	8.1	1.7	96	33

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Table 8. PCB Concentrations
1971 Lake Michigan Fish

Number	Species	Location	Date (1971)	% Over 5 µg/gm	PCB(µg/gm as Aroclor 1254) Wet Weight	S.D.	Lipid Basis	S.D.
29	CHUB	SAUGATUCK	618	95	7.8	2.2	43	16
15	CHUB	SAUGATUCK	619	86	6.9	1.8	34	12
11	CHUB	MILWAUKEE	919	36	4.6	1.2	20	8
13	CHUB	SHEBOYGAN	713	61	5.1	1.5	31	15
13	CHUB	SHEBOYGAN	722	76	6.1	1.8	21	5
6	CHUB	SHEBOYGAN	819		3.8	.6	15	2
7	CHUB	SHEBOYGAN	827	57	5.0	1.3	23	5
6	CHUB	SHEBOYGAN	1015		3.7	.8	21	5
43	CHUB	LUDDINGTON	903	93	7.4	1.8	41	12
8	CHUB	FRANKFORT	1005	12	4.7	.7	28	6
10	CHUB	MANITOU IS	910	30	4.6	1.1	24	6
6	CHUB	WASHINGTON I	907		4.1	.6	16	3
6	CHUB	ROCK IS	911	66	5.8	2.5	97	46
7	CHUB	ROCK IS	919	57	5.6	1.6	23	7
8	CHUB	ROCK IS	920	12	4.0	.7	18	3
9	CHUB	ST MARTINS I	719		3.4	.6	16	4
9	CHUB	MANISTIQUE	927	33	4.8	.7	26	6
1	CISC	GREEN ISLAND	721		3.8	.0	24	
1	CKSH	MILWAUKEE	1015	100	24.0	.0	117	
8	CKSH	MANITOWOC	1021	100	11.3	3.1	209	73

Table 8. PCB Concentrations
1971 Lake Michigan Fish

Number	Species	Location	Date (1971)	% Over 5 µg/gm	PCB (µg/gm as Aroclor 1254) Wet Weight	S.D.	Lipid Basis	S.D.
10	CKSH	STRAWBERRY CR	1021	100	9.9	2.0	373	154
2	CKSH	GILLS ROCK	916	100	12.7	.7	278	80
8	COHO	MICHIGAN CITY	917	12	3.6	1.7	91	24
8	COHO	MICHIGN CITY	927	87	17.3	8.9	255	126
4	COHO	MICHIGN CITY	1007	100	14.0	4.0	349	126
8	COHO	SHEBOYGAN	1021	100	12.1	2.8	276	38
8	COHO	LUDDINGTON	826	100	11.2	3.3	108	29
10	COHO	PLATTE RIVER	1007	100	12.9	1.3	226	49
11	COHO	GILLS ROCK	916	90	12.6	4.1	166	63
1	CRPH	ROCK IS	916		6	.0	17	
4	LKTR	MICHIGN CITY	1015	100	13.9	2.0	89	19
5	LKTR	MICHIGN CITY	90	100	21.2	6.8	121	48
10	LKTR	SAUGATUCK	821	100	11.9	3.0	70	20
7	LKTR	SAUGATUCK	710	100	15.5	2.9	78	23
9	LKTR	SAUGATUCK	1001	100	19.7	4.7	113	43
1	LKTR	MILWAUKEE	919	100	21.2	.0	90	
7	LKTR	MILWAUKEE	719	100	21.1	6.0	114	33
12	LKTR	MILWAUKEE	1015	100	10.9	3.6	127	74
1	LKTR	SHEBOYGAN	701	100	14.9	.0	58	
36	LKTR	SHEBOYGAN	713	100	12.5	3.7	82	27

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Table 8. PCB Concentrations
1971 Lake Michigan Fish

PCB(µg/gm as Aroclor 1254)

Number	Species	Location	Date (1971)	% Over 5 µg/gm	Wet Weight	S.D.	Lipid Basis	S.D.
10	LKTR	LUDDINGTON	701	100	6.1	1.8	51	14
8	LKTR	LUDDINGTON	709	100	6.5	1.7	50	11
8	LKTR	G TRAVERSE B	1019	75	11.3	5.3	56	22
10	LKTR	GREEN ISLAND	721	100	9.0	1.7	98	12
10	LKTR	GILLS ROCK	916	100	14.7	6.4	63	30
1	LOUY	GREEN ISLAND	721		2.5	.0	40	
14	PRCH	MICHIGN CITY	1015	14	4.2	.7	72	21
9	PRCH	WAUKEGAN	820	88	6.1	1.5	70	27
10	PRCH	MILWAUKEE	1013	90	10.9	3.1	203	76
3	PRCH	LUDDINGTON	706	100	6.2	1.3	139	57
2	PRCH	FRANKFORT	1012	50	5.4	1.8	69	
10	PRCH	PENSAUKEE BA	625	10	2.7	2.1	49	28
1	RBTR	MICHIGN CITY	1015	100	12.0	.0	66	
9	RBTR	GILLS ROCK	916	77	6.8	4.3	97	22
7	ROSU	HOG IS	911		2.8	.6	33	11
9	ROSU	ST MARTINS I	911		3.2	.5	37	8
12	SCUL	SAUGATUCK	1016		2.7	1.1	46	25
15	SMLT	MICHIGN CITY	1015		3.2	.9	95	15
13	SMLT	SHEBOYGAN	1015		.7	.2	18	14
5	SMLT	GREEN ISLAND	721		2.6	1.1	57	27

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Table 8. PCB Concentrations
1971 Lake Michigan Fish

PCB(ug/gm as Aroclor 1254)

Number	Species	Location	Date (1971)	% Over 5 ug/gm	Wet Weight	S.D.	Lipid Basis	S.D.
8	SMLT	ROCK IS	9-11	25	2.9	1.7	49	28
9	SMLT	ST MARTINS I	7-19		1.3	.3	31	8
6	WHSU	MICHIGAN CITY	10-15	100	10.6	4.0	100	44
3	WHSU	SAUGATUCK	10-15	60	6.0	2.9	149	99
5	WHSU	SAUGATUCK	10-16		2.3	.9	90	11
7	WHSU	PENSAUKEE BAY	8-06	14	3.2	1.1	97	35
10	WHSU	G TRAVERSE B	10-17		2.3	.7	68	26
1	WHSU	GREEN ISLAND	7-21		2.1	.0	20	
11	WHSU	ROCK IS	9-11		2.5	.9	46	25
4	WHFH	MICHIGAN CITY	10-15	100	6.1	.9	25	1
2	WHFH	SAUGATUCK	6-19		2.7	.5	16	3
12	WHFH	SAUGATUCK	8-24		3.1	1.3	10	4
7	WHFH	GRAND HAVEN	9-06	71	6.8	.9	29	5
13	WHFH	G TRAVERSE B	10-17		1.8	.3	13	4
10	WHFH	ROCK IS	9-11		1.5	.2	9	1

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near Michigan City, the mean concentration of PCBs ranged from 11 μg/gm in those near Ludington to 14 μg/gm in those near Michigan City.

The PCBs in lake trout were most concentrated in the trout from Michigan City, Saugatuck and Milwaukee where mean concentrations were generally between 15 and 22 μg/gm. The trout from the northern areas such as Sheboygan, Ludington, Grand Traverse Bay and Gill's Rock were considerably lower, and the mean concentrations ranged between 8 and 15 μg/gm.

The concentration of PCBs were unexpectedly high in the perch caught near Milwaukee in that the mean of the 10 fish was 11 μg/gm. In contrast, perch from other regions appear to be less by a factor of two, and those from lower Green Bay contained only 2.7 μg/gm.

Rainbow trout were only caught near Michigan City and Gill's Rock. The Michigan City trout had 12 ug/gm PCBs while those from Gill's Rock averaged only 8.8 μg/gm PCBs.

The concentration of PCBs in suckers and smelt were generally between 2 and 4 μg/gm, although the average concentration in the three white suckers from Saugatuck was 6.0 μg/gm. With the exception of whitefish caught at Grand Haven and Michigan City, the PCB concentration in whitefish was less than 3 μg/gm.

B. DDT and Analogs

The concentrations of pp'DDT, op'DDT, pp'TDE and pp'DDE are summarized in Table 9 along with the total DDT and percentage of fish which contained over the 5 μg/gm action level established by the FDA. The total DDT in alewives ranged from 1.6 μg/gm near Waukegan to 5.0 near the Manitou Islands. There was no trend in the variations with region. A brown trout from Michigan City contained 6.4 μg/gm total DDT whereas those from Sheboygan and Gill's Rock averaged 4.4 μg/gm. With the exception of the carp from Michigan City which averaged 4.6 μg/gm total DDT, the average concentrations in lake Michigan carp were 1.0 μg/gm or less.

The total DDT in chubs ranged from 3.8 μg/gm at Frankfort to 6.2 μg/gm at Sheboygan. There are no trends for DDT in chubs observed in

Table 9 . Concentration of DDT and Metabolites in 1971 Lake Michigan Fish (Wet-Weight Basis)

Number	Species	Location	Date	Concentration (ug/gm) pp DDE	pp TDE	pp DDT	op DDT	Total DDT	% Over 5 ug/gm
10	ALWF	MICHIGN CITY	1015	1.4	.19	.5	.08	2.2	10
10	ALWF	BENTON HRBR	902	1.6	.23	.5	.08	2.7	
2	ALWF	WAUKEGAN	823	1.0	.16	.5	.07	1.6	
9	ALWF	SAUGATUCK	811	1.6	.22	.8	.10	2.7	11
1	ALWF	SHEBOYGAN	1015	2.2	.20	.7	.07	3.2	
5	ALWF	FRANKFORT	1008	1.2	.16	.6	.06	1.9	
1	ALWF	MANITOU IS	910	3.2	.33	1.3	.16	5.0	
4	ALWF	ROCK IS	911	1.1	.11	.2	.04	1.5	
5	ALWF	ST MARTINS I	911	1.0	.16	.3	.05	1.5	
1	BRTR	MICHIGN CITY	1015	3.7	.70	1.7	.22	6.4	100
4	BRTR	SHEBOYGAN	713	2.6	.46	1.2	.18	4.4	25
10	BRTR	PILLS ROCK	910	2.8	.98	1.0	.18	4.9	40
2	CARP	MICHIGN CITY	1129	3.3	.81	.3	.14	4.6	50
10	CARP	SAUGATUCK	1015	.5	.20	.1	.02	.9	0
6	CARP	SHEBOYGAN	723	.2	.07	.0	.01	.3	
8	CARP	PENSAUKEE HR	1101	.8	.19	.0	.01	1.0	
10	CHUB	BENTON HRBR	902	2.5	.71	1.5	.19	4.9	30
8	CHUB	SAUGATUCK	810	1.9	.47	1.6	.19	4.2	37
14	CHUB	SAUGATUCK	818	2.4	.63	2.4	.25	5.7	64
3	CHUB	SAUGATUCK	715	1.8	.47	2.1	.21	5.1	66

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Table 9. Concentration of DDT and Metabolites in 1971 Lake Michigan Fish (Wet-Weight Basis)

Number	Species	Location	Date	Concentration (µg/gm) pp DDE	pp TDE	pp DDT	op DDT	Total DDT	% Over 5 µg/gm
9	CHUB	MILWAUKEE	919	3.4	.36	2.0	.20	6.0	88
2	CHUB	SHEBOYGAN	713	1.2	.40	2.2	.29	4.1	50
11	CHUB	SHEBOYGAN	722	3.4	.39	2.0	.29	5.9	91
5	CHUB	SHEBOYGAN	810	2.6	.35	1.3	.16	4.4	20
5	CHUB	SHEBOYGAN	827	3.2	.47	2.3	.28	6.2	80
7	CHUB	SHEBOYGAN	1015	2.4	.28	1.7	.17	4.5	42
20	CHUB	LUDDINGTON	703	2.0	.58	2.2	.28	5.0	45
6	CHUB	FRANKFORT	1005	2.2	.33	1.2	.16	3.8	
2	CHUB	MANITOU IS	910	3.1	.50	1.3	.26	5.0	50
9	CHUB	WASHINGTON I	907	3.2	.34	1.9	.18	5.6	60
5	CHUB	ROCK IS	911	2.6	.21	1.1	.08	4.0	20
10	CHUB	ROCK IS	910	2.7	.42	2.0	.22	5.4	50
5	CHUB	ROCK IS	910	2.6	.29	1.3	.14	4.5	40
10	CHUB	ST MARTINS I	912	2.2	.39	1.1	.17	3.8	
5	CHUB	MANISTIQUE	827	2.0	.42	1.0	.14	5.2	80
1	CISC	ROCK IS	911	.8	.32	.5	.10	1.7	
1	CKSH	MILWAUKEE	1015	6.0	1.67	4.7	.62	13.0	100
7	CKSH	MANITOWOC	1021	6.3	.82	1.2	.21	8.3	100
9	CKSH	STRAWBERY CR	1021	4.5	.29	1.0	.17	6.0	88
1	CKSH	BILLS ROCK	910	5.5	.49	1.2	.20	7.3	100

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Table 9. Concentration of DDT and Metabolites in 1971 Lake Michigan Fish (Wet-Weight Basis)

Number	Species	Location	Date	Concentration (µg/gm) pp DDE	pp TDE	pp DDT	op DDT	Total DDT	% Over 5 µg/gm
9	CHUB	MILWAUKEE	819	3.4	.36	2.0	.20	6.0	89
2	CHUB	SHEBOYGAN	713	1.3	.40	2.2	.24	4.1	50
11	CHUB	SHEBOYGAN	722	3.4	.34	2.0	.28	5.8	91
5	CHUB	SHEBOYGAN	819	2.6	.35	1.3	.16	4.4	20
5	CHUB	SHEBOYGAN	827	3.3	.47	2.3	.28	6.2	80
7	CHUB	SHEBOYGAN	1015	2.4	.28	1.7	.17	4.5	42
20	CHUB	LUDDINGTON	703	2.0	.58	2.2	.28	6.0	95
6	CHUB	FRANKFORT	1005	2.2	.33	1.2	.16	3.8	
2	CHUB	MANITOU IS	810	3.1	.40	1.8	.26	5.0	50
9	CHUB	WASHINGTON I	806	3.2	.34	1.9	.18	5.6	60
5	CHUB	ROCK IS	811	2.6	.26	1.1	.08	4.0	20
6	CHUB	ROCK IS	814	2.7	.42	2.0	.22	5.4	50
5	CHUB	ROCK IS	910	2.6	.29	1.2	.14	4.5	40
10	CHUB	ST MARTINS I	712	2.2	.38	1.1	.17	5.8	
5	CHUB	MANISTIQUE	527	2.9	.42	1.8	.14	5.2	80
1	CISC	ROCK IS	911	.8	.32	.5	.10	1.7	
1	CKSH	MILWAUKEE	1015	8.0	1.67	4.7	.53	13.0	100
7	CKSH	MANITOUOC	1021	6.3	.82	1.2	.21	8.3	100
9	CKSH	STRAWBERRY CP	1021	4.5	.25	1.0	.17	5.0	80
1	CKSH	GILLS ROCK	915	5.5	.49	1.2	.20	7.3	100

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Table 9 . Concentration of DDT and Metabolites in 1971 Lake Michigan Fish (Wet-Weight Basis)

Number	Species	Location	Date	Concentration (µg/gm) pp DDE	pp TDE	pp DDT	op DDT	Total DDT	% Over 5 µg/gm
5	COHO	MICHIGAN CITY	917	.8	.17	.5	.09	1.6	
7	COHO	MICHIGAN CITY	927	5.3	.46	1.2	.20	7.2	85
5	COHO	MICHIGAN CITY	1007	4.5	.41	1.0	.18	6.1	60
9	COHO	SHEBOYGAN	1021	6.0	.57	1.4	.27	8.0	100
3	COHO	LUDDINGTON	828	6.8	.39	.9	.19	8.3	100
9	COHO	PLATTE RIVER	1007	5.1	.40	1.4	.24	7.1	100
8	COHO	GILLS ROCK	916	4.9	.45	1.2	.20	6.7	87
3	LKTR	MICHIGAN CITY	1015	2.9	.68	3.1	.35	7.2	100
2	LKTR	MICHIGAN CITY	908	9.5	1.12	3.9	.45	14.9	100
9	LKTR	SAUGATUCK	821	4.7	.65	2.1	.27	7.8	88
6	LKTR	SAUGATUCK	710	6.9	.70	2.0	.24	9.8	100
8	LKTR	SAUGATUCK	1001	6.7	.84	2.8	.27	10.6	100
2	LKTR	MILWAUKEE	918	10.1	.86	3.0	.47	14.5	100
5	LKTR	MILWAUKEE	918	10.2	1.08	2.3	.45	13.4	100
10	LKTR	MILWAUKEE	1015	2.2	.44	1.3	.15	4.1	20
10	LKTR	SHEBOYGAN	919	4.9	.51	1.7	.24	7.8	80
10	LKTR	LUDDINGTON	701	3.3	.52	1.0	.22	5.0	20
6	LKTR	LUDDINGTON	704	3.2	.63	2.0	.30	6.1	66
9	LKTR	G TRAVERSE B	1019	6.0	.73	2.0	.30	9.0	77
11	LKTR	GREEN ISLAND	721	3.0	.50	1.5	.21	6.0	72

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Table 9. Concentration of DDT and Metabolites in 1971 Lake Michigan Fish (Wet-Weight Basis)

Number	Species	Location	Date	Concentration (µg/gm) pp DDE	pp TDE	pp DDT	op DDT	Total DDT	% Over 5 µg/gm
8	LKTR	GILLS ROCK	916	5.5	.57	1.9	.24	8.3	62
1	LOUY	GREEN ISLAND	721	.5	.14	.3	.03	.9	
10	PRCH	MICHIGN CITY	1015	.8	.15	.4	.04	1.3	
9	PRCH	MILWAUKEE	1017	1.1	.30	.7	.00	2.1	
2	PRCH	LUDDINGTON	706	2.2	.30	.9	.13	3.6	
2	PRCH	FRANKFORT	1013	1.7	.43	2.2	.19	4.5	
3	PRCH	PENSAUKEE PR	825	.4	.10	.0	.01	.5	
8	BRIT	GILLS ROCK	916	3.1	.34	.9	.16	4.5	40
6	RDSU	ROCK IS	911	1.7	.30	.6	.09	2.7	
8	RDSU	ST MARTINS I	911	1.5	.35	.8	.09	2.7	
2	COHO	GILLS ROCK	916	6.4	.52	1.5	.24	8.7	100
9	SCUL	SAUGATUCK	1016	1.9	.15	1.2	.06	2.8	11
11	SMLT	MICHIGN CITY	1015	.9	.11	.4	.05	1.4	
3	SMLT	SHEBOYGAN	1015	.6	.12	.3	.02	1.0	
4	SMLT	GREEN ISLAND	721	.7	.12	.2	.02	1.0	
9	SMLT	ROCK IS	911	1.8	.14	.5	.05	1.0	
3	SMLT	ST MARTINS I	719	.7	.09	.2	.04	1.0	
2	WHFH	MICHIGN CITY	1015	.5	.32	.5	.06	1.4	
3	WHFH	SAUGATUCK	619	.6	.21	.4	.06	1.2	
6	WHFH	GRAND HAVEN	906	.7	.38	.8	.10	1.9	

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Table 9. Concentration of DDT and Metabolites in 1971 Lake Michigan Fish (Wet-Weight Basis)

Number	Species	Location	Date	Concentration (mg/kg) pp DDE	pp TDE	pp DDT	op DDT	Total DDT	% Over 5 mg/kg
12	WHFH	G TRAVERSE B	1019	1.2	.25	.4	.09	2.0	
8	WHFH	ROCK IS	911	.7	.16	.4	.05	1.4	
5	WHSU	MICHIGN CITY	1015	1.8	.02	1.0	.06	4.0	66%
7	WHSU	SAUGATUCK	1015	.7	.14	.2	.03	1.0	
7	WHSU	PERSAUKEE BR	806	.3	.15	.2	.04	.7	
14	WHSU	G TRAVERSE B	1019	1.4	.31	.6	.05	2.1	
1	WHSU	GREEN ISLAND	721	.7	.19	.4	.03	1.3	
12	WHSU	ROCK IS	911	.9	.420	.5	.04	1.4	

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Table 9 . Similarly, the total DDT in coho was somewhat constant throughout the lake, and the mean concentration ranged between 6.5 µg/gm to 8.8 µg/gm for the coho caught in the fall of 1971. The five coho caught near Michigan City in the spring averaged only 1.6 µg/gm total DDT.

As was previously discussed, the concentration of chlorinated materials is dependent on the size of the fish. Thus, lake trout from Michigan City averaged 14.9 µg/gm total DDT on 9/8/71 while those caught on 10/15/71 averaged only 7.3 µg/gm. The difference is likely due to the size differences. The lake trout from Milwaukee also contained approximately 15 µg/gm in October, but the smaller trout caught near Milwaukee averaged only 4.2 µg/gm total DDT. The DDT in the northern areas of the lake were less than 8 µg/gm, and approximately 60 to 70 percent of the lake trout contained over 5 µg/gm total DDT.

The perch from lower Green Bay had the lowest DDT content (0.5 µg/gm) while perch from other areas contained between 1.3 and 4.5 µg/gm total DDT. None of the perch contained greater than 5 µg/gm total DDT.

The concentration of DDT in smelt, whitefish and suckers averaged approximately 1 to 2 µg/gm, although the white suckers from Michigan City averaged 4.6 µg/gm total DDT.

C. Phthalate Esters

A group of Lake Michigan fish were selected for analysis of n,n dibutyl phthalate (DBP) and 2-ethylhexyl phthalate (DEHP) by Analytical Bio-Chemist Laboratories, Inc. of Columbia, Missouri. Although the presence of DBP was indicated in most of the fish, DEHP was indicated in only five percent of the samples analyzed. The data presented in this section must be regarded as preliminary--subject to confirmatory mass spectral data and further evaluation of the procedures used for the phthalate ester analysis in fish.

Table 10 presents the data concerning the concentration of DBP in the selected fish. The mean DBP concentration in clubs ranged from 0.8 µg/gm near Saugatuck to 3.7 µg/gm at Benton Harbor. Although sufficient data were not obtained to determine trends of DBP in the lake, the concentrations in the fish from the northern regions were all

Table 10. Concentration of n,n Dibutyl phthalate in Selected Lake Michigan Fish (GLC Data Only)

Species	Region	No. of Fish in Sample	Concentration[a] (µg/gm)
Chubs	Sheboygan	3	1.5
Chubs	Rock Is.	2	1.1
Chubs	Milwaukee	4	1.1
Chubs	Benton Harbor	2	3.7
Chubs	Saugatuck	3	0.8
Chubs	Manitou Is.	1	1.5
Lake Trout	Green Bay	1	1.4
Lake Trout	Sheboygan	1	1.4
Lake Trout	Milwaukee	2	1.8
Lake Trout	Saugatuck	2	2.3
Lake Trout	Ludington	2	0.8
Lake Trout	West Arm Grand Traverse Bay	1	1.1
Perch	Green Bay	2	1.9

[a] means for more than one sample

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less than 1.5 µg/gm whereas the two chubs from Benton Harbor in southern Lake Michigan contained 2.1 and 3.7 µg/gm DBP.

The levels of DBP in lake trout and perch were similar in magnitude in that the range observed was from 0.8 µg/gm in the trout from Ludington to 2.3 µg/gm near Saugatuck. The perch from lower Green Bay were found to contain 1.8 and 2.0 µg/gm DBP.

The concentration of DEHP in five fish from Lake Michigan are presented in Table 11. The levels ranged from 1.0 µg/gm in a lake trout from Ludington to 65 µg/gm in the whitefish captured in the west arm of Grand Traverse Bay. In the limited data available, it is noted that the fish from Milwaukee and Sheboygan contained 22 and 14 µg/gm, respectively, which is considerably more than the 1.0 and 2.0 µg/gm in the fish from Ludington and Saugatuck, respectively.

D. Summary

There are insufficient data on PCBs in Great Lakes fish to adequately relate the results of this work on Lake Michigan fish with those from other Great Lakes. The concentration of PCBs ranged from less than 2 µg/gm in the small fish of low lipid content to over 20 µg/gm in the larger fish. Based on unpublished data provided by the Ontario Pesticide Residue Laboratory, the concentration of PCBs in Lake Michigan coho salmon appears to be two to three times greater than coho from Lake Huron, approximately 1.5 times greater than those in Lake Ontario and approximately ten times greater than those from Lake Erie and Lake Superior. Approximately 50 to 80 percent of the chubs from Lake Michigan contain greater than 5 µg/gm PCBs and essentially 100 percent of large salmon and trout contain greater than 5 µg/gm PCBs.

Table 11. Concentration of 2-Ethylhexylphthalate in Selected Fish from Lake Michigan (CLC Data Only).

Species	Region	Concentration (µg/gm)
Chub	Sheboygan	14
Chub	Milwaukee	22
Chub	Saugatuck	2.0
Lake Trout	Ludington	1.0
Whitefish	West Arm Grand Traverse Bay	65

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SECTION VII

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SECTION VIII

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Robert A. Koch of the Michigan City office of the Indiana Department of Natural Resources collected some of the lake trout from the Michigan City area. The remaining samples from Michigan City were captured with the assistance of William Ritter of Ritter Brother's Fish Company in Michigan City.

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Samples collected from Waukegan, Illinois, were provided by a fish population study of Industrial Bio-Test Laboratories, Incorporated of Northbrook, Illinois. Permission for the sampling was granted by Steven

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Hastings of Commonwealth Edison Company of Chicago with the cooperation of William Johnson of Industrial Bio-Test Laboratories. Bruce Muench and Jay Smith captured the fish for this study.

The Milwaukee area was sampled by the Wisconsin Department of Natural Resources and by Leland La Fond of Milwaukee. Ronald Poff of the Department of Natural Resources transported the fresh fish to the Water Chemistry Laboratory in Madison, Wisconsin. In addition, James Moore and Russell Daley of the Department of Natural Resources collected the trout from the Sheboygan and Green Island areas. Norman Schwarz of Schwarz Fish Company in Sheboygan provided fish from Sheboygan and assisted in coordinating the collection of fish from area fishermen. Donald Euers, Lake Michigan Enforcement Coordinator for the State of Wisconsin, collected and transported trout from pond nets which are operated by Marvin Weborg near Gills Rock to a Green Bay freezer plant for pickup. Steve Ellefson of Washington Island assisted immeasurably in the collection of samples for the Washington Island area as well as northern Lake Michigan. All of the fish collected from lower Green Bay were captured by Norbert, Francis and Arthur Swaer of Pensaukee, Wisconsin.

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SECTION IX
APPENDICES

A. Summary of Data on Fish Analyzed for PCBs and DDT

Appendix A. Summary of Data on Fish
Analyzed for PCBs and DDT.

Sample Number	Species	1971 Date	Location	Dph	No*	L;th	Wt	% Fat	PCB	pp' DDT	op' DDT	pp' DDE	pp' TDE	Total DDT
									(µg/gm)					
[illegible]														
[illegible]														
[illegible]														
[illegible]														
[illegible]														
[illegible]														
[illegible]														
[illegible]														
[illegible]														
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[illegible]														
[illegible]														
[illegible]														
[illegible]														
[illegible]														
[illegible]														
[illegible]														
[illegible]														
[illegible]														

*Number of fish, if composite sample

MONS 065956

Appendix A. Summary of Data on Fish
Analyzed for PCBs and DDT.

(ug/gm)

Sample Number	Species	1971 Date	Location	Dph	No*	Lgth	Wt	% Fat	PCB	pp' DDT	op' DDT	pp' DDE	pp' TDE	Total DDT
1078	ALBF	1015	4143	8555	17	2	05.8	00.024	7.0	4.6	.5	.06	1.5	.23	1.7
1068	ALBF	1015	4143	8555	17	2	05.7	00.022	5.1	3.6	.9	.10	1.4	.21	2.2
1073	ALBF	1015	4143	8555	17	2	05.9	00.025	7.1	4.0	.2	.00	1.7	.10	2.1
1077	ALBF	1015	4143	8555	17	2	05.9	00.025	3.1	3.1	.4	.00	2.0	.17	2.6
1065	ALBF	1015	4143	8555	17	2	05.9	00.024	4.2	3.7	.7	.07	1.5	.21	2.4
1074	ALBF	1015	4143	8555	17	2	05.9	00.027	7.2	1.3	.2	.03	.5	.10	.7
1061	ALBF	1015	4143	8555	17	2	07.0	00.024	1.4	7.0	1.5	.22	3.1	.41	5.2
1064	ALBF	1015	4143	8555	17	2	05.5	00.022	6.6	4.7	.3	.08	1.7	.13	2.1
1070	ALBF	1015	4143	8555	17	2	05.5	00.026	7.1	1.1	.1	.03	.1	.11	1.0
0405	ALBF	0302	4210	8540	24	2	06.7	00.041	8.0	3.3	.2	.04	1.3	.50	2.0
0400	ALBF	0302	4210	8540	24	2	07.4	00.052	12.0	5.7	.5	.15	2.4	.03	3.7
0406	ALBF	0302	4210	8540	24	2	07.8	00.054	14.3	4.6	.1	.03	1.8	.22	2.8
0401	ALBF	0302	4210	8540	24	2	07.4	00.052	9.3	4.4	1.0	.20	2.2	.27	3.8
0402	ALBF	0302	4210	8540	24	2	07.4	00.053	9.1	5.2	.2	.13	3.0	.22	3.6
0407	ALBF	0302	4210	8540	24	2	07.0	00.045	6.2	4.1	.5	.00	1.7	.21	2.4
0399	ALBF	0302	4210	8540	24	2	06.6	00.037	5.4	3.5	.5	.06	2.1	.23	2.7
0403	ALBF	0302	4210	8540	24	2	07.0	00.045	7.2	3.2	.2	.00	1.8	.20	2.2
0398	ALBF	0302	4210	8540	24	2	07.1	00.051	12.8	4.0	.5	.05	1.6	.12	2.1
0404	ALBF	0302	4210	8540	24	2	07.0	00.051	10.0	1.2	.2	.05	1.1	.10	1.4
0465	ALBF	0302	4210	8540	24	2	06.7	00.033	6.0	2.5	.4	.06	1.1	.15	1.7

*Number of fish, if composite sample

MONS 065957

Appendix A. Summary of Data on Fish
Analyzed for PCBs and DDT.

Sample Number	Species	1971 Date	Location	Drh	No.*	Lgth	Wt	% Fat	(µg/gm) PCB	pp' DDT	op' DDT	pp' DDE	pp' TDE	Total DDT
0064	ALWF	1005	4440	0425	33	2	07.4	00.049	6.8	4.8	.6	.11	1.6	.17	2.5
0072	ALWF	1005	4440	0425	33	2	07.5	00.051	11.9	3.3	.6	.06	1.3	.21	2.1
0069	ALWF	0910	4210	0230	47	1	17.3	00.215	1.9	1.0	1.3	.16	3.2	.33	5.0
0532	ALWF	0911	4210	0240	14	2	05.5	00.023	2.1	7.3	.2	.05	1.2	.13	1.6
0531	ALWF	0911	4210	0240	14	2	05.2	00.020	6.2	7.6	.6	.06	.8	.10	1.3
0533	ALWF	0911	4210	0240	14	2	05.3	00.040	5.1	15.8	.1	.02	1.4	.05	1.6
0536	ALWF	0911	4210	0240	14	2	05.3	00.024	5.3	3.7	.2	.04	.7	.11	1.2
0535	ALWF	0911	4210	0240	14	2	05.5	00.030	3.6	3.6	.3	.04	1.1	.14	1.8
0529	ALWF	0911	4210	0240	14	2	05.5	00.032	2.7	3.7	.6	.08	1.8	.17	2.1
0540	ALWF	0911	4210	0240	14	2	05.5	00.029	3.7	3.4	.2	.04	1.0	.13	1.4
0538	ALWF	0911	4210	0240	14	2	05.5	00.028	4.9	1.2	.2	.02	.6	.11	1.1
1052	BRIR	0915	4143	0455	24	1	25.0	00.430	11.9	3.7	.22	3.7	.70	8.4
0229	BRIR	0717	4145	0220	01	1	22.2	.	18.0	1.3	1.6	.24	2.8	.67	6.6
0227	BRIR	0717	4145	0220	01	1	21.5	.	20.1	2.4	2.0	.32	2.4	.36	6.2
0221	BRIR	0713	4205	0220	01	1	24.7	.	20.4	7.0	1.2	.10	2.4	.41	5.4
0228	BRIR	0717	4145	0220	01	1	19.5	.	18.6	13.2	.9	.18	1.3	.40	3.9
0947	BRIR	0916	4217	0700	1	1	11.0	02.324	12.2	4.8	.9	.12	2.2	.24	7.2
0945	BRIR	0916	4217	0700	1	1	11.0	02.724	10.9	5.3	1.0	.14	2.0	.44	7.7
0950	BRIR	0916	4217	0700	1	1	11.5	02.819	5.9	7.4	1.5	.12	2.9	.41	9.7
0947	BRIR	0916	4217	0700	1	1	14.0	01.751	14.2	4.2	1.1	.22	3.3	.22	8.9

*Number of fish, if composite sample

MONS 065958

Appendix A. Summary of Data on Fish
Analyzed for PCBs and DDT.

Sample Number	Species	1971 Date	Location	Drh	No.*	Lgth	Wt	% Fat	(ug/gm) PCB	pp' DDT	op' DDT	pp' DDE	pp' TDE	Total DDT
D988	BRIN	0916	4517	8700	1	26.0	05.675	17.5	9.0	1.3	.10	4.2	.00	5.3
D989	BRIN	0916	4517	8700	1	21.0	03.278	10.0	4.1	1.0	.11	.2	.35	1.7
D990	BRIN	0916	4517	8700	1	21.0	03.251	11.2	8.0	1.1	.14	1.0	.07	2.4
D993	BRIN	0916	4517	8700	1	21.0	03.287	11.0	8.7	.0	.12	2.7	.65	3.5
D994	BRIN	0916	4517	8700	1	22.0	03.025	11.0	11.7	1.3	.10	4.2	.00	5.6
D995	BRIN	0916	4517	8700	1	18.0	02.457	10.2	3.2	.0	.08	2.0	.22	2.3
1156	CARP	1122	4247	8605	12	1	28.0	07.760	15.0	11.1	.5	.13	4.0	15.8
1157	CARP	1122	4247	8605	12	1	27.0	05.410	12.7	10.5	.2	.10	2.7	13.4
1272	CARP	1015	4240	8820	03	1	07.0	00.102	0.0	2.0	.0	.00	.2	2.2
1273	CARP	1015	4240	8820	03	2	11.0	00.312	4.2	2.0	.0	.00	.2	2.2
1274	CARP	1015	4240	8820	03	2	09.0	00.241	2.2	2.0	.0	.00	.1	2.1
1275	CARP	1015	4240	8820	03	1	10.0	00.029	2.2	1.8	.0	.00	.1	1.9
1276	CARP	1015	4240	8820	03	1	16.0	00.087	5.4	1.7	.0	.00	.1	1.8
1167	CARP	1015	4240	8820	03	1	20.0	02.122	20.4	1.7	.0	.10	2.0	3.8
1277	CARP	1015	4240	8820	03	2	18.0	00.042	3.4	2.0	.0	.00	.1	.10
1178	CARP	1015	4240	8820	03	1	23.0	04.430	22.4	11.5	.2	.00	1.8	.00
1187	CARP	1015	4240	8820	03	1	22.0	03.020	21.5	6.3	.3	.05	.6	.33
1169	CARP	1015	4240	8820	03	1	17.0	01.550	17.7	5.2	.0	.00	.4	.27
1275	CARP	1015	4240	8820	03	2	05.0	00.049	1.0	2.1	.0	.00	.1	.06
D291	CARP	0723	4240	8720	02	1	19.0	[illegible]	[illegible]	1.5	.0	.00	.1	.09

*Number of fish, if composite sample

MONS 065959

Appendix A. Summary of Data on Fish
Analyzed for PCBs and DDT.

Sample Number	Species	1971 Date	Location	Dph	No*	Lgth	Wt	% Fat	(µg/gm) PCB	pp' DDT	op' DDT	pp' DDE	pp' TDE	Total DDT
0277	CARP	0727	[illegible]	0.7	1	21.0	[illegible]	11.2	2.1	.1	.01	.2	.11	.4
0278	CARP	0727	[illegible]	0.7	1	19.2	[illegible]	6.3	1.3	.0	.00	.1	.05	.1
0280	CARP	0727	[illegible]	0.7	1	16.2	[illegible]	1.1	1.0	.0	.01	.1	.07	.2
0284	CARP	0727	[illegible]	0.7	1	20.5	[illegible]	5.5	1.4	.1	.02	.2	.10	.4
0287	CARP	0727	[illegible]	0.7	1	21.0	[illegible]	8.2	2.6	.0	.01	.3	.12	.5
0293	CARP	0727	[illegible]	0.7	1	19.0	[illegible]	4.6	1.1	.0	.00	.1	.01	.1
0294	CARP	0727	[illegible]	0.7	1	18.0	[illegible]	2.8	1.1	.0	.00	.1	.04	.2
1217	CARP	1101	[illegible]	0.7	1	19.0	01.270	13.3	6.5	.0	.00	.0	.10	.1
1218	CARP	1101	[illegible]	0.7	1	21.0	02.160	17.4	4.8	.0	.00	.0	.21	.2
1219	CARP	1101	[illegible]	0.7	1	21.0	02.250	16.5	3.7	.1	.02	.5	.15	.7
1217	CARP	1101	[illegible]	0.7	1	20.0	01.720	17.9	7.4	.0	.00	.0	.22	.2
0476	CHUB	0902	[illegible]	25	1	07.0	00.102	19.0	5.9	2.6	.24	3.6	.72	7.3
0475	CHUB	0902	[illegible]	25	1	09.0	00.220	16.1	3.8	2.1	.28	2.0	.89	5.4
0477	CHUB	0902	[illegible]	25	1	07.5	00.115	15.2	5.2	1.2	.21	2.0	.33	4.1
0480	CHUB	0902	[illegible]	25	1	08.0	00.150	17.0	5.2	.7	.11	1.3	.19	2.3
0481	CHUB	0902	[illegible]	25	1	07.0	00.117	17.5	5.6	1.8	.23	3.0	.27	5.4
0482	CHUB	0902	[illegible]	25	1	08.5	00.130	15.5	4.0	.6	.08	1.0	.18	1.9
0486	CHUB	0902	[illegible]	25	1	09.5	00.220	19.6	4.2	1.5	.17	2.7	.26	4.4
0488	CHUB	0902	[illegible]	25	1	10.0	00.157	17.7	4.1	1.3	.18	2.5	.31	4.2
0484	CHUB	0902	[illegible]	25	1	11.5	00.211	14.9	5.1	1.7	.22	2.5	.37	4.7

*Number of fish, if composite sample

MONS 065960

Appendix A. Summary of Data on Fish
Analyzed for PCBs and DDT.

