MF 500
Papageorge #72

IN THE UNITED STATES DISTRICT COURT
FOR THE DISTRICT OF NEVADA

NEVADA POWER COMPANY,	)	
	)	
Plaintiff,	)	
-vs-	)	
	)	# CV-S-89-555-LDG (LRI
	)	
MONSANTO COMPANY, et al.,	)	
	)	
Defendants.	)	

30(b)(6) DISCOVERY
DEPOSITION OF WILLIAM B. PAPAGEORGE

On the part of the Plaintiff

July 20 & 21, 1993

Concannon & Jaeger
General Court Reporters
705 Olive Street, Suite 604
St. Louis, Missouri 63101
(314) 421-1000

WATER_PCB-SD0000073868

IN THE UNITED STATES DISTRICT COURT
FOR THE DISTRICT OF NEVADA

NEVADA POWER COMPANY,)
)
Plaintiff,)
-vs-) # CV-S-89-555-LDG (LRL)
)
)
MONSANTO COMPANY, et al.,)
)
Defendants.)

* * *

I N D E X

WITNESS: Page:

WILLIAM B. PAPAGEORGE

Direct Examination by Mr. Bradley 4

E X H I B I T S

Plaintiff's Deposition Exhibit # 422 . . . .10, 11, 12, 13

Plaintiff's Deposition Exhibit # 514 8

Plaintiff's Deposition Exhibit # 1118. . . .10, 11, 12, 13

WATER_PCB-SD0000073869

IN THE UNITED STATES DISTRICT COURT
FOR THE DISTRICT OF NEVADA

NEVADA POWER COMPANY, Plaintiff,
-vs-
MONSANTO COMPANY, et al., Defendants.
CV-S-89-555-LDG (LRL)

CONTINUATION OF THE 30(b)(6) DISCOVERY DEPOSITION OF WITNESS, to be used in an action pending in the District Court of the United States, for the District of Nevada, wherein NEVADA POWER COMPANY is Plaintiff, and MONSANTO COMPANY, et al. are Defendants, pursuant to Notice, under the provisions of Rule 26 of the Rules of Civil Procedure, taken on July 21, 1993, at the law offices of Messrs. Husch, Eppenberger, Donohue, Cornfeld & Jenkins, 100 N. Broadway, Ste. 1300, St. Louis, Missouri 63102, before Mark D. Concannon, a Notary Public within and for the State of Missouri.

A P P E A R A N C E S

The Plaintiff was represented by Attorney Ralph A. Bradley of the law firm of Jones, Jones, Close & Brown, Chartered, 700 Bank of America Plaza, 300 South Fourth Street, Ste. 700, Las Vegas, Nevada 89101.

The Defendant, Monsanto, was represented by Attorney Scott R. Bauer of the law firm of Kirkland & Ellis, 1999 Broadway, Ste. 4000, Denver, Colorado 70202.

The Defendant, Westinghouse, was represented by Robert P. Morgan, In-House Counsel, Westinghouse Electric Corporation, Westinghouse Building, Gateway Center, Pittsburgh, Pennsylvania 15222.

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WILLIAM B. PAPAGEORGE,
of lawful age, having been previously sworn to tell the truth, the whole truth, and nothing but the truth, deposes and says on behalf of the Plaintiff, as follows:

DIRECT EXAMINATION

QUESTIONS BY MR. BRADLEY:

Q. Mr. Papageorge, we're now moving to a completion of a deposition that was begun with you on February 23th and 24th of 1993. The transcript of the deposition at pages five and six indicate the subject matter for which you were tendered as Monsanto's corporate designee, and at page one oh five of the deposition there was an attempt by your attorney to withdraw you as Monsanto's corporate designee on a portion of the topic for which you had previously been identified, and without waiving any right to challenge whether Monsanto is entitled to withdraw you in the middle of a deposition on an area that you have previously been designated, we agree to at least go forward now with completion of your deposition.

The same rules will apply. If I ask you a question that you don't understand, will you tell me?

A. I will.

Q. If you want to take a break for any reason, let me know.

A. I will.

Q. In your work as project manager -- I'm sorry. Let me back up. What was your title in January of 1970 at Monsanto?

A. Manager, environmental control.

Q. And in your work as manager of environmental control, were you responsible for learning what information was available publicly regarding the real or alleged hazards of PCB's to the environment?