Sample Number	Species	1971 Date	Location	Dph	No.	Lgth	Wt	% Fat	(µg/gm) PCB	pp' DDT	op' DDT	pp' DDE	pp' TDE	Total DDT
0097	CHUB	7/31	8640	22	1	11.0		10.6	7.1	2.8	.31	2.4	.57	6.1
0098	CHUB	7/31	8640	19	1	10.2		26.7	7.8	1.5	.20	1.5	.26	3.8
0078	CHUB	7/31	8640	22	1	09.0		17.7	8.0	.8	.19	.9	.72	2.3
0104	CHUB	7/31	8640	19	1	03.0		12.6	7.0	2.1	.29	2.2	.96	5.2
0085	CHUB	7/31	8640	22	1	03.-		10.2	4.3	1.9	.26	.9	.52	2.8
0086	CHUB	7/31	8640	22	1	10.4		18.-	5.2	1.8	.21	1.0	.37	3.4
0093	CHUB	10/5	8440	3625	37	03.5	00:122	11.0	9.9	1.2	.15	2.9	.29	4.1
0094	CHUB	10/5	8440	3625	37	03.2	00:147	13.0	5.3	1.2	.10	2.0	.22	3.4
0087	CHUB	10/5	8440	3625	37	10.-	00:220	22.1	9.7	1.2	.14	2.1	.29	3.7
0095	CHUB	10/5	8440	3625	37	05.5	00:135	15.6	5.0	1.7	.20	2.2	.22	4.4
0091	CHUB	10/5	8440	3625	37	04.5	00:131	13.7	4.5	1.1	.14	2.0	.33	3.6
0089	CHUB	10/5	8440	3625	37	03.-	00:120	17.5	1.3	.3	.11	1.7	.44	2.0
0517	CHUB	9/10	8610	2520	37	14.0	00:20?	21.2	9.7	1.7	.25	3.9	.49	6.3
0515	CHUB	9/10	8610	2520	37	14.0	00:136	17.7	7.2	1.5	.22	2.8	.15	4.5
0614	CHUB	9/10	8615	8695	37	10.5	00:243	21.7	3.8	2.0	.20	2.8	.39	5.4
0613	CHUB	9/10	8615	8695	37	11.2	00:257	27.5	9.9	.5	.05	2.5	.13	4.2
0502	CHUB	9/10	8615	8695	37	11.1	00:269	30.5	8.5	2.4	.23	4.0	.49	9.1
0615	CHUB	9/10	8615	8695	37	10.8	00:222	29.1	5.8	2.7	.27	2.7	.42	6.7
0611	CHUB	9/10	8615	8695	37	09.-	00:269	28.2	3.2	1.2	.16	2.2	.22	3.9
1101	CHUB	9/13	8120	8695	14	11.-	00:300	2.0	2.1	.7	.07	1.5	.17	2.9

*Number of fish, if composite sample

MONS 065961

Appendix A. Summary of Data on Fish Analyzed for PCBs and DDT.

Sample Number	Species	1971 Date	Location	Drh	No*	Length	Wt	% Fat	PCB	pp' DDT	op' DDT	pp' DDE	pp' TDE	Total DDT
									(µg/gm)					
[illegible]	CHUB	[illegible]	[illegible]	[illegible]	1	08.5	00.160	20.5	5.1	.8	.10	2.4	.24	3.6
DD79	CHUB	0702	[illegible]	[illegible]	1	[illegible]	[illegible]	[illegible]	5.7	1.7	.24	1.6	.49	3.8
D126	CHUB	0702	[illegible]	[illegible]	1	[illegible]	[illegible]	16.0	6.4	3.5	.30	2.8	.62	7.6
DD73	CHUB	0702	[illegible]	[illegible]	1	[illegible]	[illegible]	24.0	7.5	2.4	.26	.7	.52	3.9
DD87	CHUB	0702	[illegible]	[illegible]	1	[illegible]	[illegible]	20.0	8.6	1.5	.2(	1.9	.71	4.2
D126	CHUB	0702	[illegible]	[illegible]	1	[illegible]	[illegible]	13.1	6.1	2.3	.25	2.4	.38	5.7
D128	CHUB	0702	[illegible]	[illegible]	1	[illegible]	[illegible]	20.1	5.1	1.0	.24	3.1	.42	5.4
DD87	CHUB	0702	[illegible]	[illegible]	1	[illegible]	[illegible]	21.2	6.2	2.1	.41	1.1	.60	4.1
DD81	CHUB	0702	[illegible]	[illegible]	1	[illegible]	[illegible]	12.2	6.7	2.5	.26	1.0	.14	4.3
DD82	CHUB	0702	[illegible]	[illegible]	1	[illegible]	[illegible]	16.3	4.4	2.2	.30	2.2	.50	5.2
DD84	CHUB	0702	[illegible]	[illegible]	1	[illegible]	[illegible]	22.5	3.3	1.1	.22	3.2	.14	4.7
DD85	CHUB	0702	[illegible]	[illegible]	1	[illegible]	[illegible]	14.3	11.0	3.7	.40	2.1	1.06	7.2
DD88	CHUB	0702	[illegible]	[illegible]	1	[illegible]	[illegible]	21.9	6.8	2.0	.26	1.3	.48	4.1
D131	CHUB	0702	[illegible]	[illegible]	1	[illegible]	[illegible]	20.4	5.1	1.0	.23	3.5	.66	6.0
D147	CHUB	0702	[illegible]	[illegible]	1	[illegible]	[illegible]	21.8	6.8	1.6	.21	1.5	.66	3.8
DD74	CHUB	0702	[illegible]	[illegible]	1	[illegible]	[illegible]	17.4	7.4	2.2	.23	1.6	.70	4.7
DD89	CHUB	0702	[illegible]	[illegible]	1	[illegible]	[illegible]	17.6	8.2	2.2	.31	2.1	.24	4.7
DD99	CHUB	0702	[illegible]	[illegible]	1	[illegible]	[illegible]	20.4	5.6	1.3	.22	3.2	.51	6.2
DD80	CHUB	0702	[illegible]	[illegible]	1	[illegible]	[illegible]	11.4	5.2	1.3	.32	2.2	.71	5.6
DD91	CHUB	0702	[illegible]	[illegible]	1	[illegible]	[illegible]	19.6	6.6	.5	.10	2.2	.21	3.1

*Number of fish, if composite sample

MONS 065962

Appendix A. Summary of Data on Fish Analyzed for PCBs and DDT.

Sample Number	Species	1971 Date	Location	Drh	No*	Lgth	Wt	% Fat	PCB	pp' DDT	op' DDT	pp' DDS	pp' TDE	Total DDT
									(µg/gm)					
D175	CHUB	0722	4345 8730	35	1	12.0		26.0	5.1	2.4	.19	3.9	.47	7.2
D180	CHUB	0722	4345 8730	35	1	11.4		25.0	5.0	2.2	.24	3.7	.43	6.6
D177	CHUB	0722	4345 8730	35	1	11.0		26.0	5.0	1.9	.20	3.3	.41	5.8
D179	CHUB	0722	4345 8730	35	1	11.0		29.0	5.0	1.5	.16	2.6	.19	4.5
D188	CHUB	0722	4345 8730	35	1	11.3		27.0	6.0	1.6	.24	3.3	.26	5.4
D195	CHUB	0815	4345 8730	47	1	0.5	00:224	22.3	3.7	.56	.11	2.4	.28	4.1
D205	CHUB	0815	4345 8730	47	1	0.5	00:224	30.4	3.7	.63	.13	2.6	.25	4.0
D227	CHUB	0815	4345 8730	47	1	0.5	00:192	21.5	3.0	1.4	.01	4.4	.20	5.8
D200	CHUB	0815	4345 8730	47	1	0.5	00:213	21.0	4.2	2.1	.20	2.1	.59	5.1
D209	CHUB	0815	4345 8730	47	1	0.5	00:177	24.5	4.2	1.2	.15	2.1	.27	3.7
D207	CHUB	0827	4345 8730	47	1	10.0	00:33	15.4	3.0	2.3	.21	3.3	.33	5.9
D200	CHUB	0827	4345 8730	47	1	0.5	00:192	24.6	4.7	1.3	.21	2.2	.35	4.1
D208	CHUB	0827	4345 8730	47	1	0.5	00:170	21.0	7.7	2.7	.34	4.7	.53	8.1
D210	CHUB	0827	4345 8730	47	1	0.5	00:171	17.5	3.2	1.9	.27	3.2	.47	5.8
D204	CHUB	0827	4345 8730	47	1	0.5	00:181	22.3	5.0	2.0	.20	3.4	.40	6.2
D212	CHUB	1015	4345 8730		1	0.5	00:222	15.0	2.3	2.2	.22	2.7	.43	5.7
D213	CHUB	1015	4345 8730		1	0.5	00:177	23.4	5.0	1.0	.11	1.4	.21	2.7
D240	CHUB	1015	4345 8730		1	0.5	00:131	14.2	3.1	1.6	.10	2.7	.25	4.2
D232	CHUB	1015	4345 8730		1	0.5	00:159	15.3	4.8	2.3	.17	3.3	.37	6.6
D227	CHUB	1015	4345 8730		1	0.5	00:177	15.5	4.3	1.7	.11	2.7	.20	4.3

*Number of fish, if composite sample

MONS 065963

Appendix A. Summary of Data on Fish
Analyzed for PCBs and DDT.

Sample Number	Species	1971 Date	Location	Fish No.*	Length	Wt	% Fat	(µg/gm) PCB	pp' DDT	op' DDT	pp' DDE	pp' TDE	Total DDT
0122	CHUB	06 18	8240	8220	22	1	10.2	15.0	12.0	2.1	.19	2.5	.81	5.6
0115	CHUB	06 18	8240	8220	22	1	09.4	13.9	9.0	2.1	.23	2.9	.46	5.7
0006	CHUB	06 18	8240	8220	22	1	09.0	27.0	8.1	2.0	.33	2.8	.45	5.4
0008	CHUB	06 18	8240	8220	24	1	09.0	21.2	9.1	4.5	.52	2.7	.73	8.0
0117	CHUB	06 18	8240	8220	26	1	09.0	10.0	7.4	.5	.00	1.2	.20	1.9
0590	CHUB	06 18	8240	8240	26	1	08.8	06.1165	16.1	5.7	2.4	.48	4.4	.71	8.3
0578	CHUB	06 18	8240	8240	26	1	09.0	06.1157	20.2	3.4	1.5	.20	3.7	.27	5.6
0594	CHUB	06 18	8240	8240	28	1	10.1	06.1183	19.4	6.6	2.1	.24	3.8	.51	8.6
0589	CHUB	06 18	8240	8240	28	1	09.8	06.1161	17.4	6.2	2.0	.27	3.1	.41	5.7
0587	CHUB	06 18	8240	8240	28	1	09.8	06.1182	15.6	4.2	1.9	.24	3.0	.27	5.4
0588	CHUB	06 18	8240	8240	28	1	09.8	06.1159	13.6	4.1	1.6	.14	2.7	.19	4.6
0586	CHUB	06 18	8240	8240	28	1	09.8	06.1160	16.8	8.7	2.4	.29	2.8	.27	5.5
0053	CHUB	06 17	8240	8240	30	1	09.8		18.8	8.2	2.5	.23	3.8	.42	7.0
0084	CHUB	06 17	8240	8240	30	1	10.0		17.8	8.2	1.9	.25	.6	.36	3.2
0112	CHUB	06 17	8240	8240	32	1	10.8		29.0	7.9	2.5	.19	3.2	.19	6.1
0199	CHUB	06 22	8240	8220	32	1	11.0		35.0	9.0	1.3	.21	3.6	.22	5.9
0174	CHUB	06 22	8240	8220	32	1	10.8		25.1	8.6	2.2	.26	3.5	.40	6.2
0186	CHUB	06 22	8240	8220	34	1	10.4		29.1	10.7	2.6	.29	4.9	.32	8.1
0190	CHUB	06 22	8240	8220	34	1	09.8		22.2	6.6	1.9	.17	1.6	.45	3.6
0185	CHUB	06 22	8240	8220	34	1	11.4		27.4	6.5	2.6	.27	3.1	.32	6.3

*Number of fish, if composite sample

MONS 065964

Appendix A. Summary of Data on Fish Analyzed for PCBs and DDT.

Sample Number	1971 Species	Date	Location	Dth No	Lgth	Wt	% Fat	PCB (ug/gm)	pp' DDT (ug/gm)	op' DDT (ug/gm)	pp' DDE (ug/gm)	pp' TDE (ug/gm)	Total DDT (ug/gm)
[illegible]	CHUB	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	CHUB	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	CHUB	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	CHUB	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	CHUB	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	CHUB	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	CHUB	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	CHUB	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	CHUB	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	CHUB	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	CHUB	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	CHUB	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	CHUB	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	CHUB	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	CHUB	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	CHUB	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	CHUB	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	CHUB	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	CHUB	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	CHUB	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	CHUB	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	CHUB	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	CHUB	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

*Number of fish, if composite sample

MONS 065965

Appendix A. Summary of Data on Fish
Analyzed for PCBs and DDT.

Sample Number	Species	1971 Date	Location	Dth No*	Lgth	Wt	% Fat	PCB	pp' DDT	op' DDT	pp' DDE	pp' TDE	Total DDT
								(ug/gm)					
L161	CHUB	0911	9520 8695	19 1	16.0	00.200	5.0	3.1	.7	.07	1.9	.23	2.9
L169	CHUB	0911	9520 8695	19 1	20.5	01.760	5.2	9.1	2.9	.13	3.9	.79	8.2
L159	CHUB	0911	9520 8695	19 1	23.0	01.300	5.9	6.3	1.2	.09	3.1	.29	4.7
L163	CHUB	0911	9520 8695	19 1	23.0	01.970	6.6	7.9	.2	.03	2.9	.19	3.8
L165	CHUB	0911	9520 8695	19 1	21.0	01.570	9.7	6.6	.8	.08	2.9	.31	3.6
0550	CHUB	0918	9520 8635	93 1	09.5	00.199	20.1	6.8	2.1	.27	2.5	.98	5.9
0546	CHUB	0918	9520 8635	93 1	08.8	00.178	22.2	6.8	3.6	.35	3.3	.76	8.0
0545	CHUB	0918	9520 8635	93 1	08.3	00.123	24.7	4.3	1.5	.20	2.4	.32	4.6
0509	CHUB	0916	9520 8695	17 1	10.5	00.243	20.1	4.0	1.7	.19	2.8	.35	5.0
0511	CHUB	0916	9520 8695	17 1	10.5	00.266	24.3	3.9	.9	.13	1.9	.19	3.1
0508	CHUB	0916	9520 8695	17 1	09.5	00.182	16.6	3.3	1.0	.07	2.5	.27	3.9
0509	CHUB	0916	9520 8695	17 1	11.0	00.231	24.9	3.9	1.4	.13	4.0	.31	5.8
0812	CHUB	0719	9530 8525	30 1	11.5	00.225	21.9	4.0	1.3	.21	2.3	.39	4.2
0809	CHUB	0719	9530 8525	30 1	11.5	00.259	23.9	2.5	.8	.20	1.2	.49	2.7
0813	CHUB	0719	9530 8525	30 1	10.0	00.318	26.6	2.9	1.1	.12	2.3	.27	3.8
0814	CHUB	0719	9530 8525	30 1	10.5	00.293	21.6	3.1	.8	.14	1.5	.48	3.0
0810	CHUB	0719	9530 8525	30 1	10.0	00.250	24.6	4.2	1.1	.16	2.3	.27	3.8
0807	CHUB	0719	9530 8525	30 1	11.5	00.329	16.2	3.1	1.3	.17	2.1	.33	3.8
0806	CHUB	0719	9530 8525	30 1	12.0	00.374	21.9	3.9	1.2	.17	2.9	.29	4.6
0808	CHUB	0719	9530 8525	30 1	10.5	00.282	18.9	3.1	.6	.17	2.0	.41	3.2

*Number of fish, if composite sample

MONS 065966

Appendix A. Summary of Data on Fish
Analyzed for PCBs and DDT.

Sample Number	Species	1971 Date	Location	Drh	No*	Lgth	Wt	% Fat	PCB	pp' DDT	op' DDT	pp' DDE	pp' TDE	Total DDT
									(ug/gm)					
0815	CHUB	0719	4530 6525	30	1	09.5	00.137	13.9	3.0	1.0	.11	2.1	.19	3.4
0822	CHUB	0527	4550 8615	40	1	10.6	00.165	13.0	5.0	1.8	.21	2.4	.56	5.0
0841	CHUB	0527	4550 8615	40	1	10.1	00.163	17.1	5.3	1.5	.00	3.6	.34	5.4
0838	CHUB	0527	4550 8615	40	1	09.8	00.176	15.3	4.6	1.9	.19	2.6	.42	5.1
0836	CHUB	0527	4550 8615	40	1	10.6	00.226	23.7	8.6	1.5	.10	2.7	.27	4.6
0889	CKSH	1015	4305 8745	10	1	22.5	01.936	20.9	24.0	4.7	.53	6.6	1.67	13.4
0899	CKSH	1021	4410 8740		1	29.0	03.178	5.0	15.9	2.0	.31	8.3	.65	11.3
0893	CKSH	1021	4410 8740		1	22.5	02.997	4.0	12.0	1.2	.17	5.0	.66	6.9
0905	CKSH	1021	4410 8740		1	29.0	02.997	7.7	14.0	1.2	.22	5.7	.63	7.7
0898	CKSH	1021	4410 8740		1	29.0	03.059	5.4	7.1	1.0	.16	4.9	.40	6.5
0897	CKSH	1021	4410 8740		1	27.0	04.313	3.9	10.9	1.0	.16	6.0	.40	7.6
0894	CKSH	1021	4410 8740		1	22.0	02.954	4.9	14.2	1.5	.29	9.5	.56	11.9
0896	CKSH	1021	4410 8740		1	23.0	02.724	5.9	7.8	.7	.12	5.1	.34	6.3
0919	CKSH	1021	4446 8720		1	25.0	03.178	3.6	12.3	1.2	.19	5.0	.46	6.8
0907	CKSH	1021	4446 8720		1	23.0	02.270	5.0	8.9	.9	.14	3.9	.31	5.3
0908	CKSH	1021	4446 8720		1	25.0	02.724	3.3	14.2	.9	.06	6.2	.19	7.3
0916	CKSH	1021	4446 8720		1	27.0	03.178	4.9	7.3	1.1	.23	5.1	.47	6.9
0913	CKSH	1021	4446 8720		1	25.0	03.178	2.4	6.7	1.3	.28	5.4	.62	7.6
0917	CKSH	1021	4446 8720		1	23.0	02.997	2.9	11.9	.9	.10	4.2	.35	5.6
0910	CKSH	1021	4446 8720		1	25.0	3.859	1.6	8.6	1.0	.20	3.0	.49	5.5

*Number of fish, if composite sample

Appendix A. Summary of Data on Fish
Analyzed for PCBs and DDT.

Sample Number	1971 Species	Date	Location	Dph	No*	Inch	Wt	% Fat	(µg/gm) PCB	pp' DDT	op' DDT	pp' DDE	pp' TDE	Total DDT
0916	CKSH	1021	9999	8720	1	21.0	02.093	3.6	8.5	1.1	.25	4.9	.51	6.8
0918	CKSH	1021	9999	8720	1	21.0	02.093	1.0	7.6	.8	.11	2.8	.30	3.9
0966	CKSH	0916	9517	8700	1	20.0	04.767	5.2	12.4	1.2	.20	5.5	.99	7.3
0642	COHO	0917	9193	8655	03	1	18.4	00.850	7.2	2.6	.5	.06	.6	.16	1.4
0643	COHO	0917	9193	8655	03	1	20.5	00.990	8.2	2.6	.4	.08	.9	.20	1.4
0644	COHO	0917	9193	8655	03	1	20.0	00.980	7.2	3.2	.5	.07	.9	.17	1.6
0647	COHO	0917	9193	8655	03	1	19.1	01.183	7.6	2.7	.5	.09	.8	.17	1.5
0647	COHO	0917	9193	8655	03	1	19.2	01.200	3.0	3.0	.6	.10	.8	.17	1.7
0999	COHO	0927	9193	8655	1	21.0	01.350	7.2	32.2	1.3	.21	5.0	.67	7.1
1000	COHO	0927	9193	8655	1	23.0	02.790	5.4	19.9	1.2	.25	6.7	.92	8.6
1002	COHO	0927	9193	8655	1	24.5	04.070	7.5	19.9	1.0	.16	5.0	.40	7.3
1007	COHO	0927	9193	8655	1	24.0	03.520	4.9	15.6	1.4	.25	6.2	.80	8.3
1008	COHO	0927	9193	8655	1	23.0	02.315	7.5	16.3	1.6	.23	4.5	.69	7.1
1018	COHO	0927	9193	8655	1	23.0	02.025	3.9	1.6	.3	.05	.7	.15	1.3
1023	COHO	1007	9193	8655	1	18.0	01.655	9.1	19.0	2.0	.22	6.3	.51	9.0
1025	COHO	1007	9193	8655	1	20.0	01.840	3.2	14.5	.9	.13	4.5	.28	5.8
1020	COHO	1007	9193	8655	1	20.0	02.490	5.2	18.3	2.2	.29	6.5	.50	9.4
1021	COHO	1007	9193	8655	1	19.0	01.970	3.5	11.2	1.0	.15	3.3	.37	4.8
1024	COHO	1007	9193	8655	1	13.5	00.540	0.9	10.1	1.0	.09	1.9	.39	3.3
0926	COHO	1021	9999	8720	1	27.0	03.059	4.0	11.6	1.4	.28	3.8	.55	6.0

*Number of fish, if composite sample

MONS 065968

Appendix A. Summary of Data on Fish Analyzed for PCBs and DDT.

Sample Number	Species	1971 Date	Location	Dup	No*	Lgth	Wt	% Fat	(µg/gm) PCB	pp' DDT	op' DDT	pp' DDE	pp' TDE	Total DDT
0934	COHO	1021	9395 8730		1	28.0	04.084	4.3	12.0	1.2	.17	5.9	.48	7.7
0923	COHO	1021	9395 8730		1	27.0	03.905	4.9	10.9	1.9	.33	5.7	.70	8.7
0929	COHO	1021	9395 8730		1	29.0	03.632	3.5	10.0	1.3	.35	7.0	.69	9.2
0928	COHO	1021	9395 8730		1	28.0	03.669	4.7	15.1	1.3	.27	8.3	.62	10.5
0930	COHO	1021	9395 8730		1	27.0	04.313	5.7	12.3	1.3	.22	6.8	.62	8.9
0931	COHO	1021	9395 8730		1	29.0	03.632	3.7	8.0	1.7	.31	6.6	.70	9.4
0933	COHO	1021	9395 8730		1	23.0	02.729	6.9	17.3	1.1	.29	7.5	.39	9.2
1318	COHO	0828	9355 8690		1	27.8	.	9.1	11.3	1.2	.20	5.9	.90	8.2
1314	COHO	0828	9355 8690		1	25.2	.	9.6	4.5	.6	.22	5.8	.47	7.0
1331	COHO	0829	9355 8690		1	24.8	.	9.6	12.8	.9	.16	9.5	.32	10.7
0775	COHO	1007	9393 8610		1	27.5	.	6.0	12.9	1.6	.29	6.9	.47	9.1
0781	COHO	1007	9393 8610		1	29.0	.	5.1	11.0	1.2	.19	5.1	.40	6.9
0773	COHO	1007	9393 8610		1	28.5	.	6.9	15.9	1.1	.21	6.9	.37	8.7
0783	COHO	1007	9393 8610		1	27.0	.	6.4	14.3	1.5	.23	6.0	.40	8.1
0769	COHO	1007	9393 8610		1	28.5	.	4.5	12.5	1.0	.18	5.4	.90	7.2
0779	COHO	1007	9393 8610		1	28.0	.	3.6	12.9	1.9	.29	3.9	.49	6.6
0782	COHO	1007	9393 8610		1	29.5	.	5.7	12.9	1.2	.17	5.9	.37	7.7
0771	COHO	1007	9393 8610		1	25.0	.	5.9	11.6	1.9	.34	5.9	.56	8.2
0774	COHO	1007	9393 8610		1	26.5	.	6.9	12.6	2.1	.34	6.1	.66	9.2
0958	COHO	0916	9513 8700		1	28.0	03.859	7.0	10.9	1.9	.22	6.0	.47	8.6

*Number of fish, if composite sample

MONS 065969

Appendix A. Summary of Data on Fish
Analyzed for PCBs and DDT.

(ug/gm)

Sample Number	Species	1971 Date	Location	Drh	No*	Lgth	Wt	% Fat	PCB	pp' DDT	op' DDT	pp' DDE	pp' TDE	Total DDT
0242	COHO	0916	9517	8700	1	27.0	09.767	7.0	11.9	1.6	.22	4.9	.59	7.2
1030	COHO	0916	9517	8700	1	26.0	02.810	7.0	18.9	1.7	.24	3.0	.58	5.6
0232	COHO	0916	9517	8700	1	28.0	04.998	7.1	16.9	1.2	.27	4.7	.91	6.6
0261	COHO	0916	9517	8700	1	16.0	01.135	8.2	3.2	.6	.08	1.9	.22	2.2
1027	COHO	0916	9517	8700	1	24.0	03.190	7.3	15.1	.9	.19	3.6	.38	5.0
1028	COHO	0916	9517	8700	1	25.0	03.150	7.5	15.2	.6	.20	5.3	.51	6.6
0249	COHO	0916	9517	8700	1	25.5	03.859	7.5	12.2	1.6	.25	6.8	.61	9.3
0252	COHO	0916	9517	8700	1	23.5	02.961	9.6	9.9	1.5	.20	4.3	.42	6.4
0255	COHO	0916	9517	8700	1	25.5	04.066	9.6	17.2	1.3	.24	5.5	.49	7.5
1013	LKTR	1015	9193	8655	12	1	20.5	01.815	19.3	15.9	2.5	.29	5.1	.59	8.9
1019	LKTR	1015	9193	8655	12	1	24.0	02.605	18.7	13.6	3.6	.50	10.1	1.27	15.5
1011	LKTR	1015	9193	8655	12	1	22.0	02.035	17.9	12.9	3.5	.39	5.9	.83	8.6
1018	LKTR	0908	9195	8650	10	1	29.6	02.595	15.0	21.9	3.7	.50	10.1	1.13	15.6
1017	LKTR	0908	9195	8650	10	1	22.0	01.865	20.9	24.3	3.9	.39	6.7	1.10	12.1
0236	LKTR	0421	9290	8620	10	1	22.2	.	16.1	12.0	1.8	.20	4.9	.66	7.4
0252	LKTR	0421	9290	8620	10	1	21.0	.	19.1	7.9	1.6	.29	2.5	.50	4.9
0250	LKTR	0421	9290	8620	10	1	23.8	.	16.3	11.3	1.3	.18	3.7	.41	5.6
0247	LKTR	0421	9290	8620	10	1	22.3	.	17.9	15.9	2.9	.39	4.8	.91	8.5
0238	LKTR	0421	9290	8620	10	1	23.2	.	16.6	6.0	.9	.16	4.5	.30	5.9
0246	LKTR	0421	9290	8620	10	1	29.3	.	16.5	10.7	2.8	.39	6.0	.80	10.0

*Number of fish, if composite sample

MONS 065970

Appendix A. Summary of Data on Fish
Analyzed for PCBs and DDT.

Sample Number	1971 Species	Date	Location	Drh	No*	Lgth	Wt	% Fat	PCB	pp' DDT	op' DDT	pp' DDE	pp' TDE	Total DDT
									(µg/gm)					
0295	LKTR	0621	9290 8620	13	1	20.6	.	17.6	8.2	2.5	.10	4.9	.50	7.7
0292	LKTR	0621	9290 8620	13	1	20.8	.	19.9	19.6	2.9	.30	5.0	.72	8.9
0298	LKTR	0621	9290 8620	10	1	24.5	.	15.9	13.9	2.6	.34	5.9	.95	9.3
1319	LKTR	0710	9290 8620	10	1	24.9	.	19.0	18.2	2.8	.35	8.8	.81	12.8
1317	LKTR	0710	9290 8620	10	1	25.8	.	15.0	18.3	.3	.23	9.5	.88	10.9
1327	LKTR	0710	9290 8620	10	1	21.9	.	21.9	12.3	2.1	.19	6.9	.59	9.8
1321	LKTR	0710	9290 8620	10	1	22.6	.	20.7	14.9	3.5	.29	4.9	.93	9.0
1315	LKTR	0710	9290 8620	10	1	23.6	.	22.8	13.0	2.5	.26	6.3	.69	9.7
1320	LKTR	1001	9290 8620	15	1	20.7	.	18.1	11.9	2.5	.20	2.6	.59	6.1
1324	LKTR	1001	9290 8620	15	1	22.5	.	16.1	12.3	1.9	.19	4.0	.53	6.6
1328	LKTR	1001	9290 8620	15	1	22.6	.	15.3	17.7	.3	.33	6.9	1.02	8.6
1324	LKTR	1001	9290 8620	15	1	24.0	.	24.3	19.1	4.0	.95	8.3	1.09	13.7
1333	LKTR	1001	9290 8620	15	1	23.8	.	13.6	21.1	1.9	.29	4.6	.62	7.4
1318	LKTR	1001	9290 8620	15	1	22.5	.	17.9	17.1	3.3	.26	4.6	.90	9.1
1332	LKTR	1001	9290 8620	15	1	23.8	.	18.9	20.4	4.3	.93	10.5	1.04	16.3
1310	LKTR	1001	9290 8620	15	1	22.6	.	12.9	25.6	3.7	.03	11.7	.90	16.3
1070	LKTR	0919	9305 8745	10	1	26.8	08.290	23.9	21.2	3.2	.96	9.2	1.00	13.8
1056	LKTR	0919	9305 8745	10	1	28.0	09.980	19.0	26.5	3.9	.59	15.0	1.22	20.7
1065	LKTR	0919	9305 8745	10	1	25.5	02.070	18.4	31.7	1.7	.53	13.9	1.12	16.7
1083	LKTR	0919	9305 8745	1	1	29.5	02.905	15.5	17.7	5.5	.99	7.5	1.15	15.4

*Number of fish, if composite sample

MONS 065971

Appendix A. Summary of Data on Fish
Analyzed for PCBs and DDT.

(ug/gm)

Sample Number	Species	1971 Date	Location	Dph	No.*	Length	Wt	% Fat	PCB	pp' DDT	op' DDT	pp' DDE	pp' TDE	Total DDT
1084	LKTR	0719	9305	8745	1	29.5	02.945	19.7	17.8	2.3	.31	2.2	.86	10.7
1085	LKTR	0719	9305	8745	1	25.0	03.275	16.9	21.1	2.9	.91	10.1	.93	14.9
0887	LKTR	1015	9305	8795	10	19.0	01.076	12.1	11.3	1.1	.16	2.6	.99	4.3
0895	LKTR	1015	9305	8795	10	18.5	01.012	12.2	6.9	1.0	.14	2.7	.35	4.2
0891	LKTR	1015	9305	8795	10	13.5	00.269	5.2	8.3	.8	.08	1.0	.22	2.2
0888	LKTR	1015	9305	8795	10	19.9	01.132	14.9	8.6	.9	.13	2.8	.32	4.1
0900	LKTR	1015	9305	8795	10	13.0	00.214	7.5	13.5	1.0	.10	1.5	.32	2.9
0889	LKTR	1015	9305	8795	10	19.5	01.365	16.6	13.9	1.5	.26	2.3	.70	4.7
0886	LKTR	1015	9305	8795	10	23.5	02.220	20.7	13.7	2.3	.24	3.9	.61	7.0
0902	LKTR	1015	9305	8795	10	13.0	00.292	5.8	17.8	.9	.06	1.6	.36	2.9
0896	LKTR	1015	9305	8795	10	15.8	00.329	5.9	6.1	.6	.02	1.2	.21	2.1
0673	LKTR	0713	9395	8730	1	30.0	00.295	9.0	12.1	.9	.12	3.9	.36	5.3
0313	LKTR	0713	9395	8730	15	29.4	....	29.0	15.7	3.1	.98	7.3	.83	11.5
0269	LKTR	0713	9395	8730	15	25.5	....	23.0	20.2	1.2	.29	8.2	.42	10.1
0270	LKTR	0713	9395	8730	15	17.5	....	17.0	9.9	1.6	.25	2.7	.48	5.1
0234	LKTR	0713	9395	8730	05	24.0	....	14.0	13.7	2.3	.37	7.4	.65	10.7
0233	LKTR	0713	9395	8730	05	19.5	....	16.0	9.4	1.2	.20	3.7	.39	5.4
0231	LKTR	0713	9395	8730	05	23.5	....	16.0	12.1	2.5	.32	5.3	.72	8.9
0263	LKTR	0713	9395	8730	15	21.5	....	18.1	12.9	2.6	.39	3.7	.80	7.9
0317	LKTR	0713	9395	8730	15	26.8	....	18.1	14.9	3.9	.33	7.0	.93	12.2

*Number of fish, if composite sample

MONS 065972

Appendix A. Summary of Data on Fish
Analyzed for PCBs and DDT.

(ug/gm)

Sample Number	Species	1971 Date	Location	Drh	No*	Lgth	Wt	% Fat	PCB	pp' DDT	op' DDT	pp' DDE	pp' TDE	Total DDT
0671	LKTR	0713	9395 8730				00.177	8.1	17.8	.7	.12	2.7	.33	3.8
0674	LKTR	0713	9395 8730				00.169	8.2	7.1	.6	.07	1.8	.17	2.6
0273	LKTR	0713	9395 8730	15	1	15.5		10.2	7.9	1.9	.19	2.1	.37	4.1
0675	LKTR	0713	9395 8730				00.258	13.2	10.6	1.1	.04	3.9	.32	5.4
0672	LKTR	0713	9395 8730				00.174	8.3	12.0	.7	.09	3.2	.29	4.9
0271	LKTR	0713	9395 8730	15	1	20.0		16.3	12.6	1.1	.19	2.4	.30	4.1
0265	LKTR	0713	9395 8730	15	1	23.6		21.3	17.3	2.8	.37	3.9	1.01	8.2
0311	LKTR	0713	9395 8730	15	1	25.5		19.9	12.9	2.3	.26	5.6	.69	8.8
0262	LKTR	0713	9395 8730	15	1	19.0		15.9	9.8	1.1	.19	2.6	.31	4.2
0233	LKTR	0713	9395 8730	05	1	25.2		16.5	15.9	2.5	.50	6.8	.78	10.3
0670	LKTR	0713	9395 8730				00.273	8.4	6.1	.7	.09	2.0	.29	3.1
0230	LKTR	0713	9395 8730	05	1	22.8		17.4	17.7	2.7	.38	5.3	.68	9.1
0264	LKTR	0713	9395 8730	15	1	25.5		23.7	13.3	2.0	.33	4.6	.58	7.5
0316	LKTR	0713	9395 8730	15	1	20.0		15.7	8.7	1.6	.20	3.0	.52	5.3
0318	LKTR	0713	9395 8730	15	1	21.5		14.7	12.1	1.5	.25	5.3	.55	7.6
0315	LKTR	0713	9395 8730	15	1	26.0		21.0	12.0	2.7	.31	6.2	.73	9.9
0274	LKTR	0713	9395 8730	15	1	22.0		17.8	8.9	1.3	.27	2.9	.59	5.0
0676	LKTR	0713	9395 8730				00.210	10.0	12.0	1.1	.15	3.7	.32	5.2
0669	LKTR	0713	9395 8730	1			00.148	10.9	14.0	.9	.09	3.9	.12	4.1
0310	LKTR	0701	9355 8490	13	1	20.5		20.0	6.3	1.5	.21	2.9	.55	4.6

*Number of fish, if composite sample

MONS 065973

Appendix A. Summary of Data on Fish
Analyzed for PCBs and DDT.

Sample Number	1971 Species	Date	Location	Dph	No*	Lgth	Wt	% Fat	PCB	pp' DDT	op' DDT	pp' DDE	pp' TDE	Total DDT
									(ug/gm)					
0219	LKTR	0701	9355 8690	13	1	22.8		19.1	8.7	2.2	.90	3.7	.67	7.0
0213	LKTR	0701	9355 8690	13	1	20.2		18.3	5.6	1.6	.20	1.9	.55	4.3
0215	LKTR	0701	9355 8690	13	1	20.3		14.3	6.1	1.5	.12	2.2	.46	4.3
0304	LKTR	0701	9355 8690	13	1	21.8		18.3	9.7	1.7	.22	3.9	.52	6.3
0223	LKTR	0701	9355 8690	13	1	21.7		17.9	9.1	1.8	.35	4.9	.65	7.7
0309	LKTR	0701	9355 8690	13	1	20.0		16.9	8.2	1.6	.21	3.3	.59	5.7
0308	LKTR	0701	9355 8690	13	1	22.0		17.7	11.3	2.1	.23	3.8	.60	6.7
0306	LKTR	0701	9355 8690	13	1	21.7		13.7	9.0	1.7	.20	2.8	.46	5.3
0216	LKTR	0709	9355 8690	10	1	21.0		14.2	9.5	2.4	.33	4.4	.73	7.9
0219	LKTR	0709	9355 8690	10	1	20.9		11.3	8.2	2.0	.39	4.0	.79	7.2
0256	LKTR	0709	9355 8690	10	1	20.5		13.3	6.7	1.5	.24	2.0	.48	4.2
0218	LKTR	0709	9355 8690	10	1	21.3		19.9	7.8	1.9	.79	2.5	.67	5.9
0305	LKTR	0709	9355 8690	10	1	21.6		14.6	9.9	2.1	.27	3.6	.52	6.5
0221	LKTR	0709	9355 8690	13	1	20.0		15.2	6.8	1.9	.31	1.9	.61	4.7
0761	LKTR	1019	9455 8535	1		24.0		16.0	12.2	2.6	.30	4.7	.78	8.3
0766	LKTR	1019	9455 8535	1		26.0		25.0	20.2	2.5	.49	12.8	.89	16.6
0763	LKTR	1019	9455 8535	1		28.5		24.2	12.5	2.9	.39	10.0	.93	13.8
0755	LKTR	1019	9455 8535	1		28.0		24.3	14.1	2.6	.30	5.6	.76	9.3
0764	LKTR	1019	9455 8535	1		25.0		19.3	10.6	2.0	.29	5.7	.56	8.5
0767	LKTR	1019	9455 8535	1		24.0		15.4	3.9	1.1	.17	2.5	.46	4.2

*Number of fish, if composite sample

MONS 065974

Appendix A. Summary of Data on Fish Analyzed for PCBs and DDT.

(ug/gm)

Sample Number	Species	1971 Date	Location	Dph	No*	Lgth	Wt	% Fat	PCB	pp' DDT	op' DDT	pp' DDE	pp' TDE	Total DDT
0760	LKTR	1019	4955 8535		1	26.0	.	15.6	12.6	1.8	.20	4.3	.69	7.0
0762	LKTR	1019	4955 8535		1	18.8	.	15.7	4.2	.7	.17	2.3	.50	3.7
0282	LKTR	0721	4505 8730	20	1	22.0	.	23.0	5.6	.8	.10	3.3	.22	4.4
0320	LKTR	0721	4505 8730	20	1	29.0	.	10.1	6.0	1.1	.12	3.3	.45	4.9
0279	LKTR	0721	4505 8730	20	1	23.0	.	19.1	10.9	1.1	.19	3.5	.42	5.2
0209	LKTR	0721	4505 8730	20	1	22.5	.	21.2	9.9	1.8	.22	4.5	.63	7.0
0276	LKTR	0721	4505 8730	20	1	23.0	.	19.3	10.7	1.7	.26	4.3	.54	6.8
0324	LKTR	0721	4505 8730	20	1	29.6	.	16.5	11.3	1.9	.22	5.0	.57	7.7
0211	LKTR	0721	4505 8730	20	1	22.0	.	20.6	7.3	2.3	.17	3.4	.43	6.3
0321	LKTR	0721	4505 8730	20	1	23.5	.	18.7	11.3	1.9	.19	2.2	.49	4.8
0281	LKTR	0721	4505 8730	20	1	23.5	.	21.7	9.2	1.9	.22	3.3	.60	5.8
0208	LKTR	0721	4505 8730	20	1	29.0	.	20.0	9.5	1.9	.41	5.1	.79	8.2
0212	LKTR	0721	4505 8730	20	1	23.5	.	20.8	9.8	1.5	.25	4.5	.69	6.9
1046	LKTR	0916	4517 8700		1	19.0	01.360	14.1	8.4	.9	.12	2.0	.33	3.4
1049	LKTR	0916	4517 8700		1	19.0	01.060	17.1	7.0	.9	.10	2.3	.35	3.6
1048	LKTR	0916	4517 8700		1	21.0	01.570	17.1	12.5	1.5	.23	5.0	.48	7.1
1039	LKTR	0916	4517 8700		1	26.0	03.050	15.1	18.7	1.8	.28	6.6	.54	9.2
1043	LKTR	0916	4517 8700		1	27.0	03.365	10.3	24.7	2.4	.34	9.4	.69	12.0
1045	LKTR	0916	4517 8700		1	19.5	01.185	12.3	7.5	.7	.10	2.8	.34	3.9
0762	LKTR	0916	4517 8700		1	29.0	03.370	18.6	14.2	3.6	.33	7.9	1.13	12.9

*Number of fish, if composite sample

MONS 065975

Appendix A. Summary of Data on Fish Analyzed for PCBs and DDT.

Sample Number	Species	1971 Date	Location	Dph	No*	Lgth	Wt	% Fat	PCB	pp' DDT	op' DDT	pp' DDE	pp' TDE	Total DDT
									(µg/gm)					
1050	LKTR	0916	9517	8700	1	26.0	03.440	22.7	22.1	3.5	.95	7.5	1.04	12.5
0205	LOUY	0721	9505	8730	20	1	19.0	6.1	2.6	.3	.03	.5	.15	.9
1290	PRCH	1015	9193	8655	12	1	06.0	00.072	5.0	3.8	.4	.04	.9	.15	1.5
1287	PRCH	1015	9193	8655	12	1	08.0	00.095	7.0	2.5	.2	.02	.8	.09	1.1
1297	PRCH	1015	9193	8655	12	1	08.0	00.079	5.1	5.2	.3	.05	1.1	.20	1.7
1305	PRCH	1015	9193	8655	12	1	08.0	00.084	6.3	5.0	.4	.04	.9	.15	1.5
1309	PRCH	1015	9193	8655	12	1	07.5	00.097	9.1	4.9	.5	.03	.7	.19	1.5
1303	PRCH	1015	9193	8655	12	1	07.5	00.083	5.5	3.3	.1	.02	.7	.05	.9
1300	PRCH	1015	9193	8655	12	1	07.5	00.081	6.5	4.9	.4	.04	.7	.16	1.2
1292	PRCH	1015	9193	8655	12	1	07.5	00.086	9.6	4.3	.3	.04	.6	.15	1.1
1308	PRCH	1015	9193	8655	12	1	08.0	00.106	7.2	9.9	.5	.06	.7	.20	1.5
1290	PRCH	1015	9193	8655	12	1	08.0	00.099	6.9	3.8	.4	.05	.8	.17	1.4
0790	PRCH	1013	9305	8795	10	1	09.5	00.496	5.0	14.3	.5	.05	1.0	.25	1.8
0792	PRCH	1013	9305	8795	10	1	09.0	00.194	5.1	8.0	.9	.11	.8	.25	1.9
0793	PRCH	1013	9305	8795	10	1	10.5	00.293	6.1	12.6	1.2	.16	1.4	.63	3.4
0799	PRCH	1013	9305	8795	10	1	09.5	00.146	6.2	8.9	.4	.06	.8	.21	1.5
0794	PRCH	1013	9305	8795	10	1	09.5	00.187	5.5	12.2	.6	.08	1.1	.27	2.1
0791	PRCH	1013	9305	8795	10	1	09.6	00.145	5.8	12.8	.6	.07	1.1	.27	2.1
0795	PRCH	1013	9305	8795	10	1	08.5	00.111	9.6	8.9	.5	.06	1.3	.29	2.1
0796	PRCH	1013	9305	8795	10	1	09.5	00.221	6.2	13.9	.6	.11	1.0	.41	2.9

*Number of fish, if composite sample.

MONS 065976

Appendix A. Summary of Data on Fish Analyzed for PCBs and DDT.

Sample Number	Species	1971 Date	Location	Drh	No*	Lgth	Wt	% Fat	PCB	pp' DDT	op' DDT	pp' DDE	pp' TDE	Total DDT
									(ug/gm)					
0798	PRCH	1013	9305 8745	10	1	08.5	00.134	5.8	4.8	.4	.00	.7	.12	1.3
0337	PRCH	0704	9345 8640	11	3	10.5	.	9.0	6.5	.1	.03	2.9	.12	2.7
0335	PRCH	0706	9355 8640	11	4	11.0	.	5.7	5.4	1.7	.22	2.1	.47	4.5
0719	PRCH	1012	9340 8625	11	1	11.3	.	9.0	6.2	1.7	.19	2.2	.39	4.4
0795	PRCH	1012	9340 8625	11	1	12.0	.	6.9	4.5	2.8	.09	1.3	.48	4.7
0343	PRCH	0825	9445 8750	07	1	08.5	00.132	9.9	1.5	.1	.02	.9	.12	.6
0347	PRCH	0825	9445 8750	07	1	08.8	00.165	7.9	0.1	.0	.00	.3	.06	.3
0339	PRCH	0826	9445 8750	07	1	08.6	00.190	9.9	1.5	.0	.00	.9	.11	.5
1033	RDTR	0916	9517 8700		1	24.0	04.180	22.0	7.3	1.0	.15	1.9	.32	3.3
0940	RDTR	0916	9517 8700		1	20.0	02.997	14.5	1.6	.3	.07	1.6	.13	2.1
0973	RDTR	0916	9517 8700		1	23.0	05.625	14.5	19.9	1.0	.18	5.3	.37	6.8
1036	RDTR	0916	9517 8700		1	24.0	04.035	21.8	7.3	1.5	.19	3.4	.52	5.4
1031	RDTR	0916	9517 8700		1	23.0	02.640	14.9	8.2	1.1	.16	3.1	.39	4.7
1134	RDSU	0911	9520 8645	19	1	15.0	00.550	5.1	2.3	.1	.07	1.0	.33	2.0
1133	RDSU	0911	9520 8645	19	1	15.0	00.770	8.2	3.3	.7	.09	1.5	.37	2.6
1130	RDSU	0911	9520 8645	19	1	19.5	01.990	9.4	1.5	.2	.09	2.2	.16	2.6
1127	RDSU	0911	9520 8645	19	1	17.0	00.745	9.9	2.3	.5	.07	1.5	.27	2.3
1129	RDSU	0911	9520 8645	19	1	18.0	01.195	8.5	4.1	1.0	.11	2.6	.42	4.1
1140	RDSU	0911	9520 8645	19	1	18.0	00.930	7.6	3.3	.4	.07	1.5	.25	2.3
1125	RDSU	0911	9530 8660	19	1	17.0	01.000	10.7	3.2	1.1	.15	1.9	.49	3.7

*Number of fish, if composite sample

MONS 065977

Appendix A. Summary of Data on Fish
Analyzed for PCBs and DDT.

Sample Number	Species	1971 Date	Location	Dmh	No*	Lgth	Wt	% Fat	(µg/gm) PCB	pp' DDT	op' DDT	pp' DDE	pp' TDE	Total DDT
1118	RDSU	0711	9530	8650	19	1	14.5	00.863	6.4	3.4	.7	.08	.2	.29	1.3
1124	RDSU	0711	9530	8650	19	1	16.5	01.005	8.5	2.8	.9	.06	1.5	.21	2.2
1119	RDSU	0711	9530	8650	19	1	17.5	00.800	8.5	3.3	1.1	.10	1.7	.42	3.3
1120	RDSU	0711	9530	8650	19	1	16.5	00.730	6.6	2.6	.7	.08	1.8	.31	2.9
1121	RDSU	0711	9530	8650	19	1	17.0	00.760	10.7	2.5	.7	.10	1.6	.39	2.6
1128	RDSU	0711	9530	8650	19	1	15.5	00.780	8.9	3.2	.7	.08	1.9	.29	3.0
1116	RDSU	0711	9530	8650	19	1	17.0	01.195	9.9	3.5	.7	.08	1.6	.31	2.6
1252	SCUL	1014	9290	8620	50	3	05.4	00.029	4.1	8.8	3.1	.04	2.6	.31	6.0
1240	SCUL	1014	9290	8620	50	4	04.6	00.022	6.1	2.9	.8	.05	1.4	.12	2.4
1241	SCUL	1014	9290	8620	50	5	04.6	00.017	6.5	2.3	.5	.05	.9	.10	1.5
1248	SCUL	1014	9290	8620	50	4	05.0	00.022	5.5	3.7	2.1	.07	2.2	.27	4.6
1253	SCUL	1014	9290	8620	50	4	03.8	00.012	5.5	1.8	.4	.03	.6	.09	1.1
1254	SCUL	1014	9290	8620	50	4	04.2	00.019	5.8	1.8	.69	.04	.8	.09	1.3
1250	SCUL	1014	9290	8620	50	2	05.0	00.036	6.9	4.0	2.0	.12	2.5	.23	4.8
1249	SCUL	1014	9290	8620	50	3	05.0	00.023	7.9	2.1	.6	.07	1.0	.10	1.8
1239	SMLT	1015	9193	8655	12	3	07.6	00.050	9.0	3.6	.9	.03	1.0	.12	1.5
1229	SMLT	1015	9193	8655	12	1	09.5	00.011	6.1	4.6	.7	.07	1.0	.22	2.0
1233	SMLT	1015	9193	8655	12	1	08.5	00.070	7.2	3.6	.4	.06	1.0	.12	1.5
1236	SMLT	1015	9193	8655	12	2	07.5	00.047	9.2	3.2	.8	.09	.9	.11	1.9
1231	SMLT	1015	9193	8655	12	3	06.5	00.030	7.2	2.3	.2	.03	.8	.10	1.1

*Number of fish, if composite sample

MONS 065978

Appendix A. Summary of Data on Fish
Analyzed for PCBs and DDT.

Sample Number	Species	1971 Date	Location	Dth	No*	Lgth	Wt	% Fat	PCB	pp' DDT	op' DDT	pp' DDE	pp' TDE	Total DDT
									(ug/gm)					
1298	SMLT	1015	4143 8655	12	9	05.5	00.021	5.7	1.5	.2	.02	.9	.05	.7
1290	SMLT	1015	4143 8655	12	3	04.5	00.030	5.7	1.9	.2	.03	.9	.06	1.2
1296	SMLT	1015	4143 8655	12	9	05.6	00.021	7.8	3.1	.3	.03	.7	.06	1.0
1239	SMLT	1015	4143 8655	12	1	08.5	00.072	7.8	4.3	.9	.09	1.0	.15	1.6
1293	SMLT	1015	4143 8655	12	2	06.5	00.036	7.8	3.4	.3	.03	.9	.07	1.3
1231	SMLT	1015	4143 8655	12	1	08.5	00.080	6.8	4.3	.6	.06	1.1	.17	1.9
0892	SMLT	1015	4345 8730		9	05.5	.	5.1	.7	.2	.03	.8	.15	1.2
0893	SMLT	1015	4345 8730		2	07.0	.	2.7	.8	.5	.09	.5	.12	1.0
0891	SMLT	1015	4345 8730		9	04.5	.	3.9	.5	.2	.02	.3	.10	.7
0171	SMLT	0721	4505 8730	20	2	05.5	.	5.3	2.2	.1	.01	.3	.11	.5
0172	SMLT	0721	4505 8730	20	3	04.6	.	3.5	1.0	.1	.01	.3	.06	.4
0170	SMLT	0721	4505 8730	20	9	06.5	.	3.6	3.5	.1	.01	.4	.09	.6
0168	SMLT	0721	4505 8730	20	2	09.5	.	4.9	2.2	.4	.05	2.0	.23	2.7
0527	SMLT	0911	4520 8645	14	2	06.7	00.093	8.1	5.1	.3	.05	1.8	.15	2.2
0519	SMLT	0911	4520 8645	14	1	08.0	00.061	5.2	2.4	.5	.08	.7	.14	1.4
0522	SMLT	0911	4520 8645	14	1	08.3	00.077	9.7	7.8	.8	.09	.8	.11	1.3
0517	SMLT	0911	4520 8645	14	2	07.2	00.096	6.4	5.8	.4	.03	.6	.10	1.3
0520	SMLT	0911	4520 8645	14	2	07.0	00.039	4.4	2.8	.3	.03	.8	.11	1.2
0523	SMLT	0911	4520 8645	14	1	08.0	00.064	4.6	1.4	.4	.04	.5	.10	1.1
0524	SMLT	0911	4520 8645	14	2	07.0	00.092	5.8	1.8	.3	.04	.6	.13	1.1

*Number of fish, if composite sample

MONS 065979

Appendix A. Summary of Data on Fish
Analyzed for PCBs and DDT.

Sample Number	Species	1971 Date	Location	Drh	No*	Lgth	Wt	% Fat	PCB	pp' DDT	op' DDT	pp' DDS	pp' TDE	Total DDT
									(ug/gm)					
0006	SHLT	0719	9530 8525	30	2	08.0		3.2	1.3	.9	.05	.7	.09	1.2
0004	SHLT	0719	9530 8525	30	3	06.5		4.3	1.0	.1	.05	.8	.10	1.1
0002	SHLT	0719	9530 8525	30	7	09.5		4.6	1.7	.1	.03	.5	.07	.7
0998	WHFH	1015	9193 8655	12	1	19.0	01.300	27.1	6.9	.9	.06	.6	.32	1.9
0992	WHFH	1015	9193 8655	12	1	18.0	01.350	29.2	5.6	.5	.06	.9	.31	1.3
0326	WHFH	0619	9290 8620	07	1	13.3		17.1	1.9	.6	.09	.6	.29	1.5
0324	WHFH	0619	9290 8620	07	1	14.8		22.3	2.8	.5	.10	.7	.21	1.6
0331	WHFH	0621	9290 8620	10	1	14.8		16.3	2.5	.3	.05	.9	.17	1.0
1098	WHFH	0906	9306 8625	19	1	16.0	01.135	19.0	5.5	.3	.03	.4	.21	1.1
1092	WHFH	0906	9306 8625	19	1	21.0	01.950	21.2	6.5	1.0	.09	.7	.41	2.2
1077	WHFH	0906	9306 8625	19	1	17.5	01.530	23.3	5.0	.6	.07	.4	.29	1.5
1093	WHFH	0906	9306 8625	19	1	17.0	01.390	22.7	4.6	.5	.06	.5	.23	1.3
1096	WHFH	0906	9306 8625	19	1	16.0	01.110	22.7	7.3	1.2	.21	.9	.62	2.9
1097	WHFH	0906	9306 8625	19	1	17.5	01.530	26.9	5.5	1.2	.13	.6	.53	2.5
0709	WHFH	1019	9955 8535	1	19.0			20.0	1.5	.1	.21	.9	.06	1.3
0701	WHFH	1019	9955 8535	1	18.5			12.0	1.9	.5	.06	1.3	.30	2.2
0698	WHFH	1019	9955 8535	1	18.0			13.1	1.0	.3	.06	1.2	.26	1.9
0702	WHFH	1019	9955 8535	1	19.0			13.2	2.3	.9	.07	1.6	.23	2.3
0695	WHFH	1019	9955 8535	1	19.5			14.2	1.8	.5	.06	1.1	.29	1.9
0696	WHFH	1019	9955 8535	1	18.0			15.3	1.8	.9	.06	1.2	.29	2.0

*Number of fish, if composite sample

MONS 065980

Appendix A. Summary of Data on Fish Analyzed for PCBs and DDT.

Sample Number	Species	1971 Date	Location	Dsh No*	Lgth	Wt	% Fat	PCB	pp' DDT	op' DDT	pp' DDE	pp' TDE	Total DDT
								(µg/gm)					
0692	BHFH	1019	9455 8635	1	18.0	.	12.3	1.7	.4	.04	1.3	.29	2.1
0697	BHFH	1019	9455 8635	1	19.0	.	13.9	2.0	.4	.07	1.7	.29	2.5
0699	BHFH	1019	9455 8635	1	21.5	.	9.4	1.0	.3	.04	.8	.27	1.5
0705	BHFH	1019	9455 8635	1	18.0	.	10.5	1.1	.7	.09	1.2	.21	2.2
0699	BHFH	1019	9455 8635	1	19.0	.	10.7	1.6	.4	.05	1.2	.26	1.9
0693	BHFH	1019	9455 8635	1	19.0	.	12.8	2.1	.5	.08	1.2	.32	2.0
1114	BHFH	0911	9520 8695	19	18.5	01.220	14.8	1.5	.5	.05	.7	.10	1.4
1111	BHFH	0911	9520 8695	19	16.0	00.965	14.5	1.3	.4	.04	.7	.15	1.3
1107	BHFH	0911	9520 8695	19	16.0	00.925	13.5	1.5	.4	.04	.7	.12	1.3
1101	BHFH	0911	9520 8695	19	18.0	01.270	17.5	1.5	.3	.07	.7	.17	1.3
1105	BHFH	0911	9520 8695	19	17.0	01.210	12.6	1.5	.6	.06	.8	.22	1.6
1103	BHFH	0911	9520 8695	19	18.0	01.260	13.6	1.3	.2	.04	.8	.12	1.2
1108	BHFH	0911	9520 8695	19	18.0	01.265	17.6	1.8	.5	.06	.6	.17	1.4
1104	BHFH	0911	9520 8695	19	17.0	00.991	12.5	1.3	.5	.05	.6	.22	1.4
0705	BHSU	1015	9193 8655	12	18.0	01.310	9.4	2.1	.8	.00	1.5	.55	2.8
0704	BHSU	1015	9193 8655	12	18.0	01.370	13.8	19.2	2.7	.00	2.0	.99	5.2
1166	BHSU	1015	9240 8620	03	18.5	02.030	5.8	2.9	.5	.06	.8	.34	1.8
1169	BHSU	1015	9240 8620	05	16.0	00.780	3.8	5.0	.2	.02	.6	.15	1.0
1173	BHSU	1015	9240 8620	07	13.5	00.560	7.0	1.9	.1	.02	.4	.07	.5
1172	BHSU	1015	9240 8620	07	14.0	00.510	6.1	2.6	.2	.04	.5	.15	.8

*Number of fish, if composite sample

MONS 065981

Appendix A. Summary of Data on Fish Analyzed for PCBs and DDT.

Sample Number	Species	1971 Date	Location	Dph	No*	Length	Wt	% Fat	PCB	pp' DDT	op' DDT	pp' DDS	pp' DDE	Total DDT
									(µg/gm)					
1170	WHSU	1018	9250 8620	09	1	11.0	00.330	5.2	1.6	.2	.03	1.7	.12	2.0
1171	WHSU	1018	9250 8620	09	1	11.0	00.360	5.0	2.5	.0	.00	.4	.05	.4
1178	WHSU	1018	9250 8620	09	1	12.0	00.450	9.6	2.6	.1	.02	.4	.12	.6
0302	WHSU	0806	9995 8750	06	1	11.5	00.329	3.1	1.7	.0	.01	.2	.05	.3
0297	WHSU	0806	9995 8750	06	1	12.0	00.398	6.8	2.5	.2	.02	.5	.11	.8
0298	WHSU	0806	9995 8750	06	1	13.5	00.396	9.5	3.1	.0	.00	.3	.05	.4
0300	WHSU	0806	9995 8750	06	1	12.5	00.312	5.6	2.1	.0	.01	.3	.09	.4
0299	WHSU	0806	9995 8750	06	1	13.0	00.303	7.8	10.0	1.5	.22	.3	.59	2.6
0294	WHSU	0806	9995 8750	06	1	12.0	00.309	9.9	2.6	.0	.00	.3	.05	.4
0685	WHSU	1019	9955 8535		1	16.5		5.0	3.1	.5	.00	2.1	.47	3.1
0686	WHSU	1019	9955 8535		1	17.0		9.1	3.2	.6	.07	1.7	.39	2.7
0683	WHSU	1019	9955 8535		1	17.0		2.1	1.9	.2	.02	1.0	.20	1.4
0689	WHSU	1019	9955 8535		1	15.0		3.1	1.8	.3	.03	.9	.21	1.4
0677	WHSU	1019	9955 8535		1	11.5		3.3	2.9	.3	.01	1.4	.27	1.9
0681	WHSU	1019	9955 8535		1	17.0		2.4	1.6	.4	.05	1.5	.29	2.2
0682	WHSU	1019	9955 8535		1	18.0		3.8	2.7	.3	.02	1.2	.32	1.9
0687	WHSU	1019	9955 8535		1	17.5		1.8	1.8	.1	.00	.9	.22	1.2
0685	WHSU	1019	9955 8535		1	16.5		4.8	2.0	.3	.04	1.4	.30	2.1
0690	WHSU	1019	9955 8535		1	18.5		4.9	2.5	.2	.03	1.2	.39	1.8
0678	WHSU	1019	9955 8535		1	18.0		4.9	3.5	1.5	.10	2.9	.67	4.7

*Number of fish, if composite sample

MONS 065982

Appendix A. Summary of Data on Fish Analyzed for PCBs and DDT.

Sample Number	Species	1971 Date	Location	Dph	No*	Inch	Wt	% Fat	(µg/gm) PCB	pp' DDT	op' DDT	pp' DDE	pp' TDE	Total DDT
0691	WHSU	1019	9455 8535		1	15.0		3.9	2.9	.6	.05	1.9	.37	2.3
0679	WHSU	1019	9455 8535		1	19.0		.9	1.3	.2	.01	.9	.15	1.2
0704	WHSU	0721	9505 8730	20	1	14.0		10.0	2.1	.9	.08	.7	.19	1.3
1148	WHSU	0911	9520 8695	19	1	16.5	01.045	7.2	4.7	.6	.06	1.5	.35	2.5
1152	WHSU	0911	9520 8695	19	1	18.0	01.230	6.3	1.5	.5	.03	.7	.17	1.4
1142	WHSU	0911	9520 8695	19	1	18.0	01.330	6.4	1.3	.1	.01	.4	.09	.6
1145	WHSU	0911	9520 8695	19	1	18.0	01.065	7.4	1.7	.2	.03	.7	.17	1.1
1151	WHSU	0911	9520 8695	19	1	18.5	01.240	3.5	1.7	.2	.02	.9	.11	1.3
1149	WHSU	0911	9520 8695	19	1	19.0	00.885	9.6	2.5	.9	.09	1.0	.21	2.2
1153	WHSU	0911	9520 8695	19	1	18.0	01.220	9.6	3.9	.5	.05	.9	.30	1.8
1144	WHSU	0911	9520 8695	19	1	17.5	01.020	6.7	1.8	.3	.04	.8	.17	1.3
1154	WHSU	0911	9520 8695	19	1	17.0	00.910	5.0	2.6	.4	.05	1.2	.17	1.9
1143	WHSU	0911	9520 8695	19	1	17.0	01.115	2.6	2.3	.2	.03	.8	.12	1.2
1156	WHSU	0911	9520 8695	19	1	18.0	00.950	4.0	2.7	.3	.04	.8	.27	1.4
1150	WHSU	0911	9520 8695	19	1	20.0	01.420	6.9	2.9	.3	.03	.7	.22	1.2

*Number of fish, if composite sample

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Appendix B. Selected Mass Spectra of Composite Samples of Lake Michigan Fish

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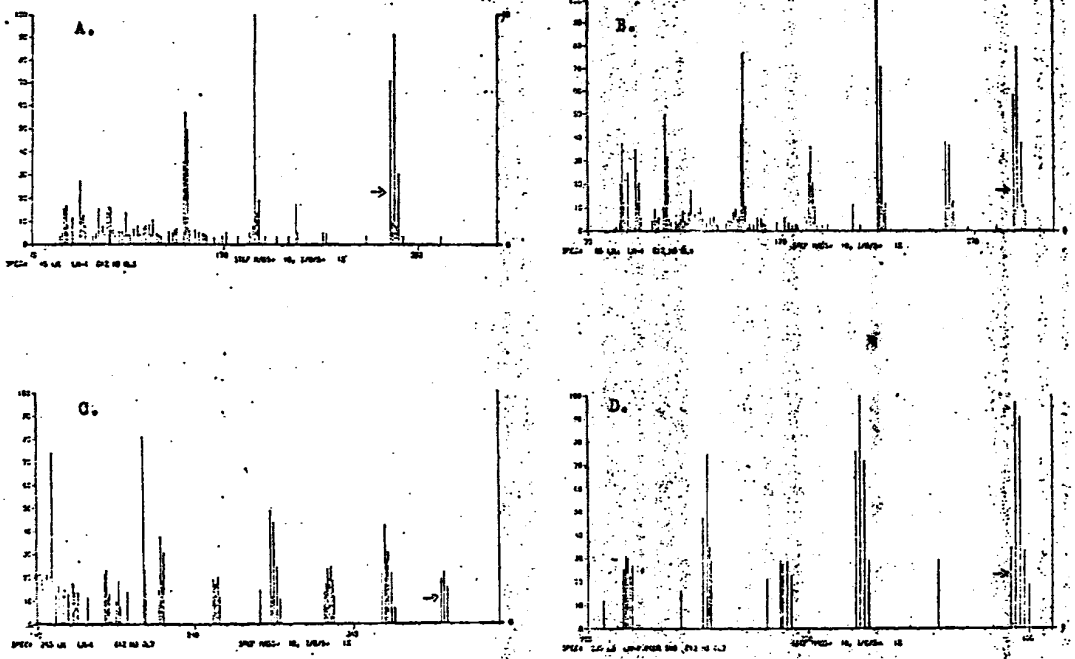

Figure I. Mass Spectra of Major PCBs in Lake Trout from the Milwaukee Area

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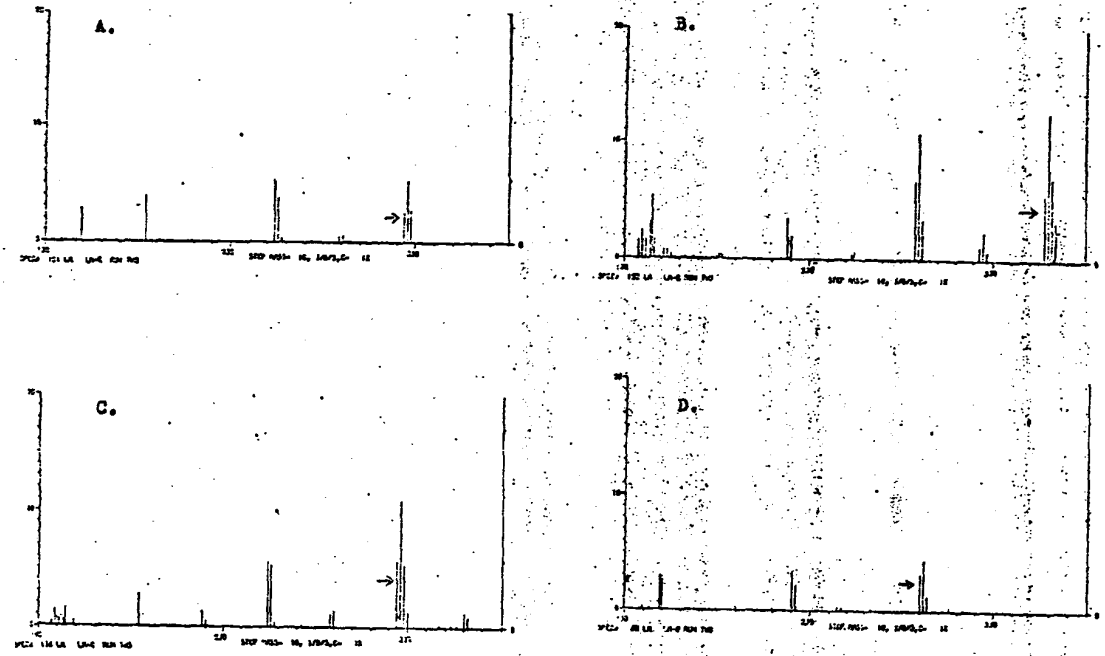

Figure II. Mass Spectra of Major PCBs in Lake Trout from the Saugatuck Area

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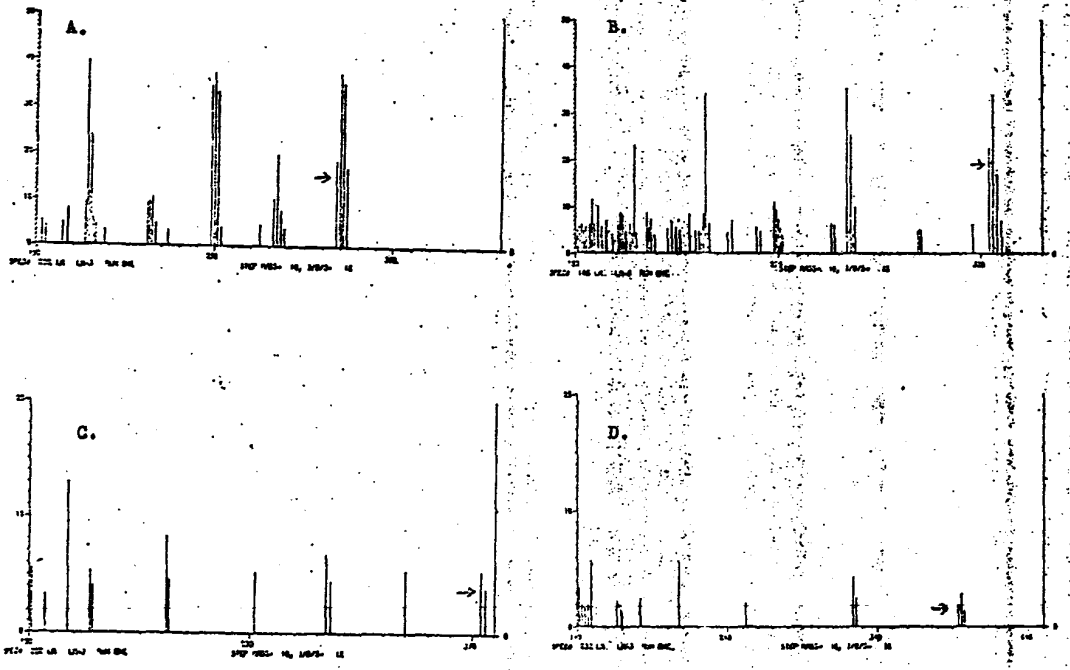

Figure XII. Mass Spectra of Major PCBs in Lake Trout from the Lexington Area

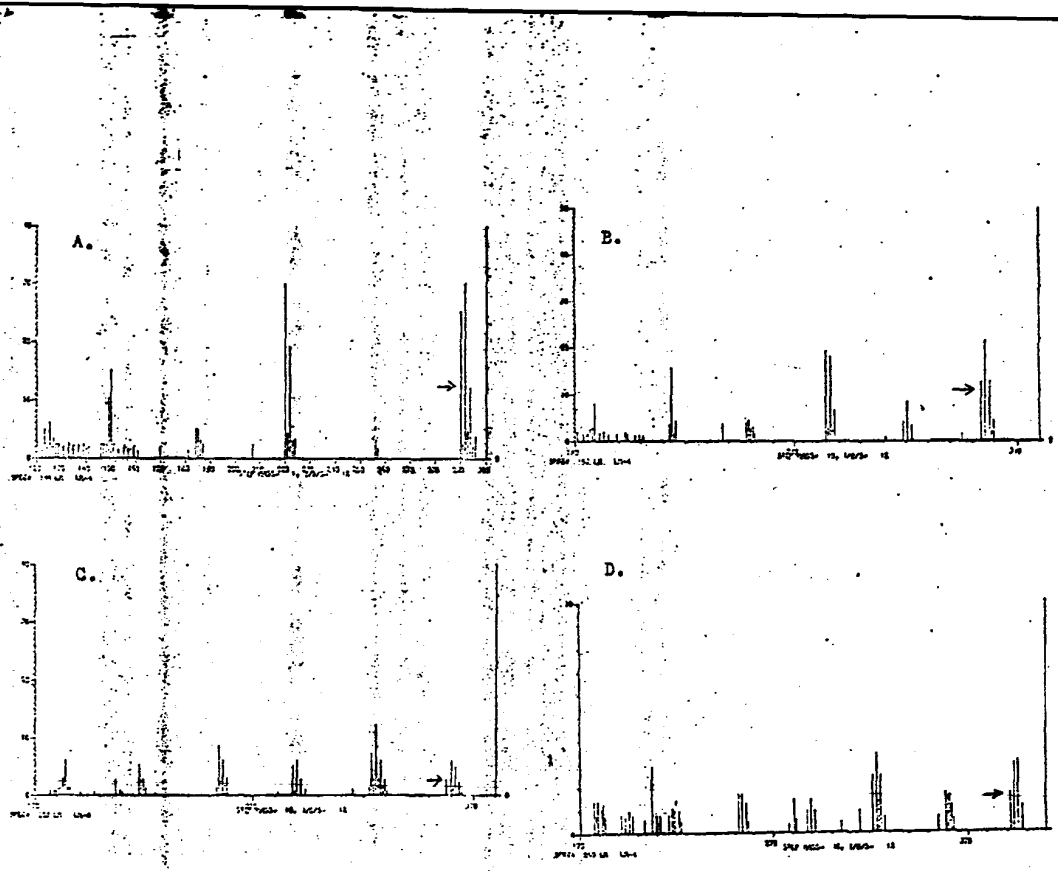

Figure IV. Mass Spectra of Major PCBs in Lake Trout from the Manitowoc Area

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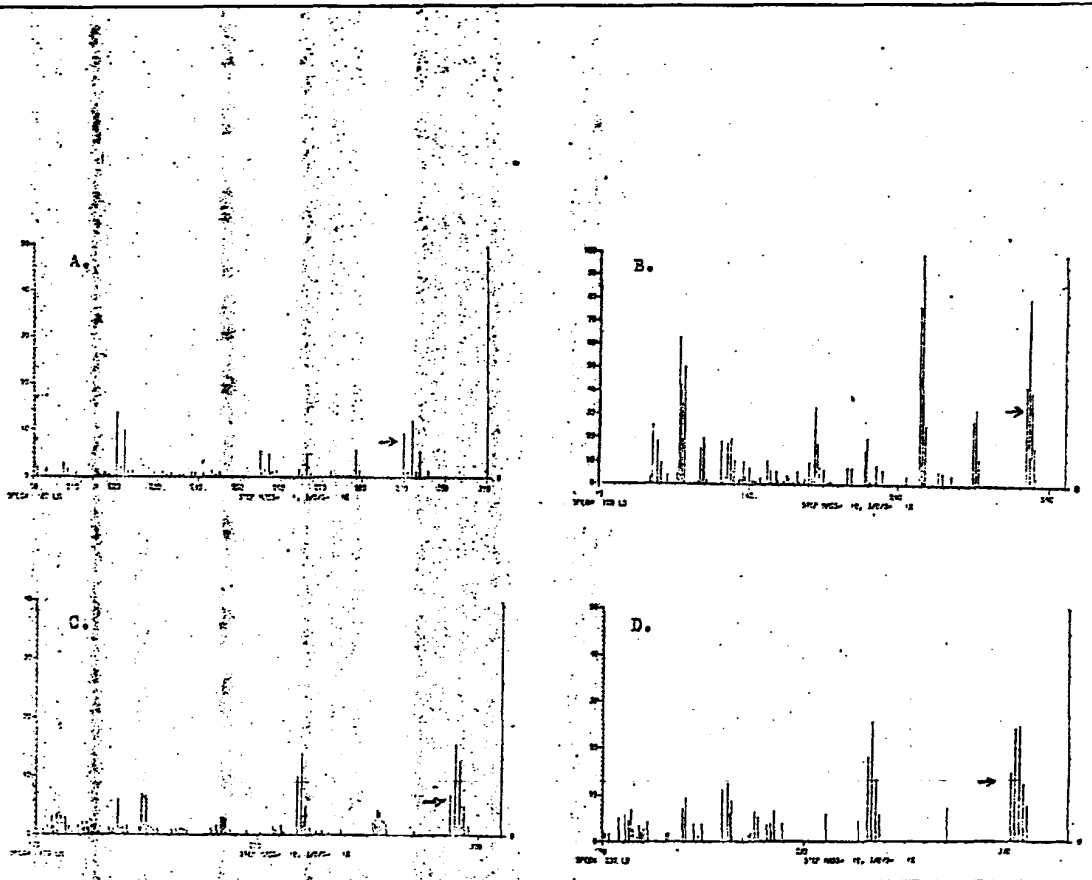