A. Yes.

Q. And in your job responsibility did you make an effort to keep current regarding the studies that were being conducted regarding that topic?

A. Yes.

Q. And how long were you manager of environmental control?

A. About a year or a year and a half.

Q. And what was your job title following being manager of environmental control?

A. I was environmental manager in environmental protection.

Q. How long did you have that job title?

A. Until about 1973.

Q. At that point what job title did you have?

A. Manager, product acceptability.

Q. How long did you have that job title?

A. Until 1977, as best I recall.

Q. Between 1970 and 1977, did you have responsibility at Monsanto regarding PCB's?

A. Within that period of time, yes.

Q. Between January of 1970, and 1977, did you attempt to keep current as part of your job responsibilities regarding knowledge of the studies that were ongoing and which were completed regarding the real or alleged hazards of PCB's to the environment?

MR. BAUER: Object to form of the question. He said within that time period he had those responsibilities, so I think it's vague as to whether you're talking about that entire time period.

Q. (by Mr. Bradley) Did you have responsibilities between January of 1970 and 1977 that required you to keep current on the ongoing studies and the results of those studies regarding the real or alleged hazards of PCB's to the environment?

A. Within that period of time, yes.

Q. And were you satisfied that during that period of time Monsanto kept current regarding the published literature describing the studies that were completed and ongoing regarding the alleged or real hazards of PCB's to the environment?

MR. BAUER: Object to the form of the ques-

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tion. There is still this ambiguity because of the statement, "Within that time period," and, for the record, Mr. Papageorge is not being designated past the early-1976 period, when he left his PCB responsibilities.

Q. (by Mr. Bradley) Then let me rephrase. Did you indicated earlier that between 1970 and 1976 your job responsibilities required you to keep current regarding the ongoing studies or study results of the real or allege hazards of PCB's to the environment?

A. Yes.

Q. What efforts during that period of time did Monsanto make to keep current regarding studies and study results regarding the real or alleged hazards of PCB's to the environment? And by "during that period of time," I mean 1970 and 1976.

A. We of course perused the appropriate literature, and also the popular press, and we attempted to make personal contact with laboratories we knew were interested in the subject. We made personal calls with individuals working in this area. We made contacts with representatives of the regulatory agencies in the Federal Government, and with some state agencies. We contacted representatives of our customers who were also interested in this subject. We talked, also, to other producers of PCB's worldwide. I believe that pretty well describes it.

Q. I take it, then, during the period 1970 to 1976, Monsanto was relatively confident that it was keeping current regarding the ongoing studies and study results of the real or alleged hazards of PCB's to the environment?

A. I feel that's a good way to describe it, relatively comfortable. You're never sure you have one hundred percent of it, but you have the essential parts of it.

Q. And is it fair to say that you were making every effort to learn a hundred percent of that information during that period of time?

A. We were striving for that, yes.

Q. I am now going to show you Plaintiff's Exhibit 514. Is that a document you have seen before?

A. It is a study, as I understand it, that summarizes the information known prior to 1972 regarding the real or alleged hazards of PCB's to the environment.

MR. BAUER: Do you know the date of this work?

MR. BRADLEY: No, I don't.

A. I have reviewed the document and it appears familiar, but so many documents are common to so many other documents of this type that I am having a difficult time placing the exact time when I was made aware of its existence.

Q. (by Mr. Bradley) In 1972 was Monsanto aware of the studies that are referred to in the bibliography

sections of that exhibit?

MR. BAUER: Object to the form. Compound. And outside of the scope with respect to this witness, because many of them are dated prior to 1966.

Q. (by Mr. Bradley) Well, then, relative to the documents that appear -- Strike that. My question stands. Go ahead and answer the question.

MR. BAUER: Same objections.

A. If I remember the question, you're asking if Monsanto was aware of the documents listed in the reference section of this exhibit.

Q. (by Mr. Bradley) Yes.

MR. BAUER: Same objections.

A. I haven't had time to look at all of them, of course, but I recognize a few.

Q. (by Mr. Bradley) Was it Monsanto's medical department that collected the studies between 1970 and 1976 regarding the real or alleged hazards of PCB's to the environment?