Figure V . Mass Spectra of Major PCBs
in Lake Trout from Traverse Bay

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MONS 065990

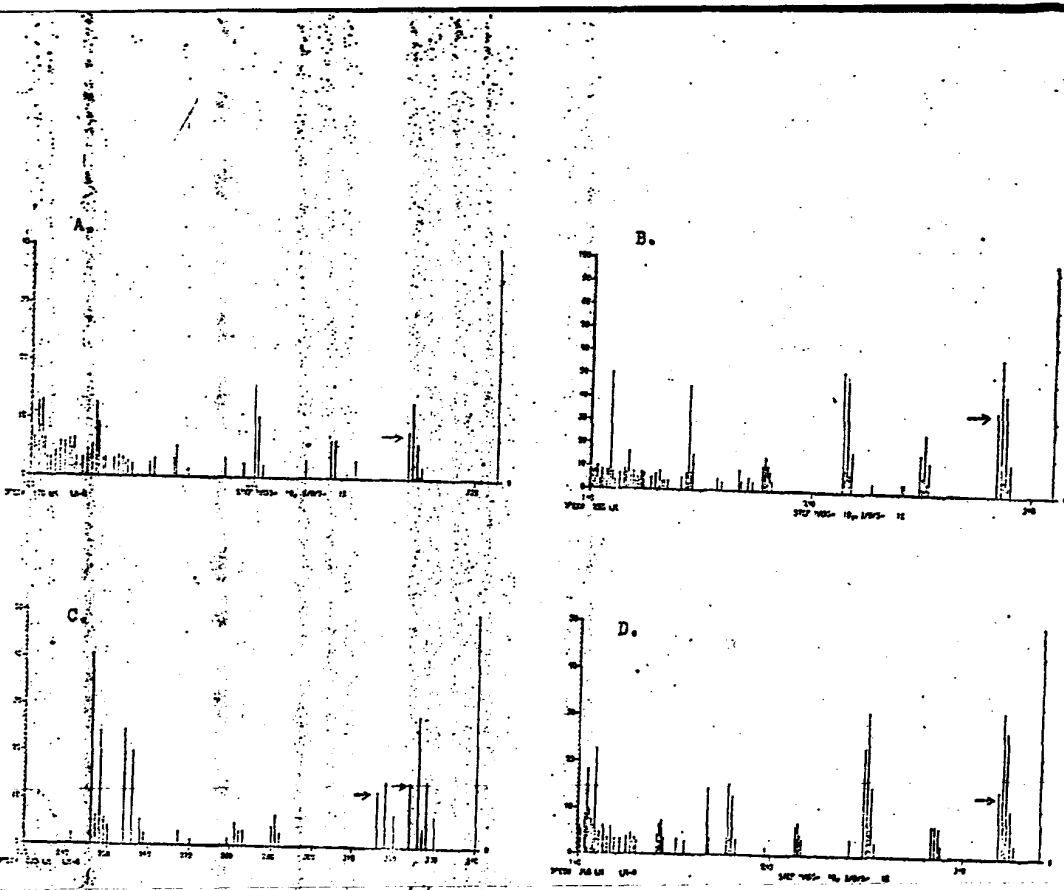

Figure VI. Mass Spectra of Major PCBs
in Lake Trout from the Michigan City Area

Appendix C. Other Field Studies
Supported by Grant 16020 FDS

Due to conflicts arising from changes in the funding period of this grant, the scheduled sampling of major rivers around the lake was not possible. Ship time for the University of Wisconsin Sea Grant Program vessel was obtained for one week in May, 1972. The cruise consisted of transects normal to the shore at Sturgeon Bay, Manitowoc, Sheboygan, Milwaukee, Waukegan, Indiana Harbor, and Michigan City in which plankton, water, sediments, and bottom organisms were sampled for PCB and pesticide analysis. The results will be presented and discussed in the forthcoming Ph.D. thesis of Mr. Richard Flotard of the Water Chemistry Program. The cruise also provided samples for two other graduate studies on trace metals in Lake Michigan by the Water Chemistry Program as well as a study of the food chain transport of PCBs into bird populations on Lake Michigan by the Department of Wildlife Ecology.

Although the data is only partially analyzed at this time, a brief examination of the available data as presented in the following table shows that the PCB levels in Contiercan are approximately five times greater off Waukegan than those from Sturgeon Bay. The trend of decreasing levels is also observed in samples from increasing depth (and distance from shore), suggesting that gradients of PCB levels in the water exit along the shore and with depth or distance from the shore.

Appendix C. Concentration of PCBs and DDT in *Pontoporeia* from the Western Shore of Lake Michigan[a] (Spring, 1972).

Sampling Region	Depth (ft)	Concentration (ug/gm-wet) PCBs[b]	DDT	DDD	DDE	"Total" DDT
Sturgeon Bay	100	0.06	0.03	0.08	0.03	0.14
Manitowoc	50	0.21	0.03	0.01	0.04	0.08
	100	0.11	0.04	0.01	0.05	0.10
	150	0.17				
Sheboygan	100	0.32	0.04	0.02	0.05	0.11
	150	0.23				
Waukegan	27	0.69				
	100	0.45	0.08	0.03	0.09	0.20
	150	0.34				

[a] Data from Ph.D. thesis (Water Chemistry) of Richard Flotard at the University of Wisconsin, partially supported by this study.

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PCB Conference II
Stockholm 1972

MAY 28 1974

MONITORING PCB IN WATER AND WILDLIFE

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INTRODUCTION

Although polychlorinated biphenyls (PCB) have been manufactured for various purposes for the past forty years, it was not until 1966 that Jensen identified them in a variety of environmental samples, using the gas chromatographic technique employed since 1962 for the detection and measurement of the persistent organochlorine pesticides such as DDT (and its metabolites) and dieldrin. Confirmation of the identity of the PCB residues was made by mass spectrometry, which at the same time indicated the presence of a larger number of polychlorinated biphenyls than was suggested by the number of gas chromatographic peaks.

In the analysis of wildlife samples for organochlorine pesticides since 1962, several workers had recorded the presence of a number of unidentifiable GLC peaks. Jensen's discovery of the presence of PCB residues, while assisting in the determination of a further group of detectable contaminants, made it evident that some of the earlier analytical results reported in the literature, particularly for pp'-DDT and pp'-DDE, were probably erroneous. Subsequently techniques have been developed to enable a reasonable degree of separation of PCB from many organochlorine pesticides to be achieved before GLC analysis, but the PCB residues must still be estimated as a group at present.

Polychlorinated biphenyls can be used for a wide variety of purposes, and the mixtures of isomers produced by the various manufacturers may range from those containing about 20% by weight of chlorine, averaging about one chlorine atom per molecule, to some containing about 70% of chlorine, averaging almost nine chlorine atoms per molecule. A total of 209 chlorinated biphenyls, containing from one to ten chlorine atoms, is theoretically possible, and it has been shown (Sissons and Welti, 1971) that one particular 54% chlorinated mixture contains at least fifty different isomers. Few of these have been prepared individually, and consequently for routine analysis of environmental

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samples the commercially-available mixtures must be used as reference standards. Some degradation of the lesser-chlorinated members of the series probably occurs in the environment, and in consequence the pattern of GLC peaks obtained from wildlife samples differs from that of the commercial mixtures. The estimation of total PCB content and toxicity of the wildlife residues are therefore only approximate at the present time.

In view of the persistence of the higher polychlorinated biphenyls, their presence at all environmental levels, their potential interference in the analysis for organochlorine pesticides, and their possible toxicity to various forms of life, considerable attention has been given in recent years to the problem of their world-wide distribution. Most studies have involved fish and birds, but in view of the possibility that global monitoring programmes for pollutants such as organochlorines may be established in the near future some consideration must be given to the types of environmental samples most suitable for the purpose of monitoring.

The Organisation for Economic Co-operation and Development (OECD) has for several years sponsored voluntary international studies of the problem of sampling and analysing wildlife specimens for organochlorine residues, and this paper summarises the results of the first six years of investigation, and indicates the difficulties involved both in the analysis of the samples and in the selection and acquisition of the necessary sample material. It has been possible to compare the efficiency of analysis in different countries, and to assess the importance of analytical errors as compared with the variations between individuals in populations of certain species. The occurrence of PCB concentrations in environmental media as opposed to living organisms is also discussed, media samples sometimes being suggested in preference to wildlife samples for monitoring purposes.

ANALYTICAL METHODS

PCBs are extracted and analysed by the same techniques as are employed for organochlorine pesticides, and appear to be recovered from water and tissue samples with the same efficiency, but must be separated from the majority of pesticides before GLC analysis to avoid interference. Separation is usually made using silica column chromatography,

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the PCB compounds being eluted with p,p'-DDE (Holden and Marsden, 1969), although Armour and Burke (1970) achieved a degree of separation of the PCBs from DDE with a more active type of silica. Several methods have been proposed for the determination of the total PCB content from the gas chromatographic trace, but a recent OECD study (Holden, in preparation) has shown that a considerable measure of agreement can be obtained among analysts using different methods of estimation.

Peak height is usually measured although peak area, measured by electronic integration or mechanical devices, is sometimes used; 4 to 6 GLC peaks are commonly involved. The estimation of PCB concentration is influenced to some extent by the choice of a suitable reference standard, which is usually arbitrary in view of the difference in proportions of the various PCB peaks, as between environmental samples and commercial products. Nevertheless, in the recent OECD study, eight analysts using different methods of estimation but similar 60% chlorinated reference mixtures obtained results on a cormorant sample which showed a coefficient of variation of 14%, a value no greater than was obtained for some individual pesticides in another exchange sample used in the same OECD study. An alternative method of assessment, not yet widely used, is the complete chlorination of all PCB residues found to the deca-chloro compound, giving a single GLC peak which is compared with the same peak produced from any PCB formulation, or a deca-chloro-biphenyl standard.

Where low-level concentrations are being determined, as in water or plankton samples, great care is necessary to avoid contamination from laboratory or other sources which may give GLC peaks in positions similar to those from the samples. Such contamination, insignificant in the analysis of samples containing high concentrations of PCBs, can be derived from plastics (particularly PVC), oil used in air compressors, human skin (if not adequately washed beforehand), internal seals of metal containers, and in the solvents or adsorbents used in analysis. All solvents must be purified by distillation, and all adsorbents or drying media (e.g. alumina, silica, sodium sulphate) must be calcined or solvent-washed before use. Blank runs through the complete analytical procedure must be made frequently to check for possible contamination.

MGNS 065995

PCB LEVELS IN THE ENVIRONMENT

(a) Air and Rain No reference has been found in the literature to concentrations of PCB in gaseous form in air, and it is quite possible that atmospheric PCB is associated with particulate matter (dust) or water droplets. In the sampling of air, such forms would be removed by filters and analysed as particulate matter. Risebrough et al (1968)[a] found 1 to 64 ppb of organochlorines in dust from air over Barbados, but did not positively identify PCB. Analysis of airborne dust off the California coast did not reveal the presence of PCB, and the deduction was made that PCB do not adsorb to particulate matter.

In the sampling and analyses of atmospheric precipitation for organochlorines, only the common pesticides ∝- and Y-BHC, dieldrin, pp' DDT and its metabolites pp'-TDE and pp'-DDE have been reported in detail. Wheatley and Hardman (1965) and Tarrant and Tatton (1968) found these residues in rain in the United Kingdom, but the latter also noted the presence of other residues believed to be PCB, without quantifying them. Their existence was confirmed in further rain samples collected in London (Annual Report 1970), of the Laboratory of the Government Chemist, with an approximate (TIC) estimate of their concentration as 50-100ng/l.

Rain samples have been collected and analysed from four different sites in Scotland during 1972, and preliminary results indicate that PCB levels are in the range 20-40ng/l, with total DDT levels of 5-20ng/l. These samples are taken in all-glass equipment, protected from birds, the aerial debris (dust, pollen, etc.) being retained separately on pre-washed glass wool filters which are also analysed. Several hundred millilitres of rain must be collected, the sampling periods being irregular according to the prevailing weather conditions. The concentrations of organochlorines found in the samples are nevertheless much higher than in river and stream waters in Scotland. Furthermore, there is so far no evidence that the residues are transported from industrial areas of Scotland by prevailing winds and it seems likely that the contamination is of more distant origin, or perhaps reflects a general level of atmospheric contamination. In this form of sampling, however, it is impossible to exclude the possibility of transient local contamination, whether from

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the excreta of flying birds, from insects, or passing transport, and such events should not be ignored.

(b) Fresh Waters A few references to PCB concentrations in rivers have appeared in the literature, although these generally refer to local contamination. In the Milwaukee River, U.S.A., 20-260ppt of Aroclor 1260 and 80-2070ppb of Aroclor 1242 were detected (Veith and Lee, 1971). In Lake Biwa, Japan, 100-1000ppt of PCB were found (Isono, 1971). Ahling & Jensen (1970) found 0.33 and 0.50ppt in natural waters in Swedon, but particulate material contained 1350ppt. The sediments in Ontario (Canada) rivers have been found to contain up to 0.6p.p.m. (Berg et al, 1972), and in several U.S. rivers up to 3.2ppm (Yates et al, 1972). The latter also found 0.1-4ppb in unfiltered river waters from the United States. The Michigan Water Resources Commission has reported 10-2900ppt in 30 tributary streams to the Great Lakes (Anon, 1972).

Analyses of Scottish streams and rivers for organochlorines in 1971 and 1972 have shown that, even in streams with no evidence of industrial or gross sewage pollution, the PCB concentrations are in the range 2-20ppt in unfiltered samples. The concentrations of organochlorine pesticides found were 0.1-5.1ppt dieldrin, 0.3-5.3ppt DDE, 0.3-6.4ppt TDE and 0.2-5.7ppt DDT, excluding badly-polluted rivers. These residues, with the possible exception of dieldrin (used for about ten years in sheep dips throughout Scotland until 1966), are believed to result from atmospheric, rather than terrestrial contamination. The PCB estimations were made on the basis of fewer peaks than is customary for tissue samples, and further examination is likely to reduce the values quoted above.

(c) Sea Water Analysis of a sea-water sample from the Firth of Clyde, West Scotland, an area which receives about one million tons of sewage sludge per annum, showed a concentration of 8ppt. Previous investigations (Holden, 1970) had shown that about one ton of PCBs were probably contained in the annual discharge of sludge but during 1972 the source from which the PCB entered the sewer was removed. Sea-water samples from the Firth of Tay, East Scotland, contained 5-20ppt, the higher values

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being in the vicinity of the city of Dundee. Much of this may have been in particulate matter.

(d) Freshwater Fish The levels of PCB in freshwater fish have been reported from only a few areas, partly due to the fact that pesticide concentrations in rivers and streams in agricultural areas are often greatly in excess of PCB levels, but also, as in Scotland, because terrestrial sources of direct contamination are often non-existent. The PCB problem has so frequently been related to the marine environment that their presence in fresh waters may have been overlooked, yet discharges of industrial wastes or crude sewage to rivers would be expected to result in significant PCB accumulation in the biomass. Possibly the fact that such rivers, if heavily polluted, may contain no fish has produced this situation, as fish are commonly used as the monitoring species for such pollutants.

Yet fish, like many other aquatic species, can concentrate PCB by at least three orders of magnitude, and it would be surprising if PCB residues were not detectable in the fish of the more polluted rivers and lakes. Zitko and Choi (1971) reported a concentration of 14.6 ppm in a coho salmon (Oncorhynchus kirutch) from Lake Michigan. Other fish from Lake Michigan analyzed by Veith and Lee (1970) contained 15-25ppm. Fish from the Great Kimi River (Kroner, 1971) had up to 150ppm, the PCB being discharged by paper mills. Zitko (1971) found 0.36-1.01ppm in American eel ([illegible]) from New Brunswick (Canada) rivers and, as there was no evidence of industrial or sewage pollution in some of these rivers, Zitko considered atmospheric fallout to be a possible source.

(e) Freshwater Invertebrates Invertebrates are less often studied than fish, but Södergren et al (1972) used the amphipod Gammarus pulex as an indicator organism for both DDT and PCB in streams in southern Sweden. There was evidence of a seasonal variation, with higher residue levels in August than in April, the PCB concentration being 0.002-0.011ppm. A number of other invertebrates were also examined, but PCB concentrations never exceeded 0.020ppm, total DDT being up to 0.046ppm.

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(f) Marine Fish and Shellfish. Zitko and Choi (1971) summarized the analytical data reported for marine fish, the concentrations in the presumably unpolluted areas being less than 0.1ppm. In areas known to be polluted, such as the California coast, the Baltic and the Bay of Fundy, values up to 1.0ppm have been found. In a heavily polluted area such as Escambia Bay, Florida, concentrations from 4.5 to 20ppm were detected. Tissues containing a high proportion of lipids were more heavily contaminated.

In a survey of the organochlorine content of commercial marine fish species from waters around the United Kingdom, (Portmann and Holden, unpublished), PCB concentrations in muscle tissue ranged from less than 0.1ppm in fish such as cod (Gadus morhua) up to 1.5ppm in plaice (Pleuronectes platessa) and mackerel (Scomber scombrus) in the polluted waters of the Firth of Clyde. Fish liver reflected contamination of the environment even more markedly, with concentrations in cod liver ranging from 0.4 to 43ppm. Expressed in terms of extractable lipid, PCB levels may range from 1ppm in unpolluted to over 300ppm in polluted areas.

The shellfish most commonly used for pollution studies have been molluscs such as oysters and mussels. However, these species seem to be able to rid themselves of contaminants such as pesticides relatively quickly, and the concentrations found may not always reflect the external conditions at the time of sampling. Nevertheless, persistent pollution in estuaries will give rise to abnormally high residue levels in mussels as found in surveys made in Scotland, using Mytilus edulis. Specimens in the Firth of Clyde contained up to 3.0ppm, while in clean waters the concentrations of 0.1-0.2ppm were more usual. The overall range, however, is not very large.

(g) Marine Plankton Marine zooplankton, with a significant lipid content, might be expected to reflect PCB levels in the surrounding aqueous medium, but two major difficulties arise in their use for monitoring. Zooplankton samples usually vary in species composition, and this may result in a between-sample variation in PCB content by virtue of the different lipid contents of the various species. Analyses based on lipid content might, however, reduce the influence of species composition. A more serious problem arises from the possibility of collecting in the plankton net

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such extraneous material as/from ships, and tar or oil, which are found almost everywhere on the ocean surface. Nets used for plankton should be cleaned when entering or leaving the water surface. An oil is an excellent solvent for PCB, even a small amount may produce a significant enhancement of PCB concentrations in plankton samples. Paint, hydraulic fluid or lubricating oil from ships could also be sources of PCB.

Despite these potential errors, analyses of mixed zooplankton samples in the eastern Atlantic and Firth of Clyde have shown a consistent pattern, the latter containing higher concentrations, as expected from the local PCB contamination. The samples from the north-east Atlantic contained 0.01-0.11ppm wet weight (0.1 - 4.2ppm in lipid), while samples from the Firth of Clyde, including some unpolluted areas, contained 0.04 - 2.20ppm wet weight (1.1 - 20.0ppm in lipid). Extremely high PCB concentrations, expressed in terms of extractable lipid, were obtained from plankton (more correctly seston) samples in the Bristol Channel, S.W. England, where the sediment is continually disturbed by tidal movements. The area receives a considerable amount of industrial waste, and PCB values of up to 7000ppm in lipid were calculated for the seston. Such a situation would be unlikely in the open ocean. Recent analyses of zooplankton from the Clyde suggest that species composition may have little influence on the PCB levels in zooplankton samples.

(h). Birds. Both terrestrial and aquatic species of birds may accumulate high PCB concentrations, but the piscivorous species, particularly in the marine environment, generally contain most. Risebrough et al (1968) recorded the results of analyses of both DDT group and PCB residues from a wide range of avian species in North America. Some species contained less than 0.01ppm in muscle tissue, but values between 0.1 and 10ppm were common, and in species feeding on fish in polluted areas concentrations between 10 and 100ppm were common. Zitko and Choi (1971) summarised the analyses of birds from a number of literature references, and in a few instances, such as in the Stockholm Archipelago, values between 100 and 10,000ppm PCB were found. Such concentrations would seem to be potentially, if not actually, toxic to the birds. The eggs of several species in contaminated areas have also been found to contain high levels of PCB, sometimes 10 - 100ppm.

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The range of PCB residues in birds from various locations is thus extremely wide, from 0.01 to 10,000ppm, and much larger than is found in fish, for example. In this respect, birds would appear to be most appropriate organisms for monitoring the distribution of PCB in the environment, although other considerations must qualify this judgement, as discussed later.

(i) Marine Mammals Holden, (1972, and 1973 in press) has described the analysis of seal and porpoise fat (blubber) for organochlorine residues, and the variation in PCB concentrations found in seals from different parts of the world. Concentrations in extractable lipid range from 1ppm in the Arctic to 250ppm on the west coast of the United Kingdom, but in starving specimens, which have metabolised most of their fat reserves, up to 2800ppm has been found. The increase in concentrations in lipid, as the result of starvation stress and reduction of body fat reserves, is a complicating factor in the use of residue concentrations in organisms for assessing the extent of local environmental contamination.

MONITORING PCB IN THE ENVIRONMENT

The above summary has indicated the range of concentrations of PCB to be found in the environment, but before any selection of species appropriate for monitoring is made several aspects of the problem of environmental contamination must be considered. The contaminant in question may enter an organism from the external medium, such as air or water, or from sediments in the case of an aquatic filter-feeder, and thus the media might be appropriate for sampling and analysis. However, contamination of water or air might fluctuate appreciably with time, and organisms, in which the fluctuations would be reduced, could reflect the general situation more effectively, while at the same time providing higher concentrations for easier determination. As uptake from food is an alternative, and often the only, source of contamination in most species, the concentration in the external medium may not be directly relevant.

Species of which the individuals move over considerable distances, either for feeding or on migration, may give residue information which is difficult to interpret, as the residues may not have been ingested in the area in which the specimens were

obtained. Thus adult migratory birds are not appropriate monitoring organisms. For the same reason, marine fish, which may move from estuarine to oceanic water, could also be unsuitable. Freshwater fish which remain in a lake over a complete life-span, or invertebrates, which move over relatively short distances, can on the other hand provide information relevant only to their local environment.

A further important consideration in the choice of species for monitoring is that sufficient individuals must be available for sampling at the required time, without having a significant influence on the total population. As residue levels often increase with age, and may also differ between the sexes, the specimens may have to be selected both for age and sex, thus increasing the problem of sampling. Furthermore, there is always a natural and sometimes considerable variation among individuals within a population, even when of one sex and age. In consequence, to obtain a reasonably accurate estimate of the mean level of contamination in any one population, a large number of individuals may be required, creating problems both in sampling and analysis.

At this point, it is worth considering the purpose for which a monitoring programme may be designed. Initially it is intended that the level of contamination in several areas will be determined, so that the more heavily contaminated areas can be identified, and the sources of pollution controlled. Yet, unless these are already known or suspected, and sampling areas chosen accordingly, a general monitoring programme is unlikely to reveal such "hot-spots". On the other hand, contamination over large areas, or due to aerial fallout from distant sources, may be detected in a general survey.

The information obtained might, however, be sufficiently accurate to establish statistically that levels of contamination appearing to be high are in fact high, by comparison with those in other areas. Similarly, it should be possible for changes in the contamination level from year to year to be detected with appropriate statistical significance. Such information is of value in assessing the consequences of government or industrial action which has been taken to reduce pollution. The accuracy of the estimates of contamination levels depends in part on the precision of the analyses, which in turn is dependent on the experience and efficiency of the analysts.

MONS 066002

In large-scale monitoring programmes many analysts will be involved, but an adequate assessment of their agreement can be obtained by the use of exchange samples.

Finally, the acquisition of analytical data is not the ultimate purpose of monitoring. The underlying fear is that contamination levels may be sufficient to have adverse biological effects at one or more points in an eco-system, but as yet adequate evidence of such effects has been established in very few instances. It is essential that the concentrations in various species which are capable of causing adverse effects should be determined, whether the effects are for example, reduced photosynthetic activity in algae, the failure to reproduce in invertebrates, abnormal behaviour in vertebrates, or mortality in any species.

OECD STUDIES OF MONITORING

The Organization for Economic Co-operation and Development (OECD), in a series of international collaborative studies on the monitoring of organochlorine residues in the environment, has attempted to examine some of the problems referred to in the preceding paragraphs.

In the second programme (Holden, 1970), the ability of analysts in several countries to obtain the same results, both qualitatively and quantitatively, in the analysis of exchange samples was measured. At that time (1968-69), the variation between analysts increased with the difficulty of processing the samples, and for the only residues in which there was general agreement on identity (dieldrin, DDE, TDE and DDT), the coefficient of variation was ±25 to ±60%. In the third programme (Holden, in preparation) a substantial improvement was noted for the period 1969-71, the coefficient of variation for six pesticide residues and PCBs in samples requiring full processing being ±10 to ±18% among 17 laboratories.

The question of the number of individuals of a population required to provide a mean value of sufficient precision for detecting differences between populations, or changes from year to year, was also examined in the second programme. In both starling and pike populations (with no selection for age or sex), fifty individuals would have been required to detect a 25% difference between means, but ten would have been

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sufficient to detect a 75% difference. The main reason for such low precision was that the residues in the individuals were usually unevenly distributed, but this may have been due to the variation in age within samples.

The third study programme included the analysis of PCB residues in addition to organochlorine pesticide residues in selected wildlife species, and samples were taken from uncontaminated and contaminated areas. The results of this programme have provided information on the extent of PCB contamination, and also on the difficulty of identifying the contaminated areas.

It must be borne in mind that, in common with all other PCB analyses at the present time, the values obtained are estimates of the total PCB concentration expressed in terms of a commercial mixture of specified chlorine content. The proportions of the various isomers and homologues present in the samples usually differ from those in the commercial mixtures, and no information on the concentrations of individual compounds is afforded by the analysis. The assessment of the potential toxicity of the residues detected is thus rendered difficult, and any such estimate must be regarded with caution.

Ten countries sampled and analysed the mussel (Mytilus edulis) in coastal waters, both in areas considered to be uncontaminated and in other areas known to be polluted. The assessment of pollution varies considerably, some polluted areas giving PCB concentration in mussels as low as 0.02mg/kg, and one unpolluted area giving 0.5mg/kg. Areas with varying degrees of pollution gave values of 0.02 - 1.7mg/kg. A similar situation arose with the samples of herring (Clupea harengus) analysed by eight countries. Those from areas classed as unpolluted had PCB concentrations in muscle tissue ranging from 0.10 to 0.54mg/kg, but the range in fish from polluted areas was 0.19 to 3.2mg/kg.

Freshwater fish show less evidence of PCB contamination. The pike (Esox lucius) sampled in six countries usually contained little PCB even in polluted waters, the values generally being less than 0.1mg/kg. Yet where serious pollution by PCB exists the concentrations can be much higher, as in the samples analysed by the Netherlands, with PCB levels of 0.47 - 0.95mg/kg.

MONS 066004

The eggs of fish-eating birds can demonstrate the accumulation of organochlorine residues from their food very effectively. Eggs of the heron Ardea cinerea were analysed by the United Kingdom and the Netherlands. In samples from remote areas of the United Kingdom concentrations below 0.5mg/kg were found in the eggs, with up to 7.3mg/kg in a very polluted area. In the Netherlands the concentrations in polluted areas were up to ten times greater, 33 - 74mg/kg. This ability to concentrate residues in eggs was also shown by the samples from two common tern (Sterna hirundo) colonies in Canada. The relatively uncontaminated colony gave 2 - 4mg/kg PCB but that in a polluted area contained a mean of 140mg/kg in eggs.

DISCUSSION

The third OECD progress has indicated the difficulties of identifying areas polluted by organochlorines, and in particular PCB, by evidence other than chemical analysis. Consequently the identification of local sources of PCB pollution by the analysis of indicator or monitoring species would entail a very large and detailed sampling and analytical programme involving numerous sites. On the other hand, the detection of more general pollution over large areas, if such pollution exists, should be disclosed by a pattern of fewer sampling sites at which an appropriate species could be used for monitoring on a regular basis. Ideally, this species should accumulate the contaminants to such an extent that there is a considerable difference between PCB content of uncontaminated and polluted specimens. The species should therefore be relatively resistant to the effects of the pollutant.

Referring to the information provided by the third OECD study, concentrations of PCB in muscle showed an overall range of about 1:100, with only a 1:30 range for herring. The eggs of herons showed at least a range of 1:150, and an even greater range might be revealed by further samples. A heron in the Stockholm Archipelago was found by Jensen et al (1969) to contain 9,400mg/kg in muscle, which suggests that eggs from such birds could also contain exceptionally high levels.

While eggs may be particularly useful in revealing areas of pollution, the numbers available for analysis could be limited. On the other hand species such as mussels or

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herring can usually be collected in quantity. The greater precision of the estimation of the mean level of contamination of a population of mussels, herring or similarly abundant species could therefore be as important in the choice of a monitoring species as the wider range of contamination levels likely to occur in the eggs of piscivorous birds.

A further restriction is placed on sampling by the habitat of the species collected. Mussels can only be from coastal waters, for example, and seals, in which extremes in contamination level have also been demonstrated (Holden, 1972) are limited in their distribution. As many coal colonies are protected, it may be difficult to acquire more than a few specimens for analysis. The major problem which arises in the selection of an appropriate monitoring species for global surveillance, however, is that very few occur in all areas of the world, although an ecologically equivalent species can often extend the range. Species which seem ideal from many points of view (adequate numbers, ease of sex and age determination, and of sampling) may be limited to the northern hemisphere, or to one continent. Marine species are sometimes more widespread, but clearly cannot reflect contamination in terrestrial or freshwater environments, where pollution may originate.

The OECD studies have enabled some assessment to be made of analytical accuracy, of the ability to obtain samples of chosen species in the required numbers (or of the attendant difficulties), and of the ranges of various residues which exist in polluted and unpolluted areas. They have also shown the difficulty of positively identifying such areas prior to performing the analyses. In particular, the choice of species which would be appropriate for global monitoring has been under constant discussion, and no species has yet been proposed which meets all the requirements for such a purpose. It is likely that a wide variety of species must eventually be proposed, the assessment of the extent of pollution being based on the results from several species in each area, rather than on any particular species.

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A Summary of NWQL Research Concerning the Effects of Polychlorinated Biphenyl on Water Quality and Aquatic Life

May 1973

Environmental Protection Agency

National Water Quality Laboratory

Duluth, Minnesota

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Exposure of Brook Trout to Aroclor® 1254

V. M. Snarski and F. A. Puglisi

Brook Trout are being exposed to Aroclor® 1254 to determine the effects of sublethal water concentrations of PCBs on growth, reproduction, hatchability, and survival of fry through absorption of the yolk-sac. The analysis for PCBs in tissue has been included to study the amount concentrated by the fish and its transfer to the eggs. Tissue analysis include measurements in muscle, gonads, and the whole body and during spawning in the eggs. Spawning is expected to occur after 15 months of exposure.

No effect on growth or survival has been observed during the first 9 months of this test. Data were obtained from sacrifices after 14 and 27 weeks of this exposure and after 8 and 14 weeks of a previous exposure terminated before completion.

The residue data from the trout exposed for 27 weeks indicate that approximately 0.55 µg/l of Aroclor® 1254 will result in 5 µg/gm of the PCB mixture in the fish (whole fish basis). The concentration in the fillet of fish exposed to 0.84 µg/l Aroclor® 1254 was 1 µg/gm. The lipid content of the fillet portion of the trout was less than two percent.

Figure 1 shows the relationship between the concentration of PCBs in water and the concentration in the tissue (wet). The linear regression lines suggest the concentration in the tissue to be directly proportional to the concentration in the water. The spread shown by these lines indicates a range of PCBs in various tissues for each water concentration. Note that similar tissues are clustered into narrow

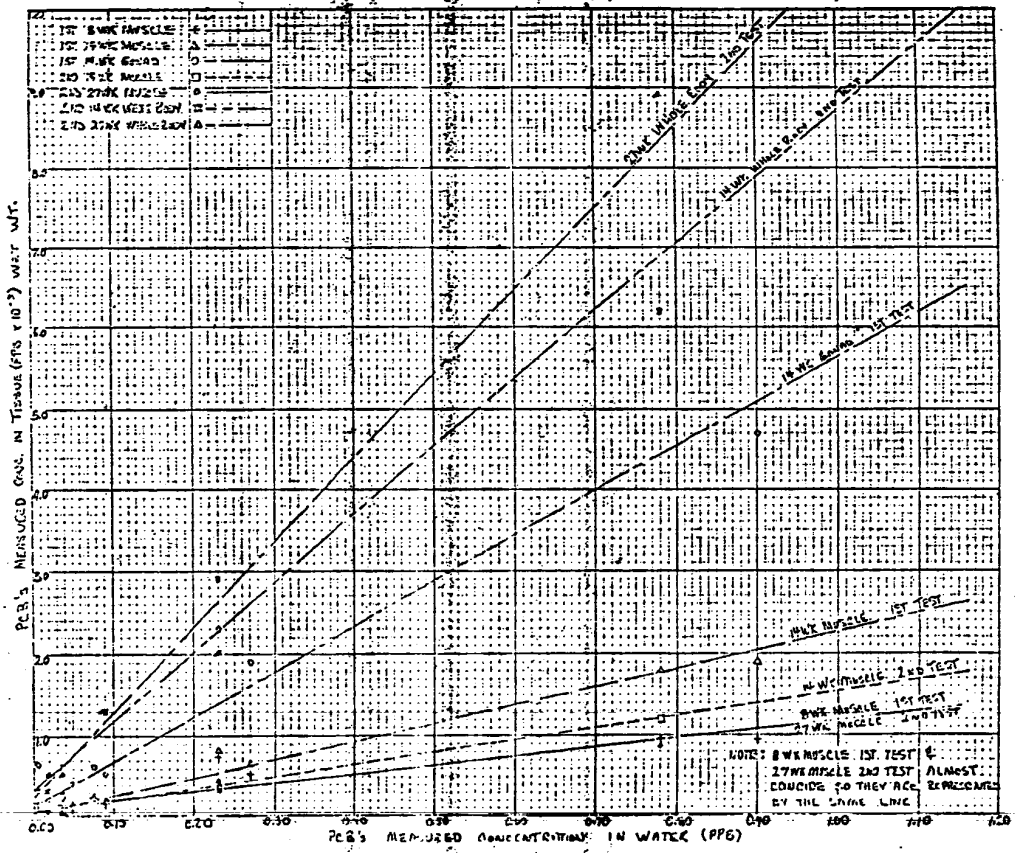

FIGURE 1 RELATIONSHIP OF PCB'S IN WATER TO PCB'S IN TISSUE

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bands of the entire range.

The concentration of PCBs in the tissue appears to be correlated to the lipid content of the tissue as indicated by Figure 2 which shows the relationship between water concentrations and PCB concentrations calculated on a lipid weight basis. Again, the PCBs in the lipid are directly proportional to the concentration in the water. The variability in concentrations in lipid is much less than the variability in the tissue based on wet weight. This suggests that the PCB level in the tissues result, in part, from the partitioning between the lipid and water.

The concentrations of Aroclor® 1254 in the brook trout lipid ranged from 110,000 to 170,000 times greater than the concentration in the water and was largely independent of the length of exposure after 14 weeks.

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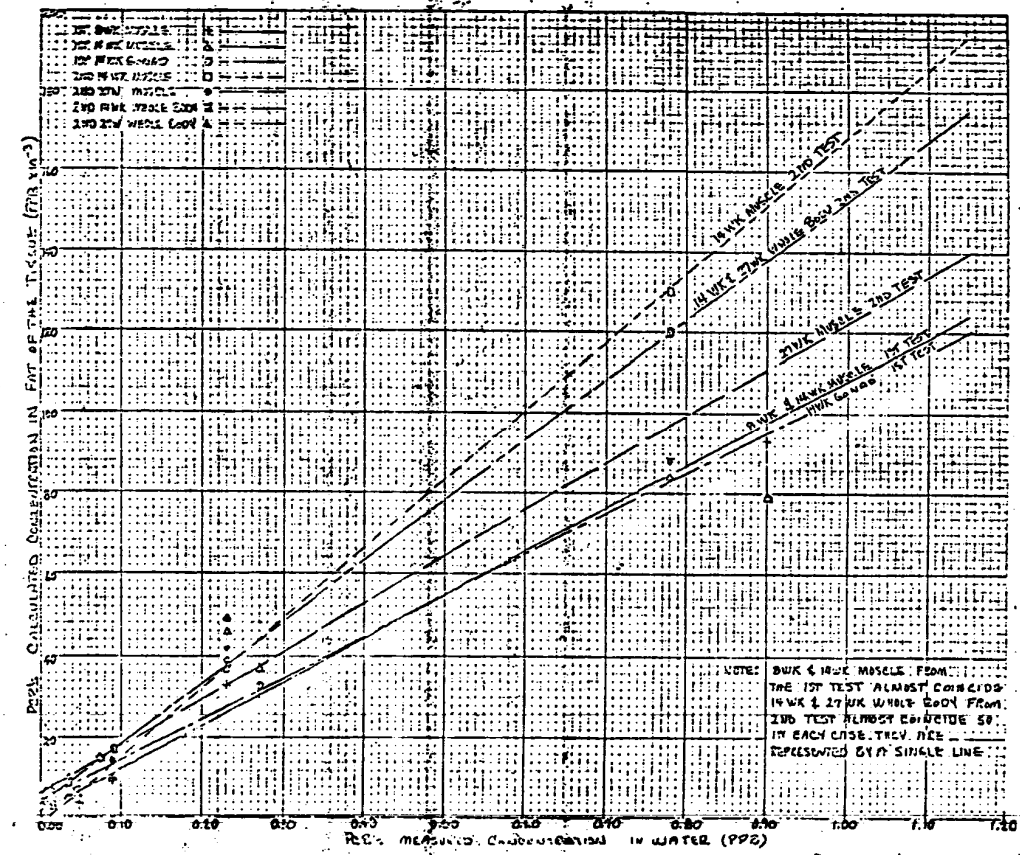


FIGURE 2 RELATIONSHIP OF PCB'S IN WATER TO PCB'S IN FAT

Exposure of Fathead Minnows to Aroclor® 1248 and 1260

D. L. Defoe, R. W. Carlson and G. D. Veith

Chronic exposures of PCB Aroclors® 1248 and 1260 to the fathead minnow have been completed. The data is being analyzed and prepared for publication.

The data presented herein which represent mean values of duplicate bioassays are normalized to the results obtained with the control fish exposed only to the acetone carrier.

More detailed studies to determine the effect of carriers on the bioassay results are underway.

The 30 day acute exposures using Aroclor® 1248 and fathead minnow fry (less than 12 hours old) has shown that 8 µg/l of A 1248 killed all the fry, 4.5 µg/l killed 50 percent of the fry and caused a 70 percent reduction in the weight of the fry, and 2.2 µg/l caused no mortality but a 20 percent reduction in weight. Similar studies with Aroclor® 1260 demonstrated that 9 µg/l killed all the fry and 4 µg/l caused 70 percent mortality and a 30 percent reduction in fry weight.

The reproduction, measured as the number of eggs spawned per female, in females exposed to 1.1 µg/l Aroclor® 1248 were only 60 percent of that of the controls. Aroclor® 1260 did not affect reproduction at concentrations up to 2.1 µg/l.

The second generation fry from adults previously exposed to the PCB mixtures were exposed to the respective mixtures for 30 days after hatching. Preliminary data analyses indicated that 3 µg/l of Aroclor® 1248

caused no mortality but a 20 percent reduction in the weight of the fry. Similarly, Aroclor® 1260 caused no mortality when the fry were exposed to 2.1 µg/l; however, the weight of the fry was reduced by 33 percent.

Figure 3 indicates that the concentration of both Aroclor® 1248 and 1260 in the male fathead minnows reached an apparent steady-state after the first 100 days. The concentration of the PCBs in the female fish was more than double that in the male when expressed on a wet weight basis. However, the concentrations expressed on a lipid basis as illustrated in Figure 4 indicate that the females contained slightly less PCB per gram of lipid than did the males. In addition, the PCB concentration in the female on a wet weight basis was much more variable than the male, presumably due to the variable lipid content of the female.

The fathead minnow accumulated Aroclor® 1260 concentrations (lipid basis) approximately 270,000 times that in the water, whereas Aroclor® 1248 was accumulated to lipid concentrations approximately 120,000 times that in the water.

Data analyses and studies concerning the 60 day growth, delays in spawning, egg hatchability, body burden of PCBs, and the elimination of PCBs from the fish are continuing.

Figure 3
Accumulation of Aroclor 1248 and 1260
in Fathead Minnows

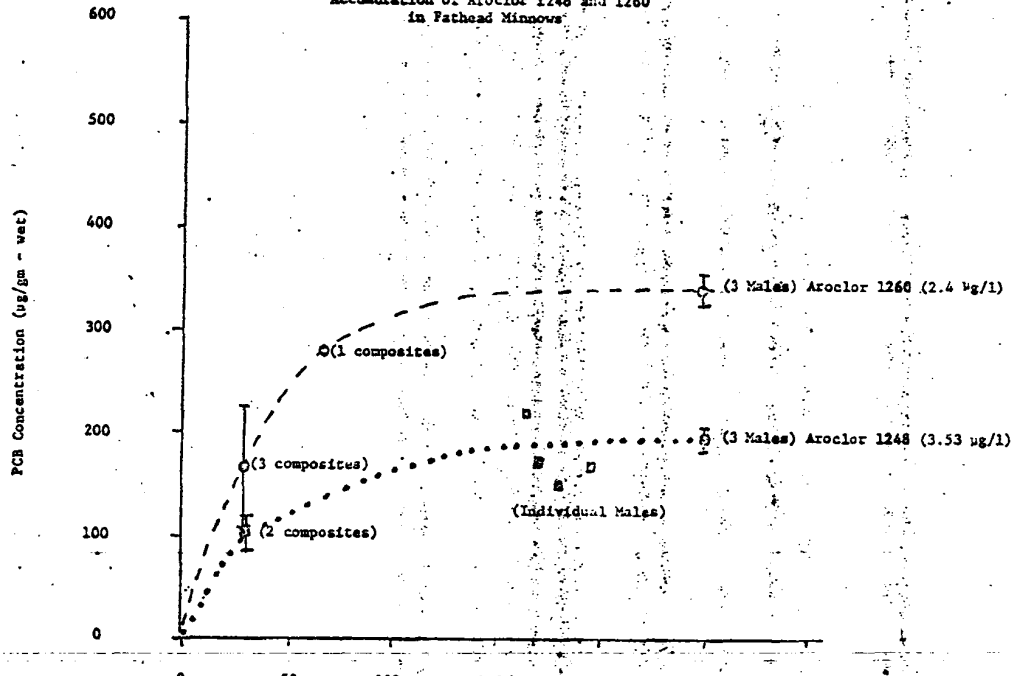
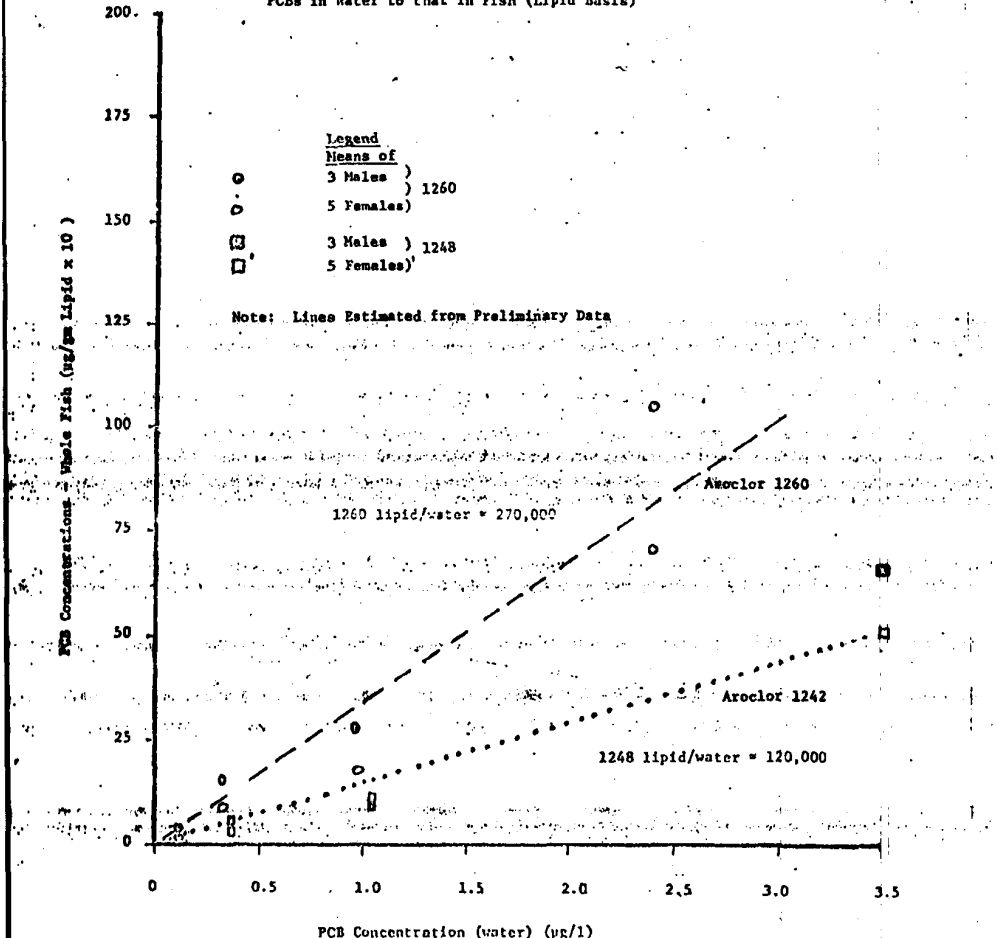


Figure 4
Relationship Between the Concentration of
PCBs in Water to that in Fish (Lipid Basis)



Summary of Other Exploratory Studies with PCBs

A. V. Nebeker, F. A. Puglisi and D. L. DeFoe

As indicated in Table 1, Aroclor 1248 was the most toxic of the eight aroclors tested to Daphnia magna in static tests, with a 3-week LC50 of 25 µg/liter. Aroclor 1254 was most toxic under continuous-flow conditions with a 3-week LC50 of 1.3 µg/liter. The Aroclors were more toxic under continuous-flow than static conditions, with 16 percent impairment of reproduction caused by 1.0 µg/liter Aroclor 1248.

The calculated 96-hour LC50 values for newly-hatched fathead minnows were 7.7 µg/l for Aroclor 1254 and 15 µg/l for 1242. Three-month-old fatheads had a 96-hour LC50 of ca. 500 µg/l for 1242. Reproduction occurred at and below 1.8 µg/l 1254 and at and below 5.4 µg/l 1242. Polychlorinated biphenyls were acutely toxic but exhibited much greater chronic toxicity at very low levels, due to their cumulative nature. Newly hatched young were the most sensitive life stage. Young fathead growth was also affected above 2.2 µg/l 1248 and none survived above 5.1 µg/l after 30 days. Young flagfish, Jordanella floridae, did not survive above 5.1 µg/l 1248 and did not grow well above 2.2 µg/l.

The ninety-six hour LC50 values for Aroclor 1242 and 1248 with Gammarus pseudolimnaeus were 73 and 29 µg/liter. Survival after 30 days was 53 percent at 8.7 µg/l 1242 and 52 percent at 5.1 µg/l 1248. Good reproduction and survival of young occurred at 2.8 µg/l 1242 and 2.2µg/l 1248.

Table 1. The Comparative Toxicity of Eight Aroclors[a] (in µg/liter) to Daphnia magna in Lake Superior Water as Determined in Static Test Conditions

Aroclor	Three Week LC50	Confidence Limits[b]	Reproductive Impairment 50%	Confidence Limits	16%	Confidence Limits
1221	180	158-205	125	116-135	89	85.6-92.6
1232	72	62.6-82.8	66	60-72.6	53	50.5-55.7
1242	67	55.4-81	63	56.3-70.5	48	45.2-50.9
1248	25	21.4-29.2	24	21.2-27.1	16	13.9-18.4
1254	31	26.8-37.2	28	23.1-33.9	18	14.5-22.3
1260	36	27.7-46.8	33	27.5-39.6	22	17.7-27.3
1262	43	37-49.9	41	33-53.3	24	17.6-32.6
1268	253	222-288	206	185-228	162	146-179

[a] Polychlorinated Biphenyls: Aroclor 1221-1268. Monsanto Chemical Company, St. Louis, Mo.

[b] Ninety-five percent confidence limits.

Abundant adult emergence of the midge Tanytarsus dissimilis did not occur above 5 µg/l 1248 or 3.5 µg/l 1254. The calculated 3-week LC50 (50 percent reduction based on control as 100 percent) for Aroclor 1254 was 0.65 µg/l for larvae and .45 µg/l for pupae.

Application factors of 0.10 for 1242 and 0.15 for 1248 were calculated for the PCB's and Gammarus. Application factors of 0.2 for 1254 and 0.16 for 1242 were calculated for fathead minnows using newly hatched fish to obtain the 96-hour LC50.

Survival and Reproduction of Daphnia magna After Three Week Exposure to PCB Mixtures

L. Uhlken, R. W. Carlson

Studies have been initiated to determine the relativity toxicities of individual chlorobiphenyls, simplified mixtures, and Aroclor® 1016 to Daphnia magna. As shown by previous studies, the toxicity of the PCBs increases with increasing chlorine content. For example, Daphnids exposed to 50 µg/l 2,2'-dichlorobiphenyl produced 515 young whereas those exposed to the same weight of a mixture of trichlorobiphenyls produced only 111 young. Daphnids exposed to tetrachlorobiphenyls and Aroclor® 1242 at the 50 µg/l did not survive.

Preliminary data suggests that some mixtures of trichloro-and tetrachlorobiphenyls may be as toxic as Aroclor® 1242. Studies with Aroclor® 1016 are continuing.

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Effect of Polychlorinated Biphenyl Compounds on Survival and Reproduction of the Fathead Minnow and Flagfish.

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Trans. Amer. Fish. Soc. 103(3): July, 1974

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MONS 066021

Abstract

Two 9-month continuous-flow bioassays and several intermediate length continuous-flow tests were conducted to determine safe levels of Aroclor 1242, 1248, and 1254 for the fathead minnow (Pimephales promelas) and Aroclor 1248 for the flagfish, Jordanella floridae. Calculated 96-hour LC50 values for newly hatched fathead minnows were 7.7 µg/liter for Aroclor 1254 and 15 µg/liter for 1242. Three-month-old fatheads had a 96-hour LC50 of 300 µg/liter for 1242. Reproduction occurred at and below 1.8 µg/liter 1254 and at and below 5.4 µg/liter 1242. Newly hatched young were the most sensitive life stage. Growth of young fatheads was also affected above 2.2 µg/liter 1248, and none survived above 5.1 µg/liter after 30 days. Young flagfish did not survive at 1248 concentrations above 5.1 µg/liter and did not grow well above 2.2 µg/liter.

Tissue residues in fathead minnows ranged from 0.7 µg/g 1248 in control fish to 1036 µg/g 1254 in fish held for 8 months in water containing 4.6 µg/liter 1254.

Introduction

Polychlorinated biphenyl compounds (PCB's) are among the many exotic chemicals now finding their way into our waters. They are detected in fish and other aquatic organisms at concentrations much higher than those found in the ambient water. Because analytical methodology for detecting and identifying low levels of PCB's in water and aquatic organisms has only recently become available, little is known about the interactions. The acute toxicities of some of the PCB's produced commercially are presently being demonstrated at the Fish-Pesticide Laboratory, USDI, Columbia, Missouri (Stalling 1970); the Gulf Breeze Laboratory, EPA, Gulf Breeze, Florida (Duke et al. 1970); and the National Water Quality Laboratory, EPA, Duluth, Minnesota (Nebeker et al. 1972). The effects of PCB's on reproduction of Daphnia magna, Gammarus pseudolimnaeus, and the midge Tanytarsus dissimilis have been detailed by Nebeker and Puglisi (In press), but no full life-cycle information is available for fish species.

This study was begun in October 1970 to determine the effects of three PCB's, Aroclor 1242, 1248, and 1254, on the survival, growth, and reproduction of the fathead minnow (Pimephales promelas) and the effects of Aroclor 1248 on the survival and growth of the flagfish, Jordanella floridae. Further studies were conducted to determine the effects of Aroclor 1242 and 1254 on maturation, egg production, egg hatch, young production, and survival of young of the fathead minnow. Tissue residues were also determined to measure uptake of PCB's.

Materials and Methods

Physical Testing Methods

Three continuous-flow testing units were used, each consisting of five duplicated test concentrations and a control. Stainless steel and glass aquaria were used for all test chambers. Twelve 10-gallon aquaria were used for adult fish in the Aroclor 1254 testing; twelve 5-gallon aquaria were used for Aroclor 1242 testing; and twenty-four 2 1/2-gallon aquaria were used for testing Jordanella and some young fathead minnows. Young fish from spawning tanks were tested in 5- and 2 1/2-gallon aquaria. Three proportional diluters (Mount and Brungs 1967) provided the necessary continuous-flow conditions. A modification of the diluter system, a gas syringe filled with acetone and PCB, was used with a mechanical injector system to deliver the toxicant to the mixing chamber of the diluter. Agitation was maintained by circulating the mixing box contents through a submersible pump. Additional mixing boxes, with two-way and four-way splits to the duplicate test aquaria, provided further mixing of the PCB solutions. All tanks were randomly distributed on the test tables. Raw Lake Superior water was used for all testing.

The diluters delivered 350 ml (1242), 200 ml (1254), and 150 ml (1248) to each tank every 3 minutes; flow rates were set primarily to maintain adequate dissolved oxygen concentrations. These flow rates ensured a complete exchange of water in the test tanks every 4-5 hours. All tanks were cleaned daily, and excess algal and bacterial growths were scraped away weekly.

Spawning substrates for fathead minnows consisted of inverted 3-inch-long logitudinal sections of glass quart beverage bottles. Egg hatchability studies were conducted in the same manner as previous fathead studies by Mount (1968), Brungs (1969), and others.

Temperatures were maintained at 24 ± 1 C. Durotest[2] (Optima FS) and wide spectrum Grow-lux fluorescent tubes provided light. The photoperiod of Evansville, Indiana, was maintained, with the adjustments in day length made every 2 weeks, as recommended by the National Water Quality Laboratory Committee on Aquatic Bioassays (Bioassay Committee MS 1971).

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[2] Mention of commercial products does not constitute endorsement by the U. S. Environmental Protection Agency.

Biological Methods

All fish were obtained from stocks at the National Water Quality Laboratory in Duluth, Minn. Ninety-six-hour acute tests with various ages of fish, conducted according to standard methods (American Public Health Association 1965), and chronic tests were carried out to obtain information for future calculation of application factors. Measured PCB concentrations were used for all calculations.

Full life-cycle studies with the fathead minnows (Aroclor 1242 and 1254) and the tests with Jordanella (1248) were started with newly hatched young (< 24 hours old). In the 30-day Jordanella test observations on survival were made daily, and growth was measured at the end of the test. Young fathead minnows were tested in the same diluter system, but in different tanks, at the same time to get comparative information on the two species.

Fathead (full life-cycle) testing was begun with 40 newly hatched young per concentration, 20 fish in each aquarium. They were fed twice daily with newly hatched live brine shrimp, frozen brine shrimp, Daphnia, and dry and frozen commercial fish foods. Growth was measured photographically (McKim and Benoit 1971) at 60 and 90 days and at the end of the test. Prior to sexual maturation five spawning substrates were placed in the aquaria, and the fish were thinned to leave 10 fish per tank. The fish that were removed were used to study the effects of PCB's on adenosine triphosphatase activity (Cutkomp and Koch In press).

Eggs laid on the spawning substrates were removed, counted, and placed in egg cups for hatchability testing. Twenty-five or fifty eggs were placed in cups, and the number hatched was recorded. Some of the newly hatched fish were transferred to smaller aquaria at the same concentrations and held for 30 days to determine survival and growth.

Analytical Methods

The ploychlorinated biphenyls tested were Aroclor 1242, 1248, and 1254, manufactured by Monsanto Chemical Company. The stock solutions were prepared by weighing the compound and dissolving it in acetone.

Six liters of test water were collected from each test concentration to be analyzed. Three liters were siphoned into each of two 1-gallon glass bottles to provide duplicate samples. Teflon-lined screw caps were constructed for the bottles. A duplicate of the control and at least one other sample were spiked with equal amounts of the toxicant being used in the system. Ten milliliters of concentrated sulfuric acid and 300 ml of glass-distilled methylene chloride were added to each sample. The caps were then tightened and the bottles placed on a mechanical shaker for 10 minutes. The samples were allowed to settle for at least 10 minutes before the aqueous phase was decanted. The organic phase and remaining water were transferred to a separatory funnel and again allowed to settle. The organic layer was drained through solvent-washed anhydrous sodium sulfate into a Kunderna-Danish evaporator. The solvent was evaporated on a steam bath until the entire sample was contained in the 10 ml evaporator receiver. The remaining solvent was evaporated by blowing a gentle stream of dry nitrogen over it until the first sign of dryness. The receiver was stoppered with a cork wrapped in acetone-washed aluminum foil and stored for gas chromatograph (G.C.) analysis.

Analysis was done on a Tracor MT-220 gas chromatograph with a 6-foot 1/4-inch OD glass column packed with 3% OV-1 chromosorb W 80/90 mesh. A Coulson conductivity detector was used in the reductive mode without a catalyst. Sixty ml/min helium carrier gas was used with a 10 ml/min helium purge through the furnace when the column was vented. A rate of 40 ml/min of electrolytic hydrogen was used for the reductive pyrolysis. The temperatures of the inlet and all transfer lines were kept at 260 C, and the column varied from 195 C to 205 C depending on the PCB mixture being measured. The pyrolysis furnace was kept at 820 C.

The residue was dissolved in a volume of n-hexane that would give a concentration such that a 50-microliter injection would give at least 25% scale response on a 1-millivolt chart recorder. The solvent was vented to prevent it from contaminating the furnace.

A single well-defined peak (Figure 1), present in all three of the PCB's tested, was used as an internal standard and was compared to the same peak in the "standard." This "quantitation" was done by alternately injecting standards and samples making sure the standards response (peak height) bracketed the response of the sample injected between them. The responses were plotted on linear graph paper, and the unknown quantity was taken from the plot. The calculated concentrations were corrected for recovery by using the ratio of the difference between the spiked and unspiked duplicate samples to the size of the spike. Mean measured concentrations were used for all calculations of biological data.

The extraction efficiencies of this method are presented in a previous report (Nebeker et al. 1972). The recovery values based on the single-peak evaluation show little difference in the Aroclors. This indicates that the extraction of the compound represented by the peak may be only slightly affected by the other compounds present.

The variability of this method on duplicate samples is less than 10%, regardless of concentration of toxicant. The variability of G.C. injection was less than 5% for duplicate injections of the standard or the same residue and up to 10% for injections of different volumes of the same residue.

A comparison of nominal and measured concentrations for all three Aroclors (Nebeker et al. 1972) indicated that, except for a few high values, the diluter systems were working well.

A standard, one/two factor analysis of variance program (ANOVA) written for the CDC 3300 was used to test for experimental differences.

Chemical characteristics of the Lake Superior Test water, measured daily or weekly with Standard Methods (American Public Health Association 1965), were as follows: pH, 7.5-8.0; acidity, 2.4-4.0 mg/liter; alkalinity, 40-43 mg/liter (as $CaCO_3$); calcium hardness, 34-36 mg/liter; and total hardness, 44-46 mg/liter.

Terminal residues of Aroclor 1242 and 1254 in fathead minnows were determined by the Fish-Pesticide Laboratory, Columbia, Missouri, using the methods of Stalling and Johnson (1971). Residues of PCB's in feed used in tests was also determined (Table 9).

Results

Fathead Minnow - Aroclor 1242

Concentrations of Aroclor 1242 above 10 µg/liter were lethal to newly hatched fry. Calculated 96-hr LC50 values for Aroclor 1242 were 15 µg/liter for newly hatched young fathead minnows and greater than 234 µg/liter (near 300 µg/liter) for 2-month-old fish. All minnows in the long-term study were dead after 96 hours in 51 µg/liter 1242, and none survived to the end of the test (8 months) at 15 µg/liter. Survival of fry was excellent when reared at the same concentrations their parents lived and spawned at. The final weights and total lengths of the fish did not differ significantly at the end of the 8-month test, however, growth of newly hatched fish was retarded prior to their death at the higher PCB concentrations.

Reproduction occurred at and below 5.4 µg/liter 1242 but spawning results and egg production were highly variable (Table 1) even when numbers of males and females were the same in some duplicate tanks. Egg hatchability was also variable but good hatching occurred at 5.4 µg/liter. Eggs were more resistant than fry at 15 and 51 mg/liter. Eggs produced by the controls but maintained at the higher concentrations hatched with good success, but none of the fry survived.

Terminal residues of Aroclor 1242 in fathead minnows exposed for 8.5 months are given in Table 5 (controls - Table 7).

Fathead Minnow - Aroclor 1248

Fathead minnows died rapidly at 18 µg/liter Aroclor 1248, and none was alive at the end of a 30-day test. Seventy-five percent were alive at 5.1 µg/liter, but their weight was only one-third that

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of the controls; their final lengths were not significantly different, however.

The final weight of the fish in 2.2 µg/liter was only half that of the controls; final lengths were the same. The results in the two lowest concentrations (0.54 and 0.18 µg/liter) were not significantly different from the controls.

Fathead Minnow - Aroclor 1254

Aroclor 1254 was more toxic to the fathead minnow than 1242 as they did not survive and reproduce above 1.8 µg/liter 1254. Calculated 96-hr LC50 values for Aroclor 1254 were 7.7 µg/liter for newly hatched young fathead minnows and greater than 33 µg/liter for 2-month-old fish. All fish in the long-term reproduction study were dead after 96 hours in 15 µg/liter 1254 in both tanks. Survival at lower concentrations was not significantly different from the controls. The mean terminal weights of the fish were not significantly different in the various concentrations, but growth in length was delayed at 4.6 µg/liter. Spawning occurred at 1.8 µg/liter, but was significantly less than that at lower concentrations. Spawning was variable during the test, even between duplicate tanks (Table 2).

Egg hatchability and fry survival were good at and below 1.8 µg/liter (Table 3). Eggs produced by the controls and maintained in higher PCB concentrations (15 µg/liter) hatched readily, but all young were dead within 96 hours. Young fish which were held for 30 days in separate tanks at the same PCB concentrations at which they were spawned survived and grew well.

Terminal residues of Aroclor 1254 in fathead minnows exposed for 8 months are given in Table 6 (controls - Table 8).

Jordanella - Aroclor 1248

Fish held in 18 µg/liter Aroclor 1248 lived for about 2 weeks before they started to die. One died every 2-3 days until all were dead at the end of the 40-day test. Thirty-five percent were alive at 5.1 µg/liter at the end of the test; mean weight was only 15% that of the controls (Table 4). Mean length at 5.1 µg/liter was 21.8 mm, compared to 24.6 mm for the controls.

The fish in 18 and 5.1 µg/liter 1248 lost their fins and tail almost completely, as if they had been eroded away. The death of the one remaining fish at 18 µg/liter and three fish in 5.1 µg/liter when the temperature dropped from 25 C to 21 C indicates the precarious condition of the fish even though they were still alive.

Discussion

The results obtained from this study indicate that polychlorinated biphenyls are acutely toxic, and cause chronic toxicity at very low levels. The newly hatched larvae apparently are the most sensitive stage in the life cycle, at least for short-term exposure. The eggs were resistant or impermeable to the PCB mixtures. The inhibition by the PCB mixtures of bacterial-fungal growths on the incubating eggs resulted in a much better egg hatch at higher PCB levels. Juvenile fish, when tested for up to 30 days, were much less susceptible than very young fish. Tissue residues were very high in test fish, with some fish containing more than 200,000 times as much PCB as the water they were tested in.

MONS 066034

Acknowledgments

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MONS 066037

Table 1. Spawning and egg production of the fathead minnow at various concentrations of Aroclor 1242

Mean measured concentration (µg/liter)	Test tanks	Number of males	Number of females	Number of spawnings	Number of spawnings per female	Total eggs produced	Number of eggs per spawning	Number of eggs per female
51	A	0	0	0	0	0	0	0
	B	0	0	0	0	0	0	0
15	A	0	0	0	0	0	0	0
	B	0	0	0	0	0	0	0
5.4	A	4	5	25	5.0	1,514	61	303
	B	4	6	0	0	0	0	0
2.9	A	5	4	24	6.0	1,923	80	481
	B	4	5	9	1.8	424	47	85
0.86	A	6	4	5	1.3	138	28	35
	B*	-	-	—	—	—	—	—
0.0 (control)	A	1	8	42	5.2	5,350	127	669
	B	3	6	24	4.0	1,288	54	215

*Accidentally killed.

Table 2. Spawning and egg production of the fathead minnow at various concentrations of Aroclor 1254.

Mean measured concentration (µg/liter)	Test tanks	Number of males	Number of females	Number of spawnings	Number of spawnings per female	Total eggs produced	Number of eggs per spawning	Number of eggs per female
15	A	0	0	0	0	0	0	0
	B	0	0	0	0	0	0	0
4.6	A	4	5	0	0	0	0	0
	B	1	5	0	0	0	0	0
1.8	A	3	7	14	2.0	1,473	105	210
	B	4	7	1	0.14	22	22	3
0.52	A	4	6	30	5.0	4,142	138	690
	B	4	6	33	5.5	2,538	77	423
0.23	A	1	8	35	4.4	2,993	86	374
	B	5	5	8	1.6	346	43	69
0.0 (control)	A	3	6	27	4.5	2,838	105	473
	B	4	6	2	0.3	206	103	34

EPA 600 SNOM

Table 3. Egg hatchability and fry survival of the fathead and DeFoe minnow at various concentrations of Aroclor 1254

Mean measured concentration (µg/liter)	Test tanks	Number of eggs used	Number of live fry obtained	Egg hatchability (%)
15	A	0	0	0
	B	0	0	0
4.6	A	0	0	0
	B	0	0	0
1.8	A	300	186	62
	B	50	48	96
0.52	A	375	251	67
	B	345	205	59
0.23	A	272	150	55
	B	0	0	0
0.0 (control)	A	250	191	76
	B	150	107	71

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Table 4. Survival and growth of newly hatched *Jordanella floridae* after 40 days' exposure to Aroclor 1248

Mean measured concentration (µg/liter)	Initial number of animals	Mean survival (%)	Final mean weight (g)	Final mean length (mm)
18	20	0	—	—
5.1	20	35	.60	21.8
2.2	20	85	3.02	24.1
0.54	20	100	4.47	26.3
0.18	20	90	3.90	25.5
0 (control)	20	100	4.33	24.6

Table 5. Terminal residues of Aroclor 1242 in fathead minnows exposed for 8.5 months.

Mean measured PCB concentration (µg/liter)	Residues (µg/g)						Concentration factor	
	A		B		Mean			
	Males	Females	Males	Females	Males	Females	Males	Females
0.86	62(2)	92(3)[a]	—	—	236	92[c]	274,000	107,000
	410[4][b]	—	—	—				
2.9	—	—	124(3)	98(3)	93	107	32,000	37,000
	—	—	62[5]	117[5]				
5.4	306(1)	364(2)	—	436(2)	345	436	63,000	81,000
	278[2]	430[4]	452[2]	514[5]				

[a]Mean of (N) individual samples.
[b]Pooled samples of [N] fish.
[c]Average of pooled and mean individual analysis for both A and B tests.

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Table 6. Terminal residues of Aroclor 1254 in fathead minnows exposed for 8 months.

Mean measured PCB concentration (µg/liter)	Residues (µg/g)						Concentration factor	
	A		B		Mean			
	Males	Females	Males	Females	Males	Females	Males	Females
0.23	57(2)	28(1)	43(2)[a]	—	54	45[c]	235,000	196,000
	—	48[6]	61[4][b]	50[4]				
0.52	133(2)	99(3)	64(2)	104(2)	81	105	156,000	201,000
	54[3]	--	74[4]	113[5]				
1.8	204(1)	458(3)	103(1)	361(2)	196	429	109,000	238,000
	83[2]	347[6]	394[4]	353[5]				
4.6	803(1)	741(1)	1110(1)	1004(5)	1036	999	225,000	217,000
	1204[3]	1253[3]	—	—				

[a] Mean of (N) individual samples.
[b] Pooled samples of [N] fish.
[c] Average of pooled and mean individual analysis for both A and B tests.

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Table 7. Terminal residues in control fish from Aroclor 1242 study

Fish (µg/g)	P,P'-DDE	Aroclor 1248	Aroclor 1260
A controls			
Males (1)[a]	0.02	---	2.2
Females (8)	0.08	3.3	2.8
B controls			
Males (3)	0.04	0.9	1.1
Females (6)	0.10	3.2	2.8

[a]Average of (N) fish.

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Table 8. Terminal residues in control fish from Aroclor 1254 study

Fish (µg/g)	p',p''-DDE	Aroclor 1248	Aroclor 1260
A controls			
Males (3)[a]	0.05	0.7	1.1
Females (6)	0.04	1.1	2.3
B controls			
Males (2)	0.03	0.9	1.9
Females (8)	0.04	1.6	2.7

[a]Average of (N) fish.

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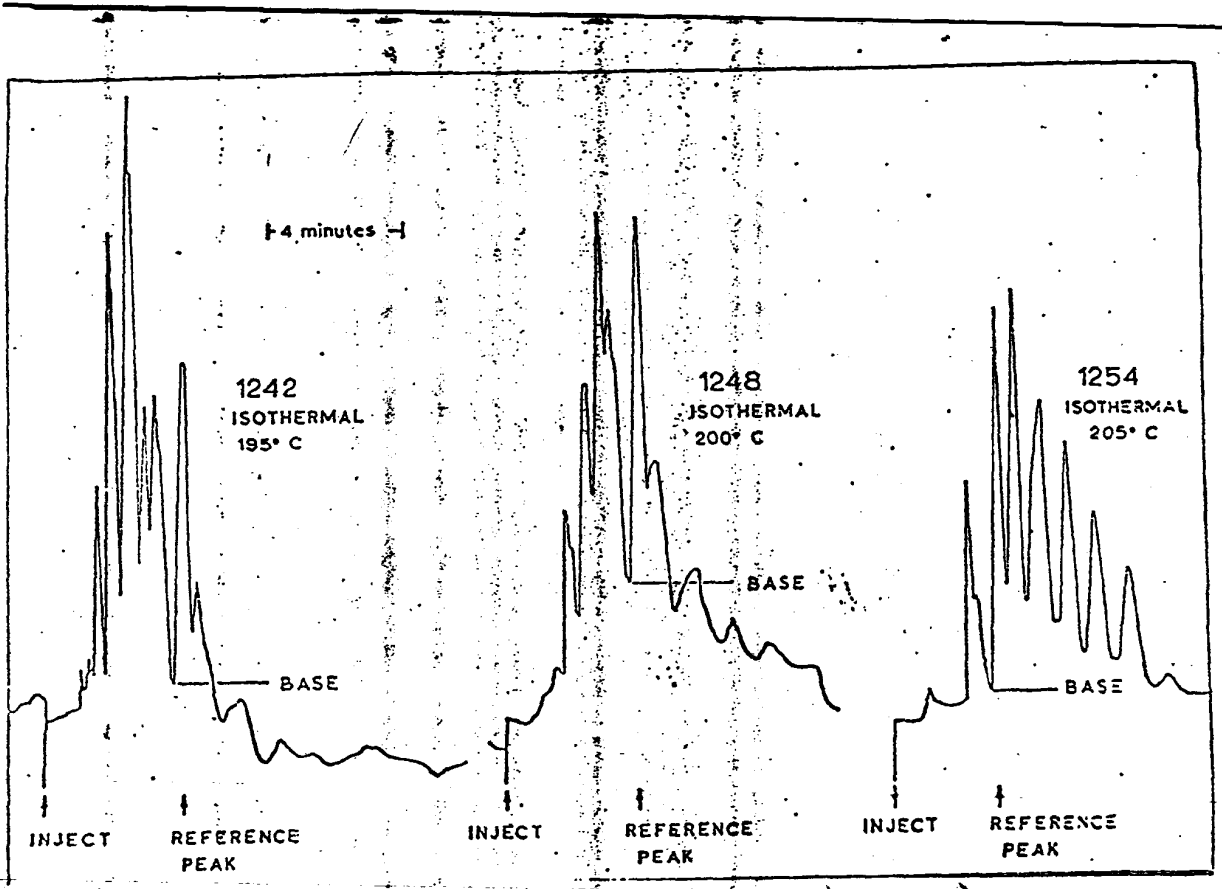
Table 9. Residues in feed used in tests

	Pesticide and PCB (ug/g)				
	p,p'-DDE	p,p'-DDD	p,p'-DDT	Aroclor 1248	Aroclor 1254
Fish food Jan., 1971	0.22	0.02	0.10	0.3	0.8
Fish food Feb., 1971	0.20	0.02	0.10	0.5	1.5

MONS 066046

Figure 3. Single peak used as reference for quantitation of Aroclors 1242, 1248, 1254.