A. Yes.

Q. Do you know whether Monsanto's medical department between 1970 and 1976 -- Excuse me -- between 1970 and 1972 maintained copies of the documents referred to in the references section of that exhibit?

MR. BAUER: Same objection.

A. I recognize some of the references. I do know that the Monsanto medical department had copies available. At this moment I can't speak for all ninety-four that are listed here.

Q. (by Mr. Bradley) Between 1966 and 1970 did Monsanto's medical department keep current regarding the studies and study results regarding the real or alleged hazards of PCB's to the environment?

A. They attempted to keep current, yes.

Q. And made their best effort to keep a hundred-percent current, though you never quite know whether you did it. Is that fair to say?

A. Yes.

Q. Are you aware of any Monsanto document that indicates that Monsanto was not advising its customers of the known environmental effects of PCB's?

A. No.

Q. Do you know whether Monsanto was keeping its customers informed of the currently-available information regarding the real or potential hazards of PCB's to the environment between the period of 1966 to 1976?

A. It was attempting to do so, yes.

Q. I am now going to show you Plaintiff's Exhibit 422 and Plaintiff's Exhibit 1118, at page five, which is identical for both documents. Do you have those in front

of you?

A. I'm getting them.

Q. All right. Under Roman Numeral V, capital A -- First of all, you have testified about these documents in two separate sets of depositions; is that correct?

A. Yes, sir.

Q. The section under Roman Numeral V, capital A, on page five of Plaintiff's Exhibits 422 and 1118 states in part, "Direct lawsuits are possible. The materials are already present in nature having done their 'alleged damage'. All customers using these products have not been officially notified about known effects nor do our labels carry this information." Do you see that?

A. Yes.

Q. The statement that "All customers using these products have not been officially notified about known effects nor do our labels carry this information," was that referring to information about the real or alleged hazards of PCB's to the environment?

MR. BAUER: Object to the form. Lacks foundation.

A. Yes.

Q. (by Mr. Bradley) And this document was authored -- or excuse me -- These documents were authored in 1969?

A. Yes.

Q. And as part of your work as project manager in January of 1970 at Monsanto, did you have discussions with the authors of Plaintiff's Exhibits 422 and 1118 regarding the information contained in those exhibits?

MR. BAUER: Objection. Outside the scope of the 30(b)(6) Deposition.

A. I had discussions with Mr. Wheeler regarding the contents of the documents we're discussing.

Q. (by Mr. Bradley) Did you have a discussion with Mr. Wheeler regarding the statement that all customers using the products have not been officially notified about known effects nor do Monsanto's labels carry that information?

MR. BAUER: Same objection.

A. Yes, but I was already working with the task force developing that piece of communication in January, and it was accomplished in February.

Q. (by Mr. Bradley) And the work of the task force was to develop what?

A. The work --

Q. Let me rephrase my question. In February of 1970, did the task force develop information to Monsanto's customers that officially notified them about the known environmental affect of PCB's on the environment?

A. Yes.

Q. And was that one of the charges of the task force? They completed that work as part of their regular business activities at Monsanto?

A. Yes, sir.

Q. And did they complete that activity because customers up to that point, customers of Monsanto's, had not been officially notified about the information that was developed by the task force in February of 1970?

MR. BAUER: Object to the form. Outside of the scope. Vague as to the use of the term "officially notified."

A. Your question has many facets to it. Some customers were informed, as we indicated earlier today, in an informal kind of way. What the task force did was advise, through me, the business group concerned with the particular product line on the kind of information that Monsanto could confidently pass on, as being as close to reality as it could determine, and compose the proper documents to be sent to all customers on record. These deliberations took place in January of 1970. By early February, the draft letters were in place and the mailing was started.

Q. (by Mr. Bradley) And looking at the language in Plaintiffs Exhibits 422 and 1118 on page five under

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Roman Numeral V, capital A, was the known effects that are referred to -- did the known effects that are referred to include the effects that were reported by Professors Jensen and Widmark of Sweden?

MR. BAUER: Same objections.

A. I think there were references to fish and wildlife. I forget the exact words.

MR. BRADLEY: I have nothing further.

MR. MORGAN: I have no questions.

MR. BAUER: I have no questions.