Nebeker, Purtill and DeFoe

MAY 28 1974

POLYCHLORINATED BIPHENYLS IN EFFLUENTS FROM SEWAGE TREATMENT PLANTS IN SOUTHEASTERN WISCONSIN

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ABSTRACT

The Wisconsin Department of Natural Resources and the State Laboratory of Hygiene conducted a survey of polychlorinated biphenyl (PCB) concentrations in 11 municipal sewage treatment plants in southeastern Wisconsin. Samples were collected 4 times over a one-year period and follow-up sampling was done at 12 and 14 months later.

The polychlorinated biphenyl found at 10 of the 11 sewage treatment plants was Aroclor 1254 at concentrations from 0.05 µg/l (determinable limit) to 2.8 µg/l. Effluents from the eleventh treatment plant contained Aroclor 1248 at concentrations as high as 42 µg/l. Mass transport of Aroclor 1254 varied from 2.4×10^{-4} to 1.42×10^{-1} pounds per day.

One sewage treatment plant was studied for 24 hours on a 2-hour sampling schedule. Samples were taken from raw sewage influent, final effluent, trickling filter effluent, primary sludges and digester sludges. The concentration in the influent varied from 0.1 to 3.1 µg/l. The sludges were found to contain PCB concentrations that were 1,000 times higher than those found in the fluid wastes. The sewage plant was removing 70 percent of the polychlorinated biphenyls from the influent.

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INTRODUCTION

Chlorinated hydrocarbons are synthetic organic chemicals which have been found to be widespread contaminants in the aquatic environment. These contaminants enter the aquatic environment as runoff from agricultural and municipal applications and waste from industrial practices.

In the past six years, the presence of pesticides in the environment has stimulated increasing study and concern. The concern over pesticides is based on possible acute and chronic toxicities, particularly reproductive failure in birds and animals. As methods of detection were improved, polychlorinated biphenyls (PCB's) (mixtures of chlorinated biphenyl compounds having various percentages of chlorination) were found along with certain pesticides. Interest in PCB's increased because some of the physiological effects of the PCB isomers were similar to those of the chlorinated pesticides.

In Wisconsin, Veith (7) found PCB's in samples taken from the Milwaukee River near Milwaukee, Wisconsin. Concentrations of this PCB (identified as Aroclor 1260) ranged from 0.02 to 0.26 µg/l. PCB's were also found in selected sewage treatment plants along the Milwaukee River at concentrations of Aroclor 1254 from 0.12 to 0.25 µg/l (7).

In order to determine the degree of contamination in other waters in southeastern Wisconsin, this study of sewage treatment plant effluents was designed. Specific objectives of the study were: (1) to determine the composition and concentration of any PCB's present in the waste waters, (2) to establish concentration fluctuations in the treatment plants and (3) to establish the number of pounds of PCB's leaving the plants each day.

STUDY AREA

Samples were collected at the municipal sewage treatment plants in eleven southeastern Wisconsin cities (Fig. 1). Factors used to select these cities were: size of population (1,500 to 100,000), volume of waste flow (140,000 gallons per day to 13 MGD), type of treatment, number and type of industries present and type of receiving water.

Beaver Dam is a city of 15,000 population with paint, glass, foundry and metal fabricators as its major industries. The domestic and industrial wastes average 250,000 gallons per day, and are treated at the municipal plant by a trickling filter, digesters and chlorine before entering the Beaver Dam River.

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Beloit has a population of 35,000. Its major industries are printing, tool and die, chemical formulators and heavy equipment. The total waste flow to the city treatment plant is 5 MGD treated by activated sludge and chlorine before entering the Rock River.

Burlington is a city of 6,000 people with cement, metal work, abrasives, paint, fiberglass, electrical equipment, and chemicals as the major industrial input to the 1.5 MGD waste flow. The waste is treated by a trickling filter, activated sludge and chlorine before it enters the Illinois-Fox River.

Cedarburg is a highly industralized city of 5,000 people. Its industries include casting, plastics, tool and die, printing and paint. The average flow of waste is one MGD which is treated by a trickling filter and chlorine before entering Cedar Creek.

Fort Atkinson has a population of 8,000 people with the following major industries: tool and die, foundry, printing, electrical equipment and paint. The total flow to the municipal sewage treatment plant is 1.3 MGD which is treated by activated sludge, digestion and chlorine before entering the Rock River.

Grafton is a city of 4,000 population with steel products, welding and cutting, casting, printing, concrete, plastics and electrical equipment as its major industries. The 780,000 gallons per day of waste is treated with activated sludge and chlorine before it is discharged into Cedar Creek.

Lake Geneva, with a population of 5,000 people, has a waste flow of 700,000 gallons per day accumulating from both sanitary and industrial wastes. Industries include plastics, electrical fixtures, rubber products and tool and die. Wastes are treated by a trickling filter and chlorine before entering the White River.

Portage is a city of 8,000 people. Concrete products, plastics, hosiery and reproducing paper are its main industries. The combined sanitary and industrial waste is 700,000 gallons per day. It is treated by a trickling filter and chlorine before it is discharged into the Fox River.

The large industrial city of Racine has a population of 100,000. Wastes from its industries--die and molding, precision stamping, casting, foundry, printing, paint, electrical products, chemical treatment and formulators--combine with sanitary wastes to produce 11 MGD of waste. This waste is treated by activated sludge and chlorine before entering Lake Michigan.

Walworth is a small city of 1,500 people with no large industries. The total waste flow is 140,000 gallons per day and is treated with a trickling filter before being released into Walworth Creek.

METHODS

Sampling

Since many plastics and polyvinyl chloride materials may contain a PCB or related interferring compound plasticizer, all-glass containers were used throughout the study to preclude the possibility of sample contamination from the vessel.

The samples were collected by immersing 2½-liter glass bottles in the waste stream at its entrance to the treatment plant, in the primary settling tank, in the trickling filter effluent, and in the final effluent of the sewage treatment plant. The samples were conveyed to the State Laboratory of Hygiene, Madison, Wisconsin, and extracted within 24 hours.

Extraction

The samples were batch-extracted with hexane in separatory funnels. The samples were not filtered because the samples contained small amounts of solids. Hexane (100 ml) was placed in the funnels and the sample (800 ml) was placed in the funnel. After vigorous agitation for one minute, the sample was passed to another funnel also containing hexane (100 ml) and again agitated for one minute. The water portion was then discarded. This procedure was followed until 2400 ml of the sample had been completely extracted. The extracts were combined and concentrated to ten ml for cleanup.

Cleanup

The hexane extracts of the unfiltered effluents were then "cleaned up" to remove certain materials which might interfere with the analyses of the samples for PCB's. This cleanup was done by means of liquid-solid chromatography of florisil *(1, 2, 3, 6)*.

The florisil column used for the cleanup was a ½-inch OD glass column with a 200-ml vessel on the top. The column was fitted with a fritted glass and Teflon stopcock at the bottom. The column was filled with ½ inch of anhydrous Na_2SO_4 and 19 grams of florisil which had been activated at 105 C. The column was then covered with another ½ inch of anhydrous Na_2SO_4 to prevent deactivation from water in the sample extract *(3)*. The columns were pre-wetted with hexane and the extracts (10 ml) were placed on the column and eluted with hexane ether mixture (200 ml, 94/6 percent) at three to five ml/minute *(5)*. This procedure removed all fats, waxes, oils and pigments, leaving an eluate containing PCB's as well as any pesticides that might have been present in the sample.

In order to separate the PCB's from the pesticides, the eluate was concentrated to two ml and passed through a second florisil column. This cleanup was done by means of florisil in a 9-mm ID glass column with 65 ml of hexane as the eluate *(7)*. This procedure removed all pesticides except for DDE [(1,1-dichloro-2,2-bis(*p*-chlorophenyl) ethylene)] which, if present, remained with the PCB's. The extracts were then concentrated to appropriate volumes for analyses of the samples on the gas-liquid chromatograph.

Analysis

Analyses of the cleaned-up extracts to determine the presence of PCB's were made by means of gas-liquid chromatography (GLC) with an electron-capture detector. This technique for isolating and identifying PCB's was the same as that used by Veith *(7)* and Veith and Lee *(8)*.

Gas chromatographic analyses were conducted on a Barber Coleman 5460 Pestalyzer gas chromatograph equipped with a concentric tube, electron-capture detector (^{90}SR). The columns used were six feet by ¼-inch glass coils packed with OV-101/QF-1 (2:2 percent) and OV-101/DC-200 (2:3 percent) coated on Gas Chrom Q (80/100 mesh). The carrier gas (purified nitrogen) was maintained at a flow rate of 28 ml per minute; and the injector, column and detector temperatures were 210 C, 200 C and 270 C respectively.

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Identification

From the charts made by the gas chromatograph, identification of the PCB's was made by comparing chromatograms of standard Aroclors with the chromatograms of the samples to determine which Aroclor the sample most resembled. Once an Aroclor was identified in a sample, determination of the concentration present was made by measuring the height of the most prominent peaks in each of the Aroclor standards and comparing these to the height of the most prominent peaks in the sample. In this study, these peaks (isomer components numbers 4 and 7) lay on either side of the first doublet peak (isomer components numbers 5 and 6) (Fig. 2).

The difficulty of this method of identifying which Aroclor is present occurs when a sample contains a mixture of two or more Aroclors. Each Aroclor formulation contains a group of characteristic isomers. These isomers are separated on a gas chromatographic column according to their physical and chemical characteristics. One of these distinguishing characteristics is the percentage of chlorine: each isomer contains a specific number of chlorine atoms. The higher the number of chlorine atoms, the longer the GLC column retains them. The amount of time the isomers are retained on the column is used as an identification technique.

Mixtures of more than one Aroclor may contain some of the same isomers. Therefore, when a sample containing several Aroclors is analyzed, the concentration of one isomer is higher because the same isomer from both Aroclors is analyzed as one component. Figure 3 shows chromatograms of a series of single Aroclors and a mixture of 3 Aroclors on a total ion monitor detector with respect to temperature. As the percent chlorine increases (from 48 to 68 percent), the retention time increases, making the identification of single mixtures less complex. The chromatogram at the bottom of figure 3 is a mixture of Aroclor 1248, 1254 and 1260 and shows the difficulty in identifying the PCB's in a sample containing more than one Aroclor. The analysis of known mixtures like this is the best method of identifying PCB's present in an unknown sample thought to contain a mixture of several Aroclors.

Confirmation

Because of possible complications caused by the presence of more than one Aroclor and because of the possible interference of DDE, identification of some of the samples was confirmed using mass spectrometry (MS). Confirmation was made on 9 of the peaks from 3 of the samples.

The mass spectrometry data was obtained at the Environmental Protection Agency's Southeast Water Laboratory in Athens, Georgia. Analyses were made on the Hatachi Perkin Elmer RMU-7 double focusing instrument interfaced to a PE-900 gas chromatograph with a Watson-Bieman separator. A constant accelerating voltage of 70 electron volts was used. The mass spectrometer data were manually reduced.

In addition to confirming the accuracy of the identification of Aroclors in some samples, confirmation of the estimates of PCB concentrations present was also made. Three samples of raw sewage and three samples of the final effluent were collected from the treatment plant at Cedarburg on October 6, 1971. Each of the 6 samples was extracted with hexane, cleaned up with florisil and injected into the gas chromatograph. Concentrations reported are the average of two injections. Precision of the estimates was determined by comparing the Aroclor concentration in each of the influent samples with the average concentration found in the three samples. Similar comparisons were made for the three samples from the final effluent.

RESULTS AND DISCUSSION

Confirmatory Data

Accuracy

Of the 3 samples analyzed on the mass spectrometer, identification of PCB's present was the same as the identification reported by the gas chromatograph. Because the original identifications were confirmed and because all samples were analyzed on the gas chromatograph in the same way, identification of the remaining samples was assumed to be qualitatively correct.

Although the MS could not preclude the possible occurrence of materials other than PCB's in the rest of the samples, the sewage treatment plant at Beaver Dam was the only site where possible interference was noted. On the gas chromatograms from this site, PCB's could be detected but the peaks on the graphs were obscured in such a way that the PCB concentrations present could not be determined. This masking effect may have been caused by the presence of DDE in the sample.

Precision

Recoveries of the samples used to test the precision of the Aroclor 1254 analyses are summarized in Table 1. The analyses of the raw sewage samples varied 7 percent from 1.4 µg/l, while analyses of the final effluent samples varied 10 percent from 1.0 µg/l.

Analytical Results

The samples analyzed in this study indicate that Aroclor 1254 is the most common PCB in the sewage effluents. Table 2 shows that PCB's were detected in all samples, at concentrations varying from <0.05 µg/l at Beaver Dam to 2.8 µg/l at Lake Geneva.[1] The mass transport (average pounds per day) of Aroclor 1254 ranged from less than 0.2×10^{-3} to 142×10^{-3} pounds per day at Beaver Dam and Racine, respectively.

Port Washington is not as highly industralized as Grafton; however, the effluents from both cities contained approximately the same concentrations of PCB's. The concentrations ranged from 0.12 to 0.23 µg/l which, based on this study, is an average for cities with little or no industry.

[1] At Beaver Dam, PCB's could be identified on the gas chromatogram, but the concentration could not be determined. In this study, concentrations could be calculated if 0.05 or more mg/l of PCB's were present in the sample.

Cedarburg is an industrialized municipality whose effluents contained concentrations of Aroclor 1254 in the range of 1.0 µg/l. Because the concentrations of PCB's for this city were so high, the fluctuations in concentration throughout a 24-hour day were determined (Table 3). The concentration of PCB's in raw sewage began to increase at the beginning of the working day (8:00) from 0.54 µg/l to a maximum of 3.1 µg/l at 16:00. This variation in PCB concentrations coming into the sewage plant is probably due to incoming wastes from the city's 5 major industries. Also noted in the 24-hour survey was the fact that wastes were retained in the sewage treatment plant from two to four hours. This conclusion was based on the presence of a pink dye in the raw influent at 20:00 and the presence of the same dye in the treated effluent at 22:00.

Figure 4 illustrates the concentration of PCB's in the influent and effluent for a 24-hour period. The concentration of PCB's in the final effluent appears to begin increasing from 0.33 µg/l at 0:00 (midnight) to a maximum of 0.77 µg/l at 14:00. PCB concentrations in both raw and final waste waters seem to increase and decrease at the same times throughout the day; however, since the PCB concentration in the effluent is approximately 30 percent of that in the influent, it is likely that the treatment plant is removing in excess of 70 percent of the PCB's. Table 4 shows that the sludges contain 1,000 times higher concentrations than do the fluid wastes.

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Racine is highly industrialized and has a high flow (11 MGD) in its sewage treatment plant. The PCB concentrations varied from 0.60 µg/l on February 19 to 0.83 µg/l on October 6 which was less than the maximum level of PCB's recorded at the Cedarburg plant. However, due to the higher flow, the mass transport of PCB's from the Racine plant is greater than 0.1 pounds per day compared with approximately 0.02 pounds per day from the Cedarburg treatment plant.

Plants in Burlington, Walworth, Beloit and Fort Atkinson have concentrations above the determinable level (0.05 mg/l) but less than 0.40 µg/l. The mass transport of PCB's from the sewage treatment plants in these four cities is less than 0.01 pounds per day.

Lake Geneva is a highly industrialized city whose treatment plant effluents had PCB concentrations between 2.2 and 2.8 µg/l. These high PCB concentrations indicate that the contamination is possibly from industrial wastes. The daily discharge of 0.02 pounds per day was comparable to that for the Cedarburg plant.

Although industries in the city of Portage are few, they contribute between 32 and 42 µg/l of Aroclor 1248 to the sanitary waste flow. A sample of the digester sludge was analyzed at 10:00 and found to contain 5.25 mg/l. It is of interest to note that the city of Portage has reported problems with the operation of their trickling filter which may be due, in part, to the presence of PCB's and other chemicals. With 32-42 µg/l Aroclor 1248 in the waste, it could be toxic to some of the filter fauna. Organic mercury compounds were also found (by the MS method) on the scum of the trickling filter at concentrations up to 90 ng/l.

Data presented in Table 3 demonstrate that the time of sampling waste effluents is of major importance in mass transport estimates. For example, if the Cedarburg effluent were sampled at 14:00 on April 15, 1971, the estimated transport of PCB's out of the plant would be approximately twice that estimated from a sample taken at 8:00. It should be noted, however, that the PCB concentration in the effluent from the plant varied considerably less than that in the raw wastes entering the plant. Consequently, the mass transport may be considered as order-of-magnitude estimates (i.e., estimates are only accurate within 1,000 percent).

The sources of the PCB's entering the sewage treatment plants have not been explicitly identified in this study or in the literature. It is possible that PCB's could be released through the use of household products such as cleaning compounds and waxes which may contain PCB's. For example, Veith (Dep. Water Chem., Univ. Wis., Madison, Wis., unpublished) found PCB's in several detergents designed for electric dishwashers. In addition to these possible household sources, PCB's may be released from leaking heat-exchanges, cutting oils, lubricants, etc. The Monsanto Company, the sole producer of PCB's in the U.S., restricted the sales of PCB's to capacitors, transformers and heat exchange systems in August, 1970, although until August, 1971, PCB's were still sold for industrial uses for which suitable replacement chemicals were not immediately available. Therefore, the presence of PCB's in waste effluents after April, 1971, suggests that this contaminant is arising from stockpiled PCB's.

In January, 1972, Monsanto Company further restricted the use of PCB's by prohibiting the sale of these chemicals for use in heat-exchangers (G. Fred Lee, Dep. Water Chem., Univ. Wis., Madison, Wis., unpublished). PCB's are now available in the U.S. solely for the manufacture of capacitors and fire-proof transformers. Further studies are needed to determine how effective these self-improved restrictions by Monsanto Company will be in reducing the quantities of PCB's entering the environment.

CONCLUSIONS

Summary

The results of this study indicate that 6 of the 11 sewage plants in the study had effluent concentrations in the range of 0.1 to 0.5 µg/l of a compound whose chromatogram appeared to match the chromatogram of Aroclor 1254. Two sites had effluent concentrations greater than 1.0 µg/l of Aroclor 1254. One city had a maximum concentration of 42 µg/l Aroclor 1248 in the effluent waters and 5.2 mg/l Aroclor 1248 in the digester sludge.

Data from the Cedarburg treatment plant show that the time of collection is important because the concentration can vary greatly. The data show that the minimum concentrations of PCB's in the Cedarburg plant are probably 0.13 to 0.30 µg/l of Aroclor 1254, while maximum concentrations range from 1.5 to 3.1 µg/l. Because of these fluctuations from hour to hour, it is difficult to precisely determine the total amount of PCB's being discharged into receiving waters without hourly sampling of the effluent at a given site.

Of the various samples of waste effluents collected, the estimated mass transport of PCB's varied from $<2.0 \times 10^{-4}$ to 142×10^{-3} pounds per day. At Racine, an equivalent of 41.1 pounds of PCB's per year flow into the near shore waters of Lake Michigan and could ultimately contaminate millions of pounds of organisms in the food chain.

The concentration of PCB's in the influent was approximately ten times the concentration in the effluent. Based on the study at the Cedarburg plant, it appears that the treatment of domestic wastes removes 70 percent or more of the PCB's (Aroclor 1254) present in incoming wastes. The fact that most of the PCB's are removed by treatment is also evident in the comparatively high concentration of PCB's found in the digester and primary settling sludges.

Recommendations

Future research on PCB's is needed in the areas of toxicities, degradation and transport. This will enable evaluation of the significance of the observed PCB concentrations in the environment.

Because PCB's were present in all sewage treatment plants studied, more research is needed to locate sources. The relative contributions of industrial and sanitary sources could be estimated by systematically sampling industrial and residential sewers.

A monitoring program on PCB's should be continued to see if the concentrations in domestic waste waters decrease to any significant extent as a result of Monsento's restriction on the sale of the compounds. In addition, further studies should be designed to estimate the significance of hourly fluctuations in PCB concentrations in the interpretation of the resulting data.

ACKNOWLEDGMENT

Grateful acknowledgment is extended to Dr. G. D. Veith for his supervision throughout the study, to Drs. G. Fred Lee and D. E. Armstrong for their reviewing of this thesis, to Jackie Zoch for her aid in the analyses, to Joe Ball for his assistance in sample collection and to Dr. Wayne Garrison and his staff from the Southeast Water Laboratory in Athens, Georgia for their help on mass spectral analyses.

This investigation was funded by the Wisconsin Department of Natural Resources and was supplemented by the Department of Civil and Environmental Engineering, University of Wisconsin.

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MONS 066071

FIGURE CAPTIONS

FIGURE 1.--Location of sampling sites in southeastern Wisconsin.

FIGURE 2.--Retention time of Aroclor 1254.

FIGURE 3.--Relative retention times of Aroclors 1248, 1254, 1260, 1262 and 1268 *(4)*.

FIGURE 4.--Hourly concentrations of PCB's in the influent and effluent from the Cedarburg treatment plant, April 15, 1971.

MONS 066072

FIGURE 1

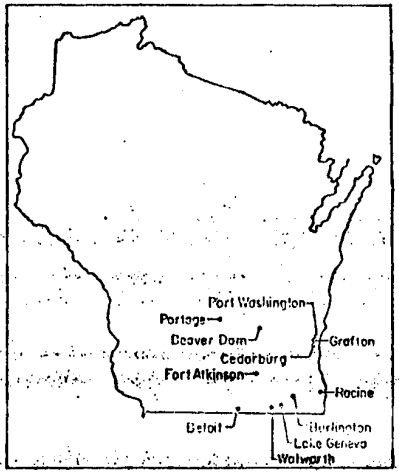

Port Washington
Portage
Beaver Dam
Grafton
Cedarburg
Fort Atkinson
Racine
Beloit
Burlington
Lake Geneva
Walworth

FIGURE 3

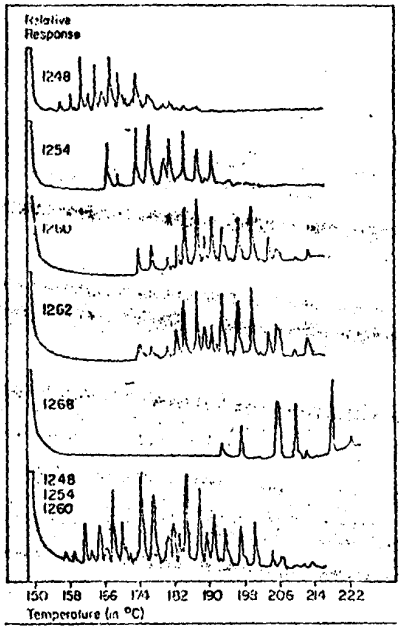

Relative Response
1248
1254
1260
1262
1268
1248
1254
1260
150 158 166 174 182 190 198 206 214 222
Temperature (in °C)

FIGURE 4

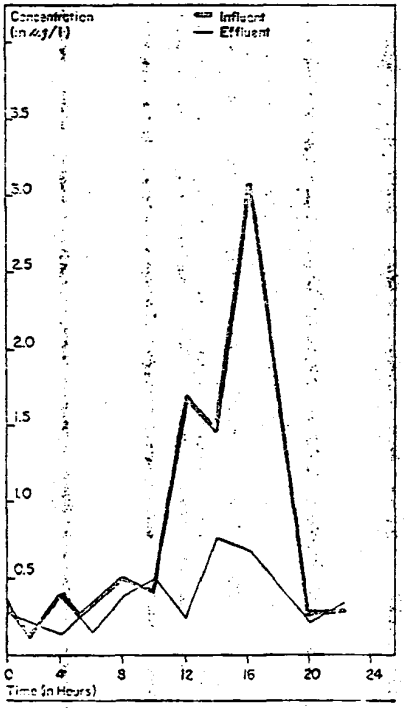
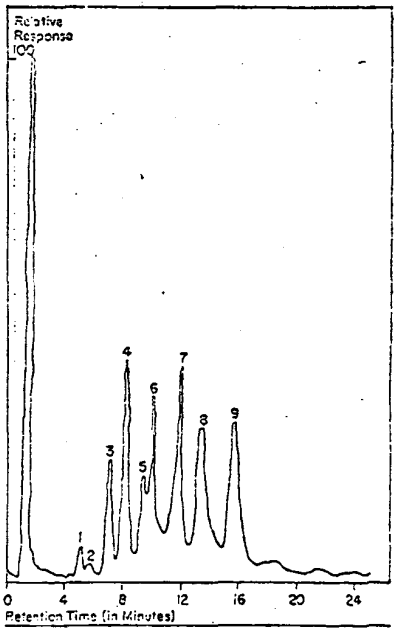


FIGURE 2



MONS 066075

TABLE 1.--Recovery of PCB's from triplicate samples taken at the Cedarburg treatment plant, October 6, 1971, at 11:30

SAMPLE TYPE & NO.	VOLUME EXTRACTED (in ml)	PCB CONCENTRATION (in $\mu g/l$)[1]
RAW SEWAGE		
Sample 1	3,000	1.5
Sample 2	3,000	1.4
Sample 3	3,000	1.4
FINAL EFFLUENT		
Sample 1	2,500	0.9
Sample 2	2,400	1.1
Sample 3	2,400	1.0

[1] The chromatograms of all samples collected most closely resembled the chromatogram of Aroclor 1254.

MONS 066076

TABLE 2.--PCB concentrations in the effluents from 11 southeastern Wisconsin sewage treatment plants, 1971

CITY	SAMPLING DATE	SAMPLING TIME	PCB CONCENTRATIONS (in µg/l)[1]	WASTE VOLUME FLOW (in MGD)	WASTE VOLUME ESTIMATED MASS TRANSPORT[2] (in lbs PCB's/day at 10^{-3})
Beaver Dam	1/20	6:30	<0.05	1.59	<0.2
	2/19	6:30	<0.05	4.33	-
	3/22	6:30	<0.05	3.50	-
	10/6	6:30	<0.05	2.34	-
Port Washington	1/20	8:30	0.14	0.70	-
	2/19	8:30	0.12	1.27	-
	3/22	8:30	0.22	1.46	2.7
	10/6	8:30	0.19	1.80	-
Grafton	1/9	9:30	0.12	0.84	0.8
	2/19	9:30	0.13	1.00	1.1
	3/22	9:30	0.23	0.78	1.5
	10/6	9:30	0.07	0.84	-
Cedarburg	1/20	10:30	0.48	1.05	4.2
	2/19	10:30	0.28	1.17	2.7
	3/22	10:30	0.97	2.57	-
	10/6	10:30	0.91	1.95	15
	10/6	10:30	1.1	1.95	18
	10/6	10:30	1.0	1.95	16

MONS 066077

TABLE 2.--PCB concentrations in the effluents from 11 southeastern Wisconsin sewage treatment plants, 1971 (cont.)

CITY	SAMPLING DATE	SAMPLING TIME	PCB CONCENTRATIONS (in µg/l)[1]	WASTE VOLUME FLOW (in MGD)	WASTE VOLUME ESTIMATED MASS TRANSPORT[2] (in lbs PCB's/day at 10^{-3})
Racine	1/20	8:30	0.72	16.45	-
	2/19	12:00	0.60	25.06	-
	3/22	12:00	0.76	23.01	-
	10/6	12:00	0.83	20.51	142
Burlington	1/20	9:30	0.14	1.74	-
	2/19	13:00	0.09	2.61	-
	3/22	13:00	0.08	2.50	1.7
	10/6	13:00	0.12	1.35	-
Lake Geneva	1/20	10:30	2.5	0.56	-
	2/19	14:00	2.2	0.66	-
	3/22	14:00	2.8	0.78	18
	10/6	14:00	2.4	0.54	-
Walworth	1/19	11:00	0.17	-	-
	2/20	14:30	0.21	-	-
	3/22	14:30	0.34	-	-
	10/6	14:30	0.18	-	-

MONS 066078

TABLE 2.--PCB concentrations in the effluents from 11 southeastern Wisconsin sewage treatment plants, 1971 (cont.)

CITY	SAMPLING DATE	SAMPLING TIME	PCB CONCENTRATIONS (in µg/l)[1]	WASTE VOLUME FLOW (in MGD)	WASTE VOLUME ESTIMATED MASS TRANSPORT[2] (in lbs PCB's/day at 10^{-3})
Beloit	1/19	12:30	0.11	3.89	-
	2/20	16:00	0.07	11.75	-
	3/22	16:00	0.06	7.56	3.8
	10/6	16:00	0.14	4.42	5.2
Fort Atkinson	1/19	2:00	0.15	1.24	-
	2/20	18:00	0.07	2.48	-
	3/22	18:00	0.10	1.85	1.5
	10/6	18:00	0.08	1.30	-
Portage	5/20	10:00	42	0.79	-
	9/20	10:00	38	1.00	-
	10/6	10:00	32	0.78	-

[1] The chromatograms from all cities except for Portage most closely resembled the chromatogram of Aroclor 1254; the chromatogram from the Portage samples most closely resembled the chromatogram of Aroclor 1248.

[2] Mass transport estimates were made by dividing the number of pounds of PCB's discharged by the plant per day by the average flow of wastes into the plant per day.

TABLE 3.--A 24-hour survey of PCB's

in the Cedarburg treatment plant on April 15, 1971

TIME	FLOW (in gal/min)	PCB CONCENTRATIONS (in μg/l)[1]		
		IN THE INFLUENT	IN THE EFFLUENT	IN THE PRIMARY TRICKLING FILTER
0:00	1480	0.30	0.33	-
1:00	1360	-	-	0.19
2:00	1300	0.20	0.10	-
4:00	1250	0.13	0.35	-
6:00	1200	-	0.16	-
8:00	2000	0.54	0.39	-
10:00	2100	0.40	0.50	-
12:00	1900	1.7	0.23	0.69
14:00	1900	1.5	0.77	-
16:00	1850	3.1	0.70	-
17:00	1900	-	-	0.25
20:00	1950	0.30	0.22	-
21:00	1800	-	-	0.14
22:00	1650	0.36	0.34	-

[1] The chromatograms of the samples most closely resembled the chromatogram of Aroclor 1254.

MONS 066080

TABLE 4.--PCB concentrations in the Cedarburg treatment plant, April 15, 1971

TIME	PCB CONCENTRATIONS (in mg/l)[1]	
	DIGESTER SLUDGE	PRIMARY SETTLING SLUDGE
10:00	24	69
16:00	20	31

[1] The chromatograms of the samples most closely resembled the chromatogram of Aroclor 1254.

MAY 2 8 1974

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PCBs and DDT in Fish From Western Lake Superior

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U. S. Environmental Protection Agency
National Water Quality Laboratory
Duluth, Minnesota

MONS 066082

PCBs and DDT in Fish

From Western Lake Superior

Fish from western Lake Superior were collected as available with gill nets by the Wisconsin Department of Natural Resources (Apostle Island region) and the National Water Quality Laboratory (Little Two Harbors and Illgen City regions) during 1972 and 1973. The fish were frozen, homogenized, and analyzed for PCBs and DDT analogues. The presence of PCBs was confirmed by perchlorinating the PCBs to decachlorobiphenyl with $SbCl_5$.

Table 1 presents mean and standard deviations for the major chlorinated hydrocarbons in burbot, lake trout, chubs, herring, and smelt from the three sampling regions. The mean concentration (whole fish) of PCBs (most resembling Aroclor® 1254) ranged from 0.3 µg/gm in smelt to 1.8 µg/gm in lake trout. The maximum concentration of PCBs was 5.6 µg/gm in a large lake trout captured in the Apostle Island region.

MONS 066083

Table 1. Concentration of Major Chlorinated Hydrocarbons in Fish from Western Lake Superior.

Species	Number of Fish	Mean Weight[a] (gm)	Mean Lipid (percent)	Dieldrin (µg/gm)	p,p' DDE (µg/gm)	Total DDT Analogues[b] (µg/gm)	PCBs (µg/gm) Aroclor 1254
APOSTLE ISLAND REGION (Wisconsin) November, 1973							
Burbot	3	1290±200 (1057-1474)	6.2±1.4 (4.8-7.7)	0.03 (0.03)	0.7±0.3 (0.4-0.9)	0.4±0.2 (0.2-0.6)	1.4±0.4 (1.0-1.7)
Lake Trout	9	2600±1700 (257-5652)	8.9±3.6 (1.4-13.0)	0.03±0.02 (<0.03-0.05)	2.2±2.3 (0.05-6.9)	3.7±4.2 (0.1-12.8)	1.8±1.6 (0.3-5.6)
Long-Nose Sucker	8	970±160 (569-1073)	6.1±3.7 (1.9-12)	0.03±0.03 (<0.03-0.09)	0.8±0.9 (0.16-2.60)	1.5±1.6 (0.3-3.3)	0.9±0.8 (0.3-2.7)
Smelt	5	64±6 (57-72)	8.2±2.2 (6.7-12)	<0.03	0.17±0.04 (0.11-0.20)	0.28±0.06 (0.18-0.33)	0.4±0.1 (0.4-0.5)
LITTLE TWO HARBORS REGION (Minnesota) July, 1972							
Burbot	4	410±80 (320-502)	3.3±0.8 (2.3-4.2)	<0.03	0.2±0.2 (0.05-0.46)	0.4±0.3 (0.08-0.77)	0.5±0.5 (<0.9-1.0)
Chubs	14	172±75 (77-390)	11.1±8.2 (1.2-26.0)	<0.03	0.8±0.4 (0.08-1.65)	1.3±0.7 (0.69-3.01)	1.0±0.3 (0.40-1.60)
Herring	3	305±70 (231-370)	5.3±3.0 (1.9-7.8)	<0.03	0.6±0.2 (0.44-0.86)	1.3±0.6 (0.89-1.93)	2.0±1.0 (1.2-3.1)
Lake Trout	12	400±100 (202-552)	6.1±2.8 (2.6-13.0)	<0.03	0.5±0.2 (0.11-0.84)	0.9±0.4 (0.21-1.45)	0.8±0.4 (<0.3-1.5)
Smelt	8	40±10 (27-52)	2.1±2.9 (0.6-6.5)	<0.03	0.2±0.1 (0.06-0.41)	0.3±0.2 (0.10-0.68)	0.4±0.5 (<0.4-1.2)

MONS 066084

Table 1 con't.

Species	Number of Fish	Mean Weight[a] (gm)	Mean Lipid (percent)	Dieldrin (ug/gm)	pp' DDE (ug/gm)	Total DDT Analogues[b] (ug/gm)	PCBs (ug/gm) Aroclor 1254
			ILLGEN CITY REGION (Minnesota) July, 1972				
Burbot	6	430±300 (138-1006)	7.1±2.4 (4.0-10.2)	<0.03	0.5±0.2 (0.31-0.74)	0.8±0.3 (0.54-1.28)	0.9±0.3 (0.5-1.2)
Chubs	6	320±90 (245-484)	9.1±3.4 (5.2-12.8)	<0.03	0.5±0.2 (0.35-0.76)	1.3±0.4 (0.85-1.92)	0.7±0.2 (0.4-0.9)
Lake Trout	10	390±210 (106-733)	4.6±1.1 (2.8-6.9)	<0.03	0.6±0.4 (0.20-1.40)	0.9±0.5 (0.28-1.68)	0.7±0.3 (0.3-1.2)
Smelt	10	45±10 (39-66)	2.8±1.2 (1.4-4.6)	<0.03	0.2±0.1 (0.12-0.30)	0.3±0.1 (0.21-0.49)	0.3±0.1 (0.2-0.5)

[a] Data expressed at mean ± S. D.; the range is presented in parenthesis.

[b] Total DDT = Σ(pp' DDE + op' DDT + pp' DDD + pp' DDT).

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MAY 2 8 1974

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1973
GREAT LAKES ENVIRONMENTAL CONTAMINANT SURVEY

39

DATA, SUMMARY AND ANALYSIS

by
Michigan Department of Agriculture
Bureau of Consumer Protection

MONS 066086

GREAT LAKES ENVIRONMENTAL

CONTAMINANT SURVEY

1973

Data from the 1973 Great Lakes Environmental Contaminant Survey (GLECS) conducted by the Michigan Department of Agriculture, the Michigan Department of Natural Resources, the U. S. Food and Drug Administration--Detroit Region, and the USDI Bureau of Sport Fisheries and Wildlife--Ann Arbor Laboratory are presented in total in this report. A summary prepared by the Michigan Department of Agriculture is also presented.

Fish were collected by DNR field personnel and analyzed in the laboratories of the other three participating agencies. Tissue sampling and analytical procedures were comparable in all cases. Procedural details are available on request to participants.

A similar program of sampling, analysis, and reporting is planned for the 1974 season. Each participating agency also conducts sampling and analysis for special purposes not included in this study.

MGNS 066087

GREAT LAKES ENVIRONMENTAL CONTAMINANT 1973 SURVEY

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SUMMARY OF 1973 GLECS DATA

Prepared by the Michigan Department of Agriculture

BROWN TROUT

Zone	Size	Number	Total DDT's ppm	Total PCB's ppm	Hg ppm	Dieldrin ppm
LAKE HURON						
MH-2	<21"	3	1.3	2.0	.19	.05
(Thunder Bay)	>21"	3	3.1	5.2	.28	.08

MDA NO.	SPECIES	LOCATION	DATE	LENGTH	WEIGHT	ANALYZED BY	LAB. NO.	TOTAL DDT'S	DIELDRIN	PCB's	MERCURY
MF0193	Br.Trout	MH-2(Th.Bay)	9-20-73	19.7	4.2	MDA	22701	1.60	0.07	2.58	0.19
MF0194	Br.Trout	MH-2(Th.Bay)	9-20-73	19.3	3.6	MDA	22701	1.00	0.02	1.37	0.20
MF0195	Br.Trout	MH-2(Th.Bay)	9-20-73	20.8	4.6	MDA	22701	1.36	0.05	2.06	0.18
MF0196	Br.Trout	MH-2(Th.Bay)	9-20-73	26.4	9.2	MDA	22701	3.78	0.07	6.89	0.25
MF0197	Br.Trout	MH-2(Th.Bay)	9-20-73	28.9	14.3	MDA	22701	3.02	0.08	5.17	0.24
MF0198	Br.Trout	MH-2(Th.Bay)	9-20-73	28.4	13.2	MDA	22701	2.48	0.08	3.44	0.35

MONS 066090

SUMMARY OF 1973 GLECS DATA

Prepared by the Michigan Department of Agriculture

CARP

Zone	Size	Number	Total DDT's ppm	PCB's ppm	Hg ppm	Dieldrin ppm
LAKE ERIE						
SWAN CREEK	18-25"	6	1.3± .7	9.3±4.9	.34±.19	.02

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FDA NO.	SPECIES	LOCATION	DATE	LENGTH	WEIGHT	ANALYZED BY	LAB. NO.	TOTAL DDT'S	DIELDRIN	PCB'S	MERCURY
3E022	Carp	Swan Creek	5-9-73	18.4	4.00	FDA	040-985G	1.07	Trace	6.7	0.44
3E023	Carp	Swan Creek	5-9-73	19.7	3.75	FDA	040-986G	0.84	Trace	7.2	0.65
3E024	Carp	Swan Creek	5-9-73	18.9	2.90	FDA	040-987G	0.21	0.02	1.9	0.07
3E025	Carp	Swan Creek	5-9-73	21.1	5.20	FDA	040-988G	1.89	0.03	11.9	0.33
3E026	Carp	Swan Creek	5-9-73	24.9	8.50	FDA	040-989G	2.01	0.03	14.5	0.26
3E027	Carp	Swan Creek	5-9-73	23.2	6.25	FDA	040-990G	1.96	0.01	13.7	0.28

MDNS 066092

SUMMARY OF 1973 GLECS DATA

Prepared by the Michigan Department of Agriculture

CATFISH

Zone	Size	Number	Total DDT's ppm	Total PCB's ppm	Hg ppm	Dieldrin ppm
LAKE HURON (Saginaw Bay)						
CONSUMER POWER	15-18"	4	.5	4.1	.42	.02
DETROIT EDISON	19-20"	2	1.1	7.1	.26	.03
STATION 4	15-18"	4	.6	2.3	.42	.02
	18-23"	5	1.5± .6	3.5±1.6	.60±.12	.04
MH-4	13-16"	3	.4	2.2	.06	.01
	21-23"	4	3.6	11.0	.25	.05
					(.26 chlordane)	

CA No.	SPECIES	LOCATION	DATE	LENGTH	WEIGHT	ANALYZED BY	LAB. NO.	TOTAL DDT'S	DIELDRIN	PCB'S	MERCURY	
-41697	Catfish	MH-4(1608)	6-29-73	25	5 lb. 3 oz.	MDA	12336	6.30	0.07	14.28	0.35	
-41696	Catfish	MH-4(1608)	6-29-73	25	6 lb. 2 oz.	MDA	12335	6.82	0.13	12.85	0.38	
-41695	Catfish	MH-4(1608)	6-29-73	21 3/4	3 lb.11 oz.	MDA	12334	4.97	0.13	8.92	0.30	
-41694	Catfish	MH-4(1608)	6-29-73	21	3 lb. --	MDA	12333	5.49	0.11	11.42	0.28	
-41693	Catfish	MH-4(1608)	6-28-73	21	3 lb. 1 oz.	MDA	12332	4.95	0.09	10.35	0.26	
-41692	Catfish	MH-4(1608)	6-28-73	21½	3 lb. --	MDA	12331	4.84	0.09	9.28	0.28	
-41691	Catfish	MH-4(1608)	6-28-73	21	3 lb. 7 oz.	MDA	12330	4.38	0.11	8.57	0.36	
-41690	Catfish	MH-4(1608)	6-28-73	19	2 lb. 2 oz.	MDA	12329	5.47	0.09	12.91	0.33	
-41689	Catfish	MH-4(1608)	6-28-73	19	2 lb. 1 oz.	MDA	12328	3.44	0.04	7.49	0.25	
-41688	Catfish	MH-4(1608)	6-28-73	18	1 lb.12 oz.	MDA	12327	3.66	0.07	7.49	0.23	
-41683	Catfish	MH-4(Heist-erman Is.)	6-28-73	22½	4 lb. 6 oz.	MDA	12322	4.38	0.07	7.69	0.29	
-41682	Catfish	MH-4 (")	6-28-73	23 3/4	5 lb. 5 oz.	MDA	12321	4.98	0.11	8.84	0.39	
-41681	Catfish	MH-4 (")	6-28-73	24	5 lb. 4 oz.	MDA	12320	4.64	0.07	9.23	0.31	
-41680	Catfish	MH-4 (")	6-28-73	23	5 lb. 1 oz.	MDA	12319	4.44	0.10	8.07	0.35	
-40422	Catfish	MH-4 (")	6-21-73	18	2 lb. 4 oz.	MDA	12311	4.09	0.12	8.00	0.22	
-40424	Catfish	MH-4 (")	6-21-73	19½	2 lb.15 oz.	MDA	12313	3.81	0.13	6.80	0.29	
-40425	Catfish	MH-4 (")	6-21-73	18½	2 lb. 2 oz.	MDA	12314	4.72	0.13	10.80	0.23	
-41676	Catfish	MH-4 (")	6-21-73	19 3/4	2 lb.12 oz.	MDA	12315	4.64	0.13	8.40	0.34	
-41677	Catfish	MH-4 (")	6-21-73	20	2 lb.14 oz.	MDA	12316	4.29	0.09	8.80	0.20	
-41678	Catfish	MH-4 (")	6-21-73	20 3/4	3 lb. 9 oz.	MDA	12317	4.77	0.14	9.60	0.23	
-41679	Catfish	MH-4 (")	6-21-73	21½	3 lb.12 oz.	MDA	12318	6.40	0.09	13.07	0.28	
-40423	Catfish	MH-4 (")	6-13-73	18	2 lb. 5 oz.	MDA	12312	2.67	0.10	4.80	0.22	
3E253	Catfish	MH-4(Sag.)	10-3-73	22.9	4.56	FDA	042-882G	3.78	0.06	10.6	0.27	0.2
3E254	Catfish	MH-4(Sag.)	10-3-73	21.3	3.42	FDA	042-883G	3.10	0.05	9.1	0.23	0.2
3E255	Catfish	MH-4(Sag.)	10-3-73	21.0	3.42	FDA	042-884G	3.14	0.06	7.5	0.25	0.2
3E258	Catfish	MH-4(Sag.)	10-23-73	22.7	4.05	FDA	042-885G	4.53	0.02	16.6	0.25	0.2

*Chlordane

MONS 060094

MDA No.	SPECIES	LOCATION	DATE	LENGTH	WEIGHT	ANALYZED BY	LAB. NO.	TOTAL DDT'S	DIELDRIN	PCB'S	MERCURY
C-41687	Catfish	MH-4(1608)	6-28-73	17½	1 lb. 12 oz.	MDA	12326	3.98	0.06	9.99	0.34
C-41686	Catfish	MH-4(1608)	6-18-73	17½	1 lb. 12 oz.	MDA	12325	2.79	0.05	4.99	0.23
C-41685	Catfish	MH-4(1608)	6-18-73	16½	1 lb. 4 oz.	MDA	12324	2.32	0.05	4.61	0.23
C-41684	Catfish	MH-4(1608)	6-18-73	16	1 lb. 3 oz.	MDA	12323	2.74	0.05	4.99	0.22
C-40421	Catfish	MH-4(Heist-erman Is.)	6-21-73	17	1 lb. 12 oz.	MDA	12310	3.47	0.10	6.80	0.11
C-40418	Catfish	MH-4(")	6-13 73	16½	1 lb. 8 oz.	MDA	12307	1.88	0.05	4.40	0.21
C-40419	Catfish	MH-4(")	6-13-73	16¼	1 lb. 8 oz.	MDA	12308	2.20	0.06	4.40	0.19
C-40420	Catfish	MH-4(")	6-13-73	16 3/4	1 lb. 10 oz.	MDA	12309	1.95	0.06	3.60	0.14
3E250	Catfish	MH-4(Sag.)	10-3-73	14.3	0.88	FDA	040-999G	0.25	0.01	1.5	0.01
3E251	Catfish	MH-4(Sag.)	10-3-73	15.9	1.16	FDA	041-000G	0.79	0.01	3.3	0.09
3E252	Catfish	MH-4(Sag.)	10-3-73	13.1	0.70	FDA	042-881G	0.22	Trace	1.8	0.08

MDNS 066095

FDA NO.	SPECIES	LOCATION	DATE	LENGTH	WEIGHT	ANALYZED BY	LAB. NO.	TOTAL DDT'S	DIELDRIN	PCB'S	MERCURY
[illegible]70335	Catfish	Cons. Power	9-9-73	15.3	1.48	FDA	040-993G	0.60	0.03	4.3	0.37
[illegible]F0336	Catfish	Cons. Power	9-9-73	14.7	1.16	FDA	040-994G	0.52	0.02	3.6	0.25
[illegible]F0337	Catfish	Cons. Power	9-9-73	16.4	1.60	FDA	040-995G	1.03	0.02	5.9	0.53
[illegible]F0338	Catfish	Cons. Power	9-9-73	18.0	2.08	FDA	040-996G	0.32	0.02	2.5	0.52
[illegible]F0339	Catfish	Det.Edison	9-12-73	19.4	2.58	FDA	040-997G	0.78	0.04	5.2	0.24
[illegible]F0340	Catfish	Det.Edison	9-12-73	19.3	2.37	FDA	040-998G	1.51	0.03	9.0	0.29

MDNS 060090

FDA NO.	SPECIES	LOCATION	DATE	LENGTH	WEIGHT	ANALYZED BY	LAB. NO.	TOTAL DDT'S	DIELDRIN	PCB'S	MERCURY
3C007	Catfish	Sta. 4	5-30-73	15.5	1.19	FDA	108-207G	0.21	Trace	1.5	0.40
3C008	Catfish	Sta. 4	5-30-73	16.1	1.20	FDA	108-208G	0.64	0.03	1.8	0.31
3C009	Catfish	Sta. 4	5-30-73	13.5	0.68	FDA	108-209G	0.29	Trace	1.4	0.42
3C010	Catfish	Sta. 4	5-30-73	17.8	2.30	FDA	108-210G	1.28	0.06	4.3	0.55
3C011	Catfish	Sta. 4	5-30-73	18.6	2.05	FDA	108-211G	0.88	0.02	2.7	0.40
3C012	Catfish	Sta. 4	5-30-73	19.8	2.79	FDA	108-212G	1.93	0.06	3.6	0.66
3C013	Catfish	Sta. 4	5-30-73	20.5	3.18	FDA	108-213G	0.79	0.03	1.2	0.70
3C014	Catfish	Sta. 4	5-30-73	25.6	6.06	FDA	108-214G	2.05	0.05	5.1	0.62
3C015	Catfish	Sta. 4	5-30-73	23.2	4.86	FDA	108-215G	1.96	0.05	5.0	0.62

MNS 066097

SUMMARY OF 1973 GLECS DATA

Prepared by the Michigan Department of Agriculture

CHUBS

Zone	Size	Number	Total DDT's ppm	Total PCB's ppm	Hg ppm	Dieldrin ppm
LAKE MICHIGAN						
MM-6	#1	3	2.5	2.3	.11	.19
	#2	3	2.8	3.0	.13	.17
MM-8	--	6	2.2±1.2	6.3±2.6	.13±.05	.03
LAKE SUPERIOR						
MS-2	--	6	1.4±1.0	1.4±.5	.19±.04	N.D.
MS-3	--	6	2.3±.5	1.7±.7	.20±.09	tr

MDA NO.	SPECIES	LOCATION	DATE	LENGTH	WEIGHT	ANALYZED BY	LAB. NO.	TOTAL DDT'S	DIELDRIN	PCB'S	MERCURY
MF0135	Chubs	MM-6	8-9-73	#1	—	MDA	18769	3.08	0.24	2.55	0.13
MF0136	Chubs	MM-6	8-9-73	#1	—	MDA	18769	1.87	0.13	1.78	0.13
MF0137	Chubs	MM-6	8-9-73	#1	—	MDA	18769	2.56	0.19	2.67	0.10
MF0138	Chubs	MM-6	8-9-73	#2	—	MDA	18770	2.43	0.15	3.12	0.13
MF0139	Chubs	MM-6	8-9-73	#2	—	MDA	18770	1.90	0.17	2.69	0.10
MF0140	Chubs	MM-6	8-9-73	#2	—	MDA	18770	4.06	0.18	3.07	0.17
	Chubs	MM-8		11.3	0.6	BSFW		3.7	0.05	11.0	0.20
	Chubs	MM-8		12.6	1.0	BSFW		3.9	0.03	7.3	0.18
	Chubs	MM-8		11.1	0.6	BSFW		1.3	0.02	5.2	0.096
	Chubs	MM-8		10.5	0.4	BSFW		1.3	0.02	3.3	0.081
	Chubs	MM-8		10.1	0.4	BSFW		1.7	0.02	6.0	0.12
	Chubs	MM-8		10.2	0.4	BSFW		1.6	0.04	4.9	0.10

MDNS 006906

MDA NO.	SPECIES	LOCATION	DATE	LENGTH	WEIGHT	ANALYZED BY	LAB. NO.	TOTAL DDT'S	DIELDRIN	PCB'S	MERCURY
SF468	Chub	MS-2(1414)	7-11-73	13.4	--	BSFW	--	3.1	N.D.	1.9	0.25
SF469	Chub	MS-2(1414)	7-11-73	12.3	--	BSFW	--	0.92	N.D.	1.2	0.16
SF470	Chub	MS-2(1414)	7-11-73	11.6	--	BSFW	--	0.56	N.D.	0.78	0.19
SF471	Chub	MS-2(1414)	7-11-73	10.9	--	BSFW	--	1.0	N.D.	1.2	0.18
SF472	Chub	MS-2(1414)	7-11-73	12.3	--	BSFW	--	2.1	N.D.	2.2	0.23
SF473	Chub	MS-2(1414)	7-11-73	11.2	--	BSFW	--	0.73	N.D.	1.1	0.13
SF197	Chub	MS-3(1127)	5-10-73	9-10-11	--	MDA	17475	2.56	0.02	1.37	0.12
SF197	Chub	MS-3(1127)	5-10-73	10	--	BSFW	--	1.6	N.D.	1.1	0.17
SF198	Chub	MS-3(1127)	5-10-73	13	--	BSFW	--	2.3	N.D.	2.3	0.26
SF198	Chub	MS-3(1127)	5-10-73	12-13-14	--	MDA	17475	2.40	0.08	2.41	0.08
SF068	Chub	MS-3(1021)	5-17-73	9-10-11	--	BSFW	--	1.9	N.D.	0.95	0.23
SF069	Chub	MS-3(1021)	5-17-73	12-13-14	--	BSFW	--	2.9	N.D.	2.2	0.33

MONS 069100

SUMMARY OF 1973 GLECS DATA

Prepared by the Michigan Department of Agriculture

DRUM

Zone	Size	Number	Total DDT's ppm	Total PCB's ppm	Hg ppm	Dieldrin ppm
LAKE ERIE						
MONROE	10-13"	6	.1	.9	.48±.26	tr

FDA NO.	SPECIES	LOCATION	DATE	LENGTH	WEIGHT	ANALYZED BY	LAB. NO.	TOTAL DDT'S	DIELDRIN	PCB'S	MERCURY
3E015	Drum	Monroe	5-4-73	10.9	0.50	FDA	040-979G	0.02	0.00	Trace	0.77
3E016	Drum	Monroe	5-4-73	11.2	0.60	FDA	040-980G	Trace	0.00	0.5	0.23
3E017	Drum	Monroe	5-4-73	10.2	0.47	FDA	040-981G	Trace	0.00	1.3	0.79
3E018	Drum	Monroe	5-4-73	12.9	0.98	FDA	040-982G	0.22	Trace	2.3	0.43
3E019	Drum	Monroe	5-4-73	12.9	0.96	FDA	040-983G	0.04	Trace	0.6	0.46
3E020	Drum	Monroe	5-4-73	12.8	0.91	FDA	040-984G	0.15	0.02	0.6	0.19

MONS 066102

SUMMARY OF 1973 GLECS DATA

Prepared by the Michigan Department of Agriculture

HERRING

Zone	Number	Total DDT's ppm	PCB's ppm	Hg ppm	Dieldrin ppm
LAKE SUPERIOR					
MS-2,3	5	2.0±.6	1.8±.8	.10±.02	.03

MDA NO.	SPECIES	LOCATION	DATE	LENGTH	WEIGHT	ANALYZED BY	LAB. NO.	TOTAL DDT'S	DIELDRIN	PCB'S	MERCURY
SF474	Herring	MS-2(1414)	7-11-73	14.9	—	MDA	17477-A	1.07	0.02	0.80	0.10
SF070	Herring	MS-3(1021)	5-17-73	14.0	—	MDA	17476	2.10	0.04	2.82	0.08
SF071	Herring	MS-3(1021)	5-17-73	12.0	—	MDA	17476	1.86	0.01	1.48	0.11
SF199	Herring	MS-3(1027)	5-10-73	12.0	—	MDA	17475-G	2.56	0.02	1.37	0.12
SF200	Herring	MS-3(1027)	5-10-73	14.0	—	MDA	17475-H	2.40	0.08	2.41	0.08

MDNS 069104

SUMMARY OF 1973 GLECS DATA

Prepared by the Michigan Department of Agriculture

LAKE TROUT

Zone	Number	Size	Total DDT's ppm	PCB's ppm	Hg ppm	Dieldrin ppm
LAKE MICHIGAN						
MM-1	1	<17"	1.6	2.2	.20	.02
	2	17-20"	2.2	3.6	.26	.02
MM-3	3	<17"	1.9	2.6	.16	.10
	3	17-20"	1.7	2.4	.21	.06
	3	>20"	6.2	10.6	.42	.14
MM-4	2	<17"	2.3	2.6	.23	.11
	1	17-20"	1.4	1.8	.20	.06
	3	>17"	5.8	8.5	.41	.08
MM-5	3	>17"	4.4	6.8	.36	.06
MM-6	1	17-20"	2.2	6.4	.21	.11
	5	>20"	4.1±2.8	6.3±3.6	.33±.11	.15
MM-7	3	>20"	7.6	11.2	.57	.24
MM-8	3	<17"	1.5	3.4	.17	.08
		>17"	8.3	11.6	.44	.37

MDA NO.	SPECIES	LOCATION	DATE	LENGTH	WEIGHT	ANALYZED BY	LAB. NO.	TOTAL DDI'S	DIELDRIN	PCB'S	MERCURY
MF0184	Lake Trout	MM-1	5-18-73	16.0	1.4	MDA	13148	1.59	0.02	2.16	0.20
MF0182	Lake Trout	MM-1	5-18-73	19.8	3.0	MDA	13148	1.75	0.03	3.24	0.26
MF0183	Lake Trout	MM-1	5-18-73	19.5	2.6	MDA	13148	2.56	0.01	4.05	0.27
MF0127	Lake Trout	MM-3	6-4-73	16.8	1.9	MDA	13145	1.49	0.12	2.30	0.22
MF0123	Lake Trout	MM-3	4-30-73	16.9	1.5	MDA	11951	2.75	0.13	3.91	0.15
MF0124	Lake Trout	MM-3	4-30-73	16.5	1.5	MDA	11951	1.46	0.05	1.73	0.12
MF0126	Lake Trout	MM-3	6-4-73	18.2	2.5	MDA	13145	1.41	0.05	1.79	0.21
MF0128	Lake Trout	MM-3	6-4-73	18.2	2.4	MDA	13145	1.31	0.07	2.05	0.23
MF0125	Lake Trout	MM-3	4-30-73	17.1	1.7	MDA	11951	2.39	0.06	3.47	0.18
MF0120	Lake Trout	MM-3	4-30-73	30.0	10.6	MDA	11951	6.07	0.14	8.25	0.34
MF0121	Lake Trout	MM-3	4-30-73	28.5	8.7	MDA	11951	7.08	0.15	13.47	0.50
MF0122	Lake Trout	MM-3	4-30-73	28.2	8.0	MDA	11951	5.51	0.13	9.99	0.41
MF0129	Lake Trout	MM-4(S½)	6-27-73	15.8	1.5	MDA	15509	2.14	0.09	2.50	0.22
MF0131	Lake Trout	MM-4(S½)	6-27-73	15.4	1.2	MDA	15509	2.49	0.12	2.75	0.24
MF0130	Lake Trout	MM-4(S½)	6-27-73	18.3	2.0	MDA	15509	1.43	0.06	1.75	0.20
MF0132	Lake Trout	MM-4(S½)	6-27-73	26.7	6.4	MDA	15510	3.89	0.08	7.00	0.40
MF0133	Lake Trout	MM-4(S½)	6-27-73	26.2	6.7	MDA	15510	6.68	0.15	8.75	0.43
MF0134	Lake Trout	MM-4(S½)	6-27-73	28.2	9.7	MDA	15510	6.71	0.02	9.72	0.40
MF0173	Lake Trout	MM-5	5-8-73	27.5	8.0	MDA	11954	4.05	0.02	6.66	0.27
MF0174	Lake Trout	MM-5	5-8-73	24.9	6.0	MDA	11954	3.83	0.08	5.83	0.36
MF0175	Lake Trout	MM-5	5-8-73	27.5	8.5	MDA	11954	5.18	0.08	7.91	0.45
MF0145	Lake Trout	MM-6	8-13-73	18.1	2.1	MDA	18768	2.22	0.11	6.42	0.21
MF0141	Lake Trout	MM-6	8-13-73	26.9	8.2	MDA	18767	8.16	0.28	16.00	0.47
MF0142	Lake Trout	MM-6	8-13-73	25.0	5.5	MDA	18767	2.10	0.18	7.69	0.36
MF0143	Lake Trout	MM-6	8-13-73	27.5	8.4	MDA	18767	6.01	0.17	9.37	0.40
MF0144	Lake Trout	MM-6	8-13-73	20.2	2.9	MDA	18768	2.16	0.07	7.50	0.23
MF0146	Lake Trout	MM-6	8-13-73	20.6	2.5	MDA	18768	2.27	0.07	6.78	0.21

MONS 066106

LDA NO.	SPECIES	LOCATION	DATE	LENGTH	WEIGHT	ANALYZED BY	LAB. NO.	TOTAL DDT'S	DIELDRIN	PCB'S	MERCURY
F0147	Lake Trout	MM-7	8-22-73	28.0	9.0	MDA	18771	6.92	0.23	9.23	0.69
F0148	Lake Trout	MM-7	8-22-73	28.8	10.4	MDA	18771	9.86	0.27	16.66	0.59
F0149	Lake Trout	MM-7	8-22-73	25.1	7.3	MDA	18771	5.88	0.23	7.69	0.44
F0159	Lake Trout	MM-8(N½)	10-1-73	15.2	1.5	MDA	22703	1.58	0.11	4.00	0.16
F0160	Lake Trout	MM-8(N½)	10-1-73	17.9	1.9	MDA	22703	1.09	0.09	2.75	0.14
F0161	Lake Trout	MM-8(N½)	10-1-73	17.0	1.6	MDA	22703	1.87	0.04	3.44	0.20
F0156	Lake Trout	MM-8(N½)	10-1-73	28.1	7.6	MDA	22702	7.13	0.24	10.34	0.43
F0157	Lake Trout	MM-8(N½)	10-1-73	28.1	9.0	MDA	22702	6.76	0.32	9.48	0.52
F0158	Lake Trout	MM-8(N½)	10-1-73	28.7	10.1	MDA	22702	10.86	0.56	14.94	0.37

MONS 066107

SUMMARY OF 1973 CLECS DATA

Prepared by the Michigan Department of Agriculture

LAKE TROUT

Zone	Size	Number	Total DDT's ppm	Total PCB's ppm	Hg ppm	Dieldrin ppm
LAKE SUPERIOR						
MS-1	<17"	4	2.1	2.4	.57	tr
	17-20"	1	2.4	2.9	.51	tr
	>20"	6	7.9±1.4	5.3± .9	.80±.30	.08±.05
MS-2	<17"	3	.3	.5	.18	tr
	17-20"	3	.9	1.8	.36	tr
	>20"	5	1.8± .6	4.2±1.8	.43±.17	.04
MS-3	<17"	12	.9± .7	1.6±1.4	.29±.12	.03
	17-20"	16	1.1± .7	1.9±1.3	.32±.15	.04
	>20"	19	3.3±1.4	4.7±2.2	.69±.27	.06
MS-4	17-20"	6	0.7± .3	1.0± .5	.25±.05	.01
	>20"	15	2.1±1.7	3.3±2.7	.48±.17	.03
MS-5	17-20"	4	.5	.8	.32	.02
	>20"	5	1.5± .2	1.8± .5	.30±.05	.03
MS-6	<17"	3	.6	.9	.21	.01
	17-20"	3	1.0	1.0	.26	.02
	>20"	6	1.4±.3	1.4± .2	.34±.04	.04

MONS 066108

MDA NO.	SPECIES	LOCATION	DATE	LENGTH	WEIGHT	ANALYZED BY	LAB. NO.	TOTAL DDT'S	DIELDRIN	PCB'S	MERCURY
SF049	Lake Trout	MS-1 (623)	5-11-73	17.3	—	MDA	13135	5.88	0.04	6.42	1.18
SF050	Lake Trout	MS-1 (623)	5-11-73	16.2	—	MDA	13135	1.52	0.04	1.90	0.37
SF051	Lake Trout	MS-1 (623)	5-11-73	14.1	—	MDA	13135	0.67	Trace	0.81	0.41
SF052	Lake Trout	MS-1 (623)	5-11-73	11.5	—	MDA	13135	0.31	Trace	0.27	0.33
SF048	Lake Trout	MS-1 (623)	5-11-73	19.4	—	MDA	13135	2.37	0.02	2.85	0.51
SF044	Lake Trout	MS-1 (623)	5-11-73	33.6	—	MDA	13135	8.90	0.16	5.88	1.44
SF045	Lake Trout	MS-1 (623)	5-11-73	24.4	—	MDA	13135	9.42	0.10	6.61	0.83
SF046	Lake Trout	MS-1 (623)	5-11-73	22.2	—	MDA	13135	7.20	0.07	6.24	0.51
SF047	Lake Trout	MS-1 (623)	5-11-73	23.1	—	MDA	13135	6.99	0.09	4.99	0.90
SF072	Lake Trout	MS-1 (623)	5-11-73	28.7	—	MDA	13135	7.91	0.03	4.57	0.70
SF073	Lake Trout	MS-1 (623)	5-11-73	29.4	—	MDA	13135	6.09	0.04	3.99	0.60
SF074	Lake Trout	MS-1 (623)	5-11-73	27.6	—	MDA	13135	8.54	0.04	4.89	0.59
SF456	Lake Trout	MS-2(1317)	6-22-73	13.2	0.7	MDA	17478	0.08	Trace	0.10	0.18
SF457	Lake Trout	MS-2(1317)	6-22-73	12.0	0.9	MDA	17478	0.32	0.01	0.40	0.16
SF458	Lake Trout	MS-2(1317)	6-22-73	13.3	1.1	MDA	17478	0.56	0.01	0.93	0.21
SF462	Lake Trout	MS-2(1317)	6-22-73	17.7	1.6	MDA	17478	0.56	Trace	1.02	0.40
SF463	Lake Trout	MS-2(1317)	6-22-73	18.9	2.9	MDA	17478	1.06	0.02	1.60	0.34
SF464	Lake Trout	MS-2(1317)	6-22-73	17.5	1.6	MDA	17478	1.13	0.02	2.82	0.34
SF455	Lake Trout	MS-2(1317)	6-22-73	23.8	4.0	MDA	17478	1.74	0.04	4.35	0.17
SF459	Lake Trout	MS-2(1317)	6-22-73	24.0	4.7	MDA	17478	1.11	0.04	1.60	0.39
SF461	Lake Trout	MS-2(1317)	6-22-73	26.9	6.8	MDA	17478	2.59	0.07	6.66	0.60
SF466	Lake Trout	MS-2(1317)	6-22-73	25.1	5.0	MDA	17478	1.36	0.02	3.84	0.40
SF460	Lake Trout	MS-2(1317)	6-22-73	20.6	2.8	MDA	17478	1.99	0.01	4.35	0.57
SF065	Lake Trout	MS-3(1021)	5-17-73	15.2	—	MDA	17476	1.41	0.03	2.22	0.45
SF066	Lake Trout	MS-3(1021)	5-17-73	14.5	—	MDA	17476	1.35	0.02	3.58	0.43
SF067	Lake Trout	MS-3(1021)	5-17-73	13.0	—	MDA	17476	0.81	0.01	1.11	0.29
SF060	Lake Trout	MS-3(1021)	5-17-73	18.2	—	MDA	17476	2.00	0.07	2.75	0.67
SF061	Lake Trout	MS-3(1021)	5-17-73	17.6	—	MDA	17476	1.79	0.07	2.59	0.38
SF063	Lake Trout	MS-3(1021)	5-17-73	18.1	—	MDA	17476	2.64	0.06	3.33	0.57
SF064	Lake Trout	MS-3(1021)	5-17-73	17.0	—	MDA	17476	0.98	0.02	2.05	0.25

SNOW 001609

MDA NO.	SPECIES	LOCATION	DATE	LENGTH	WEIGHT	ANALYZED BY	LAB. NO.	TOTAL DDT'S	DIELDRIN	PCB'S	MERCURY
SF421	Lake Trout	MS-3(1130)	4-27-73	28.5	--	MDA	13138	5.35	0.06	6.57	0.55
SF422	Lake Trout	MS-3(1130)	4-27-73	29.7	--	MDA	13138	4.15	0.06	5.35	0.56
SF423	Lake Trout	MS-3(1130)	4-27-73	28.8	--	MDA	13138	5.23	0.03	6.28	0.52
SF442	Lake Trout	MS-3(1323)	5-8-73	19.7	--	MDA	13140	0.57	0.01	0.55	0.25
SF443	Lake Trout	MS-3(1323)	5-8-73	19.9	--	MDA	13140	0.63	Trace	0.83	0.26
SF444	Lake Trout	MS-3(1323)	5-8-73	17.3	--	MDA	13140	0.77	0.01	1.11	0.24
SF439	Lake Trout	MS-3(1323)	5-8-73	28.5	--	MDA	13140	2.31	0.03	2.22	0.53
SF440	Lake Trout	MS-3(1323)	5-8-73	28.6	--	MDA	13140	5.78	0.08	5.55	0.83
SF441	Lake Trout	MS-3(1323)	5-8-73	29.7	--	MDA	13140	2.37	0.04	2.22	0.61
	Lake Trout	MS-4(1533)		19.9		MDA		0.71	0.02	1.72	0.30
	Lake Trout	MS-4(1533)		19.9		MDA		0.50	0.02	0.70	0.31
	Lake Trout	MS-4(1533)		19.9		MDA		0.28	0.01	0.45	0.23
	Lake Trout	MS-4(1533)		19.0		MDA		0.98	0.01	0.81	0.23
	Lake Trout	MS-4(1533)		18.7		MDA		2.57	0.01	0.81	0.23
	Lake Trout	MS-4(1533)		18.1		MDA		0.92	0.01	1.62	0.18
	Lake Trout	MS-4(1533)		22.5		MDA		0.38	0.02	0.45	0.24
	Lake Trout	MS-4(1533)		24.9		MDA		1.24	0.02	1.74	0.50
	Lake Trout	MS-4(1533)		22.9		MDA		1.25	0.05	2.40	0.27
	Lake Trout	MS-4(1533)		26.6		MDA		5.93	0.06	7.20	0.80
	Lake Trout	MS-4(1533)		29.5		MDA		2.32	0.05	2.80	0.45
	Lake Trout	MS-4(1533)		27.8		MDA		1.77	0.04	2.80	0.47
	Lake Trout	MS-4(1533)		30.0		MDA		4.54	0.02	8.53	0.59
	Lake Trout	MS-4(1533)		29.6		MDA		2.10	0.04	4.16	0.55
	Lake Trout	MS-4(1533)		29.0		MDA		4.33	0.01	8.33	0.68
	Lake Trout	MS-4(1533)		28.4		MDA		2.00	0.02	3.74	0.61
	Lake Trout	MS-4(1533)		27.1		MDA		3.08	0.01	3.24	0.67
	Lake Trout	MS-4(1533)		26.4		MDA		1.02	0.02	1.85	0.44
	Lake Trout	MS-4(1533)		22.9		MDA		0.43	0.02	0.81	0.30
	Lake Trout	MS-4(1533)		21.3		MDA		0.55	0.02	0.92	0.25
	Lake Trout	MS-4(1533)		21.0		MDA		0.69	0.01	0.81	0.43

MDNS 006110

MDA NO.	SPECIES	LOCATION	DATE	LENGTH	WEIGHT	ANALYZED BY	LAB. NO.	TOTAL DDT'S	DIELDRIN	PCB'S	MERCURY
SF035	Lake Trout	MS-5(1440)	5-11-73	19.0	--	MDA	13130	0.50	0.02	0.78	0.29
SF036	Lake Trout	MS-5(1440)	5-11-73	19.9	--	MDA	13130	0.46	0.02	0.72	0.31
SF037	Lake Trout	MS-5(1440)	5-11-73	19.9	--	MDA	13130	0.61	0.04	0.90	0.30
SF038	Lake Trout	MS-5(1440)	5-11-73	21.8	--	MDA	13130	0.47	0.02	0.72	0.37
SF039	Lake Trout	MS-5(1440)	5-11-73	23.0	--	MDA	13130	1.45	0.02	1.51	0.38
SF040	Lake Trout	MS-5(1440)	5-11-73	24.9	--	MDA	13130	1.34	0.03	1.51	0.32
SF041	Lake Trout	MS-5(1440)	5-11-73	28.5	--	MDA	13130	1.80	0.05	2.12	0.26
SF042	Lake Trout	MS-5(1440)	5-11-73	26.2	--	MDA	13130	1.27	0.03	1.21	0.27
SF043	Lake Trout	MS-5(1440)	5-11-73	26.8	--	MDA	13130	1.56	0.04	2.41	0.29
SF023	Lake Trout	MS-6(1444)	5-10-73	16.2	--	MDA	13133	0.54	0.01	0.88	0.24
SF024	Lake Trout	MS-6(1444)	5-10-73	14.4	--	MDA	13133	0.43	0.01	0.58	0.19
SF025	Lake Trout	MS-6(1444)	5-10-73	15.2	--	MDA	13133	0.73	0.02	1.17	0.21
SF026	Lake Trout	MS-6(1444)	5-10-73	17.5	--	MDA	13133	0.85	0.02	0.88	0.26
SF027	Lake Trout	MS-6(1444)	5-10-73	17.8	--	MDA	13133	0.84	0.02	0.88	0.28
SF028	Lake Trout	MS-6(1444)	5-10-73	19.1	--	MDA	13133	1.17	0.03	1.17	0.24
SF029	Lake Trout	MS-6(1444)	5-10-73	22.4	--	MDA	13133	1.60	0.04	1.47	0.32
SF030	Lake Trout	MS-6(1444)	5-10-73	23.4	--	MDA	13133	1.38	0.03	1.72	0.36
SF031	Lake Trout	MS-6(1444)	5-10-73	23.0	--	MDA	13133	1.14	0.03	1.21	0.29
SF032	Lake Trout	MS-6(1444)	5-10-73	28.0	--	MDA	13133	1.39	0.04	1.21	0.31
SF033	Lake Trout	MS-6(1444)	5-10-73	27.4	--	MDA	13133	1.02	0.04	1.21	0.34
SF034	Lake Trout	MS-6(1444)	5-10-73	29.7	--	MDA	13133	1.67	0.03	1.51	0.40

MDNS 096111

MDA NO.	SPECIES	LOCATION	DATE	LENGTH	WEIGHT	ANALYZED BY	LAB. NO.	TOTAL DDT'S	DIELDRIN	PCB'S	MERCURY
SF054	Lake Trout	MS-3(1021)	5-17-73	27.0	—	MDA	17476	2.96	0.09	8.62	1.24
SF055	Lake Trout	MS-3(1021)	5-17-73	22.5	—	MDA	17476	3.44	0.08	4.82	0.88
SF056	Lake Trout	MS-3(1021)	5-17-73	25.6	—	MDA	17476	4.98	0.05	6.89	1.18
SF057	Lake Trout	MS-3(1021)	5-17-73	24.4	—	MDA	17476	5.30	0.13	7.58	0.91
SF058	Lake Trout	MS-3(1021)	5-17-73	21.8	—	MDA	17476	3.20	0.12	3.94	0.86
SF059	Lake Trout	MS-3(1021)	5-17-73	20.4	—	MDA	17476	2.79	0.06	3.44	0.73
SF062	Lake Trout	MS-3(1021)	5-17-73	21.5	—	MDA	17476	2.65	0.07	8.46	1.08
SF191	Lake Trout	MS-3(1127)	5-10-73	16.8	—	MDA	17475	2.54	0.14	4.88	0.55
SF192	Lake Trout	MS-3(1127)	5-10-73	14.5	—	MDA	17475	1.13	0.07	2.32	0.23
SF193	Lake Trout	MS-3(1127)	5-10-73	12.3	—	MDA	17475	0.46	0.01	0.69	0.21
SF194	Lake Trout	MS-3(1127)	5-10-73	18.7	—	MDA	17475	1.11	0.10	3.95	0.46
SF195	Lake Trout	MS-3(1127)	5-10-73	17.2	—	MDA	17475	2.11	0.07	3.72	0.47
SF196	Lake Trout	MS-3(1127)	5-10-73	17.0	—	MDA	17475	1.86	0.08	3.72	0.37
SF430	Lake Trout	MS-3(1122)	5-8-73	13.6	—	MDA	13134	0.46	Trace	0.83	0.28
SF431	Lake Trout	MS-3(1122)	5-8-73	15.8	—	MDA	13134	0.58	0.01	0.83	0.22
SF432	Lake Trout	MS-3(1122)	5-8-73	16.9	—	MDA	13134	0.64	Trace	1.11	0.25
SF433	Lake Trout	MS-3(1122)	5-8-73	19.0	—	MDA	13134	0.74	0.02	0.88	0.23
SF434	Lake Trout	MS-3(1122)	5-8-73	18.6	—	MDA	13134	1.05	0.03	0.88	0.25
SF435	Lake Trout	MS-3(1122)	5-8-73	19.0	—	MDA	13134	1.09	0.03	1.17	0.23
SF436	Lake Trout	MS-3(1122)	5-8-73	28.4	—	MDA	13134	1.93	0.04	2.35	0.36
SF437	Lake Trout	MS-3(1122)	5-8-73	30.4	—	MDA	13134	3.35	0.05	4.82	0.58
SF438	Lake Trout	MS-3(1122)	5-8-73	28.5	—	MDA	13134	1.64	0.03	2.41	0.41
SF075	Lake Trout	MS-3(1122)	5-8-73	22.0	—	MDA	13134	2.32	0.02	3.44	0.53
SF076	Lake Trout	MS-3(1122)	5-8-73	23.8	—	MDA	13134	1.86	0.04	2.75	0.34
SF077	Lake Trout	MS-3(1122)	5-8-73	24.9	—	MDA	13134	1.88	0.05	1.76	0.38
SF427	Lake Trout	MS-3(1130)	4-27-73	15.5	—	MDA	13138	0.17	0.01	0.28	0.20
SF428	Lake Trout	MS-3(1130)	4-27-73	16.6	—	MDA	13138	0.25	0.01	0.39	0.17
SF429	Lake Trout	MS-3(1130)	4-27-73	16.4	—	MDA	13138	0.49	N.D.	0.75	0.15
SF424	Lake Trout	MS-3(1130)	4-27-73	17.9	—	MDA	13138	0.37	0.03	0.85	0.20
SF425	Lake Trout	MS-3(1130)	4-27-73	19.7	—	MDA	13138	0.43	0.01	0.85	0.15
SF426	Lake Trout	MS-3(1130)	4-27-73	19.2	—	MDA	13138	0.39	0.01	0.57	0.14

MONS 066112

SUMMARY OF 1973 GLECS DATA

Prepared by the Michigan Department of Agriculture

MENOMINEE

Zone	Size	Number	Total DDT's ppm	Total PCB's ppm	Hg ppm	Dieldrin ppm
LAKE MICHIGAN						
MM-5	—	6	.7+.2	1.0±.6	.06±.04	.02
LAKE HURON						
MH-1 (N½)	—	6	.4±.2	.4±.2	.03	.03

MONS 066113

MDA NO.	SPECIES	LOCATION	DATE	LENGTH	WEIGHT	ANALYZED BY	LAB. NO.	TOTAL DDT'S	DIELDRIN	PCB'S	MERCURY
MF0185	Menominee	MH-1(N½)	4-24-73	16.2	1.4	MDA	10496	0.61	0.03	0.66	0.04
MF0186	Menominee	MH-1(N½)	4-24-73	16.2	1.5	MDA	10496	0.38	0.06	0.33	0.02
MF0187	Menominee	MH-1(N½)	4-24-73	17.1	1.7	MDA	10496	0.42	0.01	0.41	0.03
MF0188	Menominee	MH-1(N½)	4-24-73	13.0	0.7	MDA	10496	0.28	0.03	0.24	0.02
MF0189	Menominee	MH-1(N½)	4-24-73	12.7	0.6	MDA	10496	0.23	0.02	0.24	0.02
MF0190	Menominee	MH-1(N½)	4-24-73	13.4	0.7	MDA	10496	0.21	0.02	0.33	0.02

MDNS 0069114

MDA NO.	SPECIES	LOCATION	DATE	LENGTH	WEIGHT	ANALYZED BY	LAB. NO.	TOTAL DDT'S	DIELDRIN	PCB'S	MERCURY
M30167	Menominee	MM-5	5-7-73	13.2	0.7	MDA	11952	0.58	0.03	0.65	0.02
M30168	Menominee	MM-5	5-7-73	13.3	0.7	MDA	11952	0.33	0.01	0.34	0.03
M30169	Menominee	MM-5	5-7-73	12.6	0.6	MDA	11952	0.46	0.03	0.72	0.04
M30170	Menominee	MM-5	5-7-73	17.2	0.8	MDA	11953	0.92	Trace	1.68	0.10
M30171	Menominee	MM-5	5-7-73	16.4	1.6	MDA	11953	0.73	0.02	1.20	0.11
M30172	Menominee	MM-5	5-7-73	16.9	1.5	MDA	11953	0.92	0.02	1.68	0.06

MONS 066115

SUMMARY OF 1973 GLECS DATA

Prepared by the Michigan Department of Agriculture

YELLOW PERCH

Zone	Size	Number	Total DDT's ppm	PCB's ppm	Hg ppm	Dieldrin ppm
LAKE MICHIGAN						
MM-8	8-10"	6	.1+.08	.4±.2	.12±.04	tr
LAKE HURON						
MH-1 (N½)		6	.1	.2	.16	.01
LAKE ERIE						
MONROE	<9"	3	tr	.2	.40	0
	>9"	3	tr	tr	.55	0
LAKE ST. CLAIR						
STATION 4	<8"	5	0	tr	.25±.04	0
	>8"	3	1.3	2.2	.52	tr

MDA NO.	SPECIES	LOCATION	DATE	LENGTH	WEIGHT	ANALYZED BY	LAB. NO.	TOTAL DDT'S	DIELDRIN	PCB'S	MERCURY
MF0150	Y.Perch	MM-8(N½)	9-26-73	10.6	0.5	MDA	22704	0.29	0.03	0.56	0.18
MF0151	Y.Perch	MM-8(N½)	9-26-73	9.3	0.4	MDA	22704	0.17	0.03	0.61	0.08
MF0152	Y.Perch	MM-8(N½)	9-26-73	10.3	0.5	MDA	22704	0.12	0.01	0.42	0.14
MF0153	Y.Perch	MM-8(N½)	9-26-73	8.5	0.2	MDA	22704	0.09	Trace	0.25	0.11
MF0154	Y.Perch	MM-8(N½)	9-26-73	8.3	0.3	MDA	22704	0.05	Trace	0.18	0.10
MF0155	Y.Perch	MM-8(N½)	9-26-73	8.7	0.3	MDA	22704	0.13	Trace	0.49	0.09

MONS 066117

MDA NO.	SPECIES	LOCATION	DATE	LENGTH	WEIGHT	ANALYZED BY	LAB. NO.	TOTAL DDT'S	DIELDRIN	PCB'S	MERCURY
HF0354	Perch	MH-1(N½)	10-4-73	7.8)							
HF0354	Perch	MH-1(N½)	10-4-73	7.9)	Fillets	MDA	24262	0.08	0.01	0.24	0.15
HF0354	Perch	MH-1(N½)	10-4-73	8.6)							
HF0355	Perch	MH-1(N½)	10-4-73	12.6)							
HF0355	Perch	MH-1(N½)	10-4-73	9.8)	Fillets	MDA	24262	0.07	0.01	0.20	0.17
HF0355	Perch	MH-1(N½)	10-4-73	9.5)							

MONS 066118

NDA NO.	SPECIES	LOCATION	DATE	LENGTH	HEIGHT	ANALYZED BY	LAB. NO.	TOTAL DDT'S	DIELDRIN	PCB'S	MERCURY
3E005	Y. Perch	Monroe	5-4-73	7.3	0.16	FDA	040-969G	0.00	0.00	Trace	0.39
3E006	Y. Perch	Monroe	5-4-73	8.5	0.26	FDA	040-970G	Trace	0.00	0.4	0.39
3E007	Y. Perch	Monroe	5-4-73	8.1	0.28	FDA	040-971G	Trace	0.00	0.3	0.42
3E008	Y. Perch	Monroe	5-4-73	10.6	0.60	FDA	040-972G	Trace	0.00	Trace	0.61
3E009	Y. Perch	Monroe	5-4-73	9.2	0.37	FDA	040-973G	0.00	0.00	Trace	0.43
3E010	Y. Perch	Monroe	5-4-73	10.1	0.52	FDA	040-974G	0.00	0.00	Trace	0.61

MONS 066119

MDA NO.	SPECIES	LOCATION	DATE	LENGTH	WEIGHT	ANALYZED BY	LAB. NO.	TOTAL DDT'S	DIELDRIN	PCB'S	MERCURY
3C016	Y. Perch	Sta. 4	5-31-73	7.3	0.13	FDA	108-216G	0.00	0.00	0.0	0.30
3C017	Y. Perch	Sta. 4	5-31-73	7.9	0.20	FDA	108-217G	0.00	0.00	Trace	0.29
3C021	Y. Perch	Sta. 4	6-1-73	7.2	0.17	FDA	040-961G	0.00	0.00	0.0	0.22
3C022	Y. Perch	Sta. 4	6-1-73	7.1	0.19	FDA	040-962G	0.00	0.00	Trace	0.22
3C023	Y. Perch	Sta. 4	6-1-73	7.3	0.18	FDA	040-963G	0.00	0.00	0.0	0.21
3C018	Y. Perch	Sta. 4	5-31-73	9.6	0.33	FDA	108-218G	Trace	0.00	Trace	0.56
3C019	Y. Perch	Sta. 4	5-31-73	9.5	0.32	FDA	108-219G	2.46	0.06	3.8	0.61*
3C020	Y. Perch	Sta. 4	5-31-73	9.3	0.36	FDA	108-220G	0.08	0.00	0.6	0.41

*Trace of Endrin

MDNS 066120

SUMMARY OF 1973 GLECS DATA

Prepared by the Michigan Department of Agriculture

SALMON

Zone	Size	Number	Total DDT's ppm	PCB's ppm	Hg ppm	Dieldrin ppm
LAKE MICHIGAN						
-Chinook-						
MM-5	---	2	3.6	6.4	.58	.09
-Coho-						
MM-5	---	2	2.9	4.9	.37	.18
LAKE HURON						
MH-1	---	1	2.5	4.2	.40	.01
MH-3	---	5	5.8±1.5	9.2±2.4	.27±.05	.20±.02

MDA NO.	SPECIES	LOCATION	DATE	LENGTH	WEIGHT	ANALYZED BY	LAB. NO.	TOTAL DDT'S	DIELDRIN	PCB'S	MERCURY
C-45994	Chinook	MM-5	--	--	--	MDA	24259	2.63	0.12	4.99	0.52
C-45993	Chinook	MM-5	--	--	19.0	MDA	24258	4.66	0.05	7.90	0.64
C-45995	Coho	MM-5	--	--	6.0	MDA	24260	2.68	0.14	4.44	0.39
C-45996	Coho	MM-5	--	--	6.0	MDA	24261	3.10	0.22	5.33	0.34

MONS 066122

MDA NO.	SPECIES	LOCATION	DATE	LENGTH	WEIGHT	ANALYZED BY	LAB. NO.	TOTAL DDT'S	DIELDRIN	PCB'S	MERCURY
HFO348	Chinook	MH3	9-5-73	31.6	16.0	MDA	20028	4.23	0.19	7.50	0.25
HFO349	Chinook	MH3	9-5-73	30.6	13.6	MDA	20028	5.46	0.20	8.57	0.23
HFO350	Chinook	MH3	9-5-73	31.7	14.5	MDA	20028	4.64	0.19	7.33	0.30
HFO351	Chinook	MH3	9-5-73	38.5	25.4	MDA	20028	7.97	0.23	13.14	0.24
HFO352	Chinook	MH3	9-5-73	38.1	23.3	MDA	20028	6.45	0.20	9.60	0.34
HF C-43577	Coho	Nagel's Cr. MH1	2-21-73	Fillets 3½	—	MDA	2125	2.52	0.01	4.16	0.40

MGNS 066123

SUMMARY OF 1973 GLECS DATA

Prepared by the Michigan Department of Agriculture

SMELT

Zone	Size	Number	Total DDT's ppm	PCB's ppm	Hg ppm	Dieldrin ppm
LAKE MICHIGAN						
MM-1	--	3	.8	1.6	.09	.03
LAKE HURON						
MH-3	--	2	.5	.6	.12	.02

MDA NO.	SPECIES	LOCATION	DATE	LENGTH	WEIGHT	ANALYZED BY	LAB. NO.	TOTAL DDT'S	DIELDRIN	PCB'S	MERCURY
MF0176	Smelt	MM-1	5-17-73	Finger Group	0.6	MDA	13146	0.97	0.01	2.11	0.08
MF0177	Smelt	MM-1	5-17-73	Finger Group	0.6	MDA	13146	0.67	0.05	1.08	0.09
MF0178	Smelt	MM-1	5-17-73	Finger Group	0.6	MDA	13146	0.72	0.03	1.59	0.09

MONS 066125

MDA NO.	SPECIES	LOCATION	DATE	LENGTH	WEIGHT	ANALYZED BY	LAB. NO.	TOTAL DDT'S	DIELDRIN	PCB'S	MERCURY
HF0191	Smelt	MH-3(AuSable)	6-14-73	—	Approx.3 lbs.	MDA	15511	0.41	Trace	0.54	0.10
HF0192	Smelt	MH-3	8-23-73	Varied	250 g.	MDA	20027	0.57	0.04	0.64	0.15

MONS 066126

SUMMARY OF 1973 GLECS DATA

Prepared by the Michigan Department of Agriculture

SUCKERS

Zone		Size	Number	Total DDT's ppm	Total PCB's ppm	Hg ppm	Dieldrin ppm
LAKE MICHIGAN							
MM-1	(LN)	12-13"	3	.5	.7	.06	.05
	(WH)	17-18"	3	.1	.2	.21	tr

MDA NO.	SPECIES	LOCATION	DATE	LENGTH	WEIGHT	ANALYZED BY	LAB. NO.	TOTAL DDT'S	DIELDRIN	PCB'S	MERCURY
MF0179	Suckers(LN)	MM-1	5-17-73	12.6	1.6	MDA	13147	0.55	0.05	0.74	0.08
MF0181	Suckers(LN)	MM-1	5-17-73	12.7	1.7	MDA	13147	0.57	0.05	0.81	0.04
MF0180	Suckers(LN)	MM-1	5-17-73	12.6	1.6	MDA	13147	0.47	0.04	0.62	0.06
MF0185	Suckers(Wh.)	MM-1	5-23-73	17.8	2.4	MDA	13149	0.06	N.D.	0.18	0.23
MF0186	Suckers(Wh.)	MM-1	5-23-73	17.9	2.2	MDA	13149	0.12	0.01	0.25	0.23
MF0187	Suckers(Wh.)	MM-1	5-23-73	17.6	1.9	MDA	13149	0.12	N.D.	0.18	0.21

MDNS 066128

SUMMARY OF 1973 GLECS DATA

Prepared by the Michigan Department of Agriculture

WALLEYE

Zone	Size	Number	Total DDT's ppm	Total PCB's ppm	Hg ppm	Dieldrin ppm
LAKE HURON						
MH-1 (N½)	--	6	.9±1.3	1.1±1.4	.55±.36	.03
LAKE ERIE						
MONROE	--	6	.04	.5	.56±.16	tr
LAKE ST. CLAIR						
STATION 4	--	6	.3	.4	1.11±.46	tr

MONS 066129

MDA No.	SPECIES	LOCATION	DATE	LENGTH	WEIGHT	ANALYZED BY	LAB. NO.	TOTAL DDT'S	DIELDRIN	PCB'S	MERCURY
HFO356	Walleye	MR-1(N½)	10-4-73	23.5	—	MDA	24263	0.55	0.04	0.74	1.05
HFO357	Walleye	MR-1(N½)	10-4-73	21.5	—	MDA	24263	3.60	0.08	3.74	0.80
HFO358	Walleye	MR-1(N½)	10-4-73	20.3	—	MDA	24263	0.93	0.02	1.24	0.76
HFO359	Walleye	MR-1(N½)	10-4-73	14.2	—	MDA	24263	0.16	0.01	0.16	0.23
HFO360	Walleye	MR-1(N½)	10-4-73	15.4	—	MDA	24263	0.14	0.01	0.16	0.26
HFO361	Walleye	MR-1(N½)	10-4-73	14.7	—	MDA	24263	0.21	0.05	0.41	0.22

MDNS 0661 30

FDA NO.	SPECIES	LOCATION	DATE	LENGTH	WEIGHT	ANALYZED BY	LAB. NO.	TOTAL DDT'S	DIELDRIN	PCB'S	MERCURY
3E000	Walleye	Monroe	5-4-73	15.8	1.38	FDA	040-964G	0.03	Trace	0.4	0.87
3E002	Walleye	Monroe	5-4-73	14.4	1.02	FDA	040-966G	0.02	Trace	0.3	0.42
3E003	Walleye	Monroe	5-4-73	20.1	3.07	FDA	040-967G	0.03	Trace	0.6	0.44
3E004	Walleye	Monroe	5-4-73	18.0	2.13	FDA	040-968G	0.05	Trace	0.6	0.52
3E021	Walleye	Monroe	5-4-73	18.4	2.37	FDA	040-991G	0.07	Trace	0.6	0.52
3E001	Walleye	Monroe	5-4-73	13.8	0.88	FDA	040-965G	0.03	Trace	0.4	0.56

MONS 066131

MDA NO.	SPECIES	LOCATION	DATE	LENGTH	WEIGHT	ANALYZED BY	LAB. NO.	TOTAL DDT'S	DIELDRIN	PCB'S	MERCURY
3C001	Walleye	Sta. 4	5-29-73	14.3	0.95	FDA	108-201G	Trace	Trace	Trace	0.61
3C002	Walleye	Sta. 4	5-29-73	14.0	0.91	FDA	108-202G	Trace	0.00	0.03	0.46
3C003	Walleye	Sta. 4	5-29-73	14.0	0.88	FDA	108-203G	Trace	0.00	Trace	1.23
3C004	Walleye	Sta. 4	5-29-73	19.0	2.04	FDA	108-204G	0.21	0.01	0.7	1.43
3C005	Walleye	Sta. 4	5-29-73	19.4	2.32	FDA	108-205G	1.19	0.01	1.3	1.58
3C006	Walleye	Sta. 4	5-29-73	19.2	2.36	FDA	108-205G	0.19	Trace	0.4	1.34

MDNS 066132

SUMMARY OF 1973 GLECS DATA

Prepared by the Michigan Department of Agriculture

WHITE BASS

Zone	Size	Number	Total DDT's ppm	PCB's ppm	Hg ppm	Dieldrin ppm
LAKE ERIE						
MONROE		4	.3	2.5	.54	.01

FDA NO.	SPECIES	LOCATION	DATE	LENGTH	WEIGHT	ANALYZED BY	LAB. NO.	TOTAL DDT'S	DIELDRIN	PCB'S	MERCURY
3E011	Wh. Bass	Monroe	5-4-73	8.7	0.3	FDA	040-975G	0.16	0.01	2.0	0.40
3E012	Wh. Bass	Monroe	5-4-73	10.3	0.52	FDA	040-976G	0.03	0.00	0.5	0.29
3E013	Wh. Bass	Monroe	5-4-73	11.6	0.79	FDA	040-977G	0.37	0.01	3.5	0.81
3E014	Wh. Bass	Monroe	5-4-73	11.8	0.82	FDA	040-978G	0.43	0.02	1.5	0.66

MDNS 069134

SUMMARY OF 1973 GLECS DATA

Prepared by the Michigan Department of Agriculture

WHITEFISH

Zone	Number	Total DDT's ppm	Total PCB's ppm	Hg ppm	Dieldrin ppm
LAKE SUPERIOR					
MS-3	6	.5±.2	.5±.2	.11±.02	.06
MS-6	9	.2±.1	.2±.1	.12±.08	.01
LAKE MICHIGAN					
MM-1	3	.9	.9	.07	.12
LAKE HURON					
MH-1	18	.6±.3	.5±.2	.07±.07	.09

MDA NO.	SPECIES	LOCATION	DATE	LENGTH	WEIGHT	ANALYZED BY	LAB. NO.	TOTAL DDT'S	DIELDRIN	PCB'S	MERCURY
SF448	Whitefish	MS-3(1026)	5-9-73	18.5	—	MDA	13137	0.34	0.02	0.43	0.14
SF449	Whitefish	MS-3(1026)	5-9-73	19.5	—	MDA	13137	0.37	0.06	0.37	0.11
SF450	Whitefish	MS-3(1026)	5-9-73	19.0	—	MDA	13137	0.30	0.06	0.30	0.10
SF451	Whitefish	MS-3(1026)	5-9-73	22.0	—	MDA	13137	0.66	0.10	0.57	0.11
SF452	Whitefish	MS-3(1026)	5-9-73	24.2	—	MDA	13137	0.66	0.06	0.74	0.10
SF453	Whitefish	MS-3(1026)	5-9-73	24.6	—	MDA	13137	0.75	0.05	0.68	0.12
SF014	Whitefish	MS-6(1544)	5-10-73	16.9	—	MDA	13139	0.11	0.02	0.20	0.05
SF015	Whitefish	MS-6(1544)	5-10-73	16.5	—	MDA	13139	0.12	0.03	0.25	0.08
SF016	Whitefish	MS-6(1544)	5-10-73	16.2	—	MDA	13139	0.18	0.01	0.25	0.10
SF017	Whitefish	MS-6(1544)	5-10-73	18.7	—	MDA	13139	0.22	N.D.	0.30	0.09
SF018	Whitefish	MS-6(1544)	5-10-73	19.6	—	MDA	13139	0.14	N.D.	0.11	0.13
SF019	Whitefish	MS-6(1544)	5-10-73	18.7	—	MDA	13139	0.17	0.01	0.17	0.08
SF020	Whitefish	MS-6(1544)	5-10-73	22.3	—	MDA	13139	0.23	0.01	0.29	0.12
SF021	Whitefish	MS-6(1544)	5-10-73	21.6	—	MDA	13139	0.32	N.D.	0.23	0.12
SF022	Whitefish	MS-6(1544)	5-10-73	22.3	—	MDA	13139	0.25	0.01	0.29	0.32

MONS 066136

MDA NO.	SPECIES	LOCATION	DATE	LENGTH	WEIGHT	ANALYZED BY	LAB. NO.	TOTAL DDT'S	DIELDRIN	PCB'S	MERCURY
MF0188	Whitefish	MM-1	5-24-73	18.1	2.5	MDA	13150	1.11	0.19	1.15	0.07
MF0189	Whitefish	MM-1	5-24-73	19.5	2.7	MDA	13150	0.74	0.10	0.72	0.07
MF0190	Whitefish	MM-1	5-24-73	--	--	MDA	13150	0.83	0.08	0.90	0.07

MDNS 066137

MDA NO.	SPECIES	LOCATION	DATE	LENGTH	WEIGHT	ANALYZED BY	LAB. NO.	TOTAL DDT's	DIELDRIN	PCB'S	MERCURY
HFO167	Whitefish	MH-1(S¼)	4-19-73	20.0	3.1	MDA	10491	0.64	0.11	0.58	0.10
HFO170	Whitefish	MH-1(S¼)	4-19-73	15.2	1.2	MDA	10491	0.35	0.06	0.41	0.03
HFO171	Whitefish	MH-1(S¼)	4-19-73	12.0	0.7	MDA	10491	0.37	0.05	0.41	0.02
HFO172	Whitefish	MH-1(S¼)	4-19-73	10.2	0.4	MDA	10492	0.16	Trace	0.33	0.02
HFO173	Whitefish	MH-1(S¼)	4-19-73	17.1	1.9	MDA	10492	0.23	0.07	0.33	0.37
HFO174	Whitefish	MH-1(S¼)	4-19-73	19.2	2.4	MDA	10492	0.32	0.04	0.33	0.05
HFO175	Whitefish	MH-1(S¼)	4-19-73	17.3	2.2	MDA	10492	0.34	0.06	0.32	0.04
HFO168	Whitefish	MH-1(S¼)	4-19-73	20.2	3.2	MDA	10491	0.38	0.05	0.33	0.04
HFO169	Whitefish	MH-1(S¼)	4-19-73	20.2	3.6	MDA	10491	0.56	0.08	0.49	0.05
HFO179	Whitefish	MH-1(N¼)	4-24-73	19.5	2.6	MDA	10494	0.44	0.08	0.40	0.05
HFO180	Whitefish	MH-1(N¼)	4-24-73	18.6	2.6	MDA	10494	0.55	0.08	0.48	0.07
HFO181	Whitefish	MH-1(N¼)	4-24-73	17.6	2.0	MDA	10494	0.65	0.10	0.56	0.04
HFO182	Whitefish	MH-1(N¼)	4-24-73	16.1	1.5	MDA	10495	0.50	0.04	0.48	0.04
HFO183	Whitefish	MH-1(N¼)	4-24-73	15.3	2.2	MDA	10495	0.51	0.03	0.58	0.08
HFO184	Whitefish	MH-1(N¼)	4-24-73	16.3	1.7	MDA	10495	0.63	0.05	0.66	0.03
HFO176	Whitefish	MH-1(N¼)	4-24-73	23.3	4.2	MDA	10493	1.11	0.13	0.80	0.07
HFO177	Whitefish	MH-1(N¼)	4-24-73	23.8	4.5	MDA	10493	0.93	0.10	0.64	0.06
HFO178	Whitefish	MH-1(N¼)	4-24-73	22.9	4.7	MDA	10493	1.37	0.51	1.12	0.06

MONS 066138

Identification of Chlorinated Dibenzofurans in American Polychlorinated Biphenyls (Aroclor®)

MONS 058480

ABSTRACT

Chlorinated dibenzofurans, highly toxic compounds structurally related to the chlorinated dibenzodioxins, have been detected as contaminants in American preparations of polychlorinated biphenyls (PCB). They are assumed to account for some of the toxic properties of the crude PCB mixtures.

Polychlorinated biphenyls (PCB) are now ubiquitous on Earth. These industrial chemicals have been detected in polar bears (Ursus maritimus) from remote areas of the Canadian Arctic and in snow petrels (Pagodroma nivea) from the Antarctic (1). They are widespread in both marine and fresh-water ecosystems, with highest concentrations recorded in fish-eating birds and mammals from waters adjacent to industrialized areas (2). The reproductive failures of many of these populations, particularly of the fish-eating birds, are among the examples of environmental degradation to which PCB may contribute; a role in eggshell thinning, however, has been discounted (3). Embryonic mortality accounts for a substantial portion of the reproductive failures; embryos in 20 per cent of the eggs of the herring gulls (Larus argentatus) in Lake Ontario colonies in 1973 were found to die during the first week of incubation (4). Experimental work has demonstrated the embryotoxic effects of PCB (5); the active components in German and French PCB, however, have been identified as chlorinated dibenzofurans, present in trace amounts as contaminants in the preparations (6). Like the structurally related chlorinated dibenzodioxins (Figure 1), the chlorinated dibenzofurans are toxic to embryos in sub-microgram amounts (6, 7). They are therefore among the most toxic compounds known. Since the chlorinated dibenzofurans and dibenzodioxins share chemical properties with the dominant chlorinated hydrocarbons in environmental samples, principally the DDT and PCB compounds, they are difficult to detect in the small amounts at which they exert biological effects (8). Techniques which detected the chlorinated dibenzofurans in the French and German PCBs failed to demonstrate their presence in the American PCB Aroclor® 1260 (6).

In the present paper we report the presence of chlorinated dibenzofurans in the American PCBs Aroclor® 1248, 1254, and 1260, and their absence in detectable quantities in Aroclor® 1016.

Samples of PCB examined, obtained from the Monsanto Company in the years indicated, include: Aroclor® 1248, 1254, and 1260 (1969); Aroclor® 1254 (1970); and Aroclor® 1016 (1972). Amounts ranging from 1.0 to 2.0 g were dissolved in 400 ml hexane, placed on a Florisil column (180 g, column i.d. 31.5 mm), and eluted with: 1) an additional 1600 ml hexane, and successive 800 ml volumes each of 2) 5% ethyl-ether/hexane, 3) 25% ethyl-ether/hexane, and 4) acetone, at a rate of approximately 7 ml/min. The major portion of the PCB was eluted in the hexane fraction. This was discarded. Upon addition of the 5% mixture, the eluates were collected in 6 successive 400 ml volumes. To eliminate the polar solvents, each eluate was evaporated twice just to dryness and taken up each time in a minimal amount of hexane. Each fraction, in 1 ml hexane, was placed on a micro alumina column (9) and eluted with 10 ml each of 1% and 20% methylene chloride in hexane. These were also taken twice just to dryness and made up to a volume of 1 ml in hexane to eliminate the methylene chloride prior to gas chromatographic analysis. Aliquots of all fractions obtained before and after partitioning on alumina were injected into a 6 foot glass column containing 3% OV-1 on 100-120 mesh Supelcoport in a Tracor MT-220 gas chromatograph equipped with ^{63}Ni electron-capture detectors. PCB compounds were found to be present in each fraction eluted from the Florisil column in amounts sufficient to interfere with the detection of trace contaminants. Partitioning on the alumina columns separated most of the PCB interference into the 1% methylene chloride fractions.

Upon removal of this interference different peak patterns appeared in the chromatograms of the 20% methylene chloride fractions.

Compounds eluting in the 20% methylene chloride fraction were collected for mass spectrometric analysis with use of a 20:1 effluent splitter, and a trap consisting of a 1 mm i.d., 100 mm long capillary tube, bent to a U shape, immersed in a liquid nitrogen bath. Four microliters of 20% methylene chloride in hexane were injected into the capillary as a rinse, removed with a 1.0 µl micropipet, and placed directly upon the mass spectrometer probe. The probe was inserted into a GEC AEI MS-902 high resolution mass spectrometer and the solvent removed by the fore pump. The probe was rapidly inserted into the ion source and multiple scans were recorded in the on-line high resolution mode (10).

A gas chromatogram showing components derived from the Aroclor® 1254 obtained in 1969 is represented in Figure 2. The components were eluted in the second 400 ml Florisil fraction and recovered from the alumina column in 20% methylene chloride/hexane. Each of the numbered peaks was trapped as described above, and identified by mass spectrometric analysis. A nominal mass plot of the high resolution mass spectrum of peak 2 is shown in Figure 2. The plot includes all the ions with elemental compositions ranging to the maximum empirical formula $C_{13}H_6O^{35}Cl_5{}^{37}Cl_4{}^{13}C_2$. The molecular ion cluster at nominal m/e 304-310 fragments by successive losses of Cl to yield the ions at m/e 269-275 and CO to the ions at m/e 241-245. A minor loss of Cl from the peaks at m/e 269-275 also occurs to yield the ions at m/e 234-238, followed by CO elimination to m/e 206-210. The group of peaks at m/e 152-154 are the doubly charged molecular ions. An identical spectrum

was obtained from an authentic standard of 2,3,7,8,-tetrachlorodibenzofuran. This latter compound has a retention time identical to that of peak 4. Peak 2 is therefore a steric isomer. The accurate mass measurements for the characteristic ions are within 2 ppm of the calculated exact masses. Peaks identified on this chromatogram and their retention times relative to dieldrin are as follows: (1) a mixture of tetra- and pentachlorobiphenyl (1.02); (2) tetrachlorodibenzofuran (1.30); (3) pentachlorobiphenyl (1.46); (4) tetrachlorodibenzofuran (1.57); (5) hexachloronaphthalene (1.75); (6) pentachlorobiphenyl (1.86); (7) hexachloronaphthalene (2.00); and (8) heptachloronaphthalene (3.46). In Aroclor® 1248, three tetrachloro- and four pentachlorodibenzofurans were found. Each of the Aroclor® 1254 preparations and Aroclor® 1260 contained eleven chlorinated dibenzofurans: two tetrachloro-, four pentachloro- and five hexachlorodibenzofurans.

Initially, because authentic standards were not available, the tetrachlorodibenzofurans were quantitated against 2,4,5,2',4',5'-hexachlorobiphenyl; pentachloro- and hexachlorodibenzofurans were quantitated against 2,3,5,6,2',3',5',6'-octachlorobiphenyl. Later an authentic standard of 2,3,7,8-tetrachlorodibenzofuran was obtained and its electron capture response was compared to that of the hexachlorobiphenyl. This comparison showed that use of the hexachlorobiphenyl had yielded estimates of the tetrachlorodibenzofurans that were high by a factor of approximately 2. In the absence of authentic standards of the penta- and hexachlorodibenzofurans it is assumed that the original estimates of their concentrations based upon the octachlorobiphenyl are also high by the same factor. Corrected estimates of the dibenzofuran concentrations in Aroclors® are presented in Table 1.

No chlorinated dibenzofurans were found in Aroclor® 1016, a PCB mixture containing approximately 42% chlorine which has replaced Aroclor® 1242 in many applications, principally as the dielectric fluid in capacitors (11).

Among the PCB preparations obtained in 1969, 1) the total dibenzofuran concentration decreases with increasing chlorine content of the PCB; 2) the total concentration of the tetrachlorodibenzofurans decreases by a factor of ten from Aroclor® 1248 to Aroclor® 1260; 3) hexachlorodibenzofurans could not be detected in the Aroclor® 1248 preparation, but constituted 17% and 57% respectively of Aroclor® 1254 and 1260. The relative proportions of the dibenzofuran components in the Aroclor® 1254 obtained in 1970 were similar to those of the Aroclor® 1254 obtained in 1969, but the total concentration was 74% lower.

PCB residues in the North American environment and in human food have been the subject of extensive scientific investigations, have prompted governmental action and have resulted in substantial changes in many industrial processes which formerly used PCB. Toxic and sublethal effects of crude PCB mixtures include, in addition to embryotoxicity, the production of subcutaneous and abdominal edema, hydropericardium, liver necrosis, porphyria, chloracne, immunosuppression, and the induction of hepatic enzymes that cause elevated levels of steroid metabolism (7). Edema production and embryotoxicity, and the major portion of the acnegenic and hepatotoxic effects of European PCB were attributed to contaminant dibenzofurans. Our results suggest that many of the toxic effects of PCB in North America, such as the low hatchability of eggs from chickens on PCB-contaminated diets (12), were caused by dibenzofurans in the PCB preparations. The possibility therefore exists that chlorinated dibenzofurans are present in

the environment and contribute to the reproductive failures and occasional birth defects observed in populations of fish-eating species of birds, including the herring gulls of Lake Ontario (4), and the ospreys (Pandion haliaetus) and common terns (Sterna hirundo) of Long Island Sound (13).

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MONS 058487

Table 1. Chlorinated dibenzofuran concentrations in Aroclor®*

PCB	4-Cl	5-Cl	6-Cl	Total
1248	0.24(20.9)	0.91(79.1)	nd	1.15
1254 (1969)	0.12(13.5)	0.62(69.7)	0.15(16.9)	0.89
1260	0.017(2.5)	0.27(40.3)	0.38(56.7)	0.67
1016	nd	nd	nd	----
1254 (1970)	0.012(5.2)	0.14(60.9)	0.08(34.8)	0.23

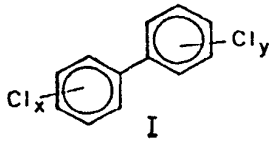
* Quantities are expressed as µg/g Aroclor®. Values in parentheses represent quantity as % of total dibenzofuran.

nd - not detected (< 0.001 µg/g)

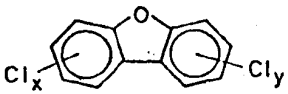
Figure Captions

Figure 1. Skeletal structures of I: chlorinated biphenyl; $x + y = 1$ to 10; II: chlorinated dibenzofurans, $x + y = 1$ to 8; III: chlorinated dibenzodioxins, $x + y = 1$ to 8.

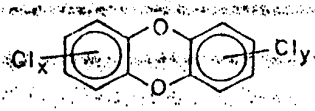
Figure 2. Top: Gas chromatogram of a fraction of Aroclor® 1254 containing a mixture of chlorinated biphenyls, dibenzofurans, and naphthalenes. Conditions and identity of peaks are given in the text. Bottom: Mass spectrum of peak 2, a tetrachlorodibenzofuran.



I



II



III