MR. BRADLEY: Mr. Papageorge -- or let's see. Please mark this as --

MR. BAUER: For the record, the 30(b)(6) on hazards is concluded with respect to Mr. Papageorge's limited designation for the limited time period that he was talking about.

MR. BRADLEY: For Nevada Power's purposes, the deposition of Mr. Papageorge as the 30(b)(6) designee on this topic is not closed, because Nevada Power is not satisfied that Mr. Papageorge can be tendered as a 30(b)(6) on the subject matter for which he was tendered in his deposition, which included effects on humans, only to have an attorney withdraw Mr. Papageorge on that subject matter roughly during the halfway point of his deposition, so Nevada Power Company takes the position that this deposi-

tion remains open to quiz Mr. Papageorge further about that topic.

MR. BAUER: But with the exception of that topic, you're in agreement that it's closed?

MR. BRADLEY: That is correct.

_____
WILLIAM B. PAPAGEORGE

Subscribed and sworn to before me this _____ day of _____, A. D., 1993.

MY COMMISSION EXPIRES:

_____
Notary Public, within and
for the State of Missouri

WATER_PCB-SD0000073882

STATE OF MISSOURI)
) SS
COUNTY OF ST. LOUIS)

I, Mark D. Concannon, a Notary Public within and for the State of Missouri, duly commissioned, qualified and authorized to administer oaths and to take and certify to depositions, do hereby certify that pursuant to Notice in the civil cause now pending and undetermined in the District Court of the United States, within and for the District of Nevada, entitled NEVADA POWER COMPANY, Plaintiff, -vs- MONSANTO COMPANY, et al., Defendants, to be used in the trial of said cause in said Court, I was attended at the law offices of Messrs. Husch, Eppenberger, Donohue, Cornfeld & Jenkins, 100 N. Broadway, Ste. 1300, in the City of St. Louis, State of Missouri, by Ralph A. Bradley, attorney for the Plaintiff; by Scott R. Bauer, attorney for the Defendant Monsanto; by Robert P. Morgan, In-House Counsel for the Defendant Westinghouse; and by WILLIAM B. PAPAGEORGE, the witness, in said office on July 21, 1993.

The said witness, WILLIAM B. PAPAGEORGE, being of sound mind and being by me first carefully examined and duly cautioned and sworn to testify the truth, the whole truth and nothing but the truth in the case aforesaid, thereupon testified as is shown in the foregoing transcript, said testimony being by me reported in shorthand

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and caused to be transcribed into typewriting, and that the foregoing pages correctly set out the testimony of the aforementioned witness, WILLIAM B. PAPAGEORGE, together with the questions propounded by counsel and the remarks and objections of counsel thereto, and is in all respects a full, true and complete transcript of the questions propounded to and the answers given by said witness; and that said testimony, so transcribed, was subscribed to by the witness on the _____ day of _____, A.D., 1993.

I FURTHER CERTIFY that I am not of counsel nor attorney for any of the parties to said suit, nor related, nor interested in any of the parties or their attorneys.

I FURTHER CERTIFY that Plaintiff's Deposition Exhibits marked for identification and attached to and made a part of this deposition are the identical exhibits referred to and identified by the witness in the foregoing deposition.

WITNESS MY HAND and Notarial Seal, given this _____ day of _____, A. D., 1993, at St. Louis, Missouri.

MY COMMISSION EXPIRES MARCH 21, 1994.

_____
MARK D. CONCANNON,
Notary Public, within and
for the State of Missouri

WATER_PCB-SD0000073884

Concannon and Jaeger
General Court Reporters
705 Olive Street, Ste. 604
St. Louis, Missouri 63101

August 10, 1993

Mr. Scott R. Bauer
Kirkland & Ellis
1999 Broadway
Denver, Colorado 80202

Re: Nevada Power Vs. Monsanto

Dear Mr. Bauer:

This letter, incorporated as the last page of Mr. Papageorge's deposition, taken on July 21, 1993, will serve as notice to you that Mr. Papageorge's testimony is now ready for his reading and signing of same.

Enclosed, please find your copy of the deposition, along with the original signature page, (pg.15), and errata sheets. Please have Mr. Papageorge read his deposition at his earliest possible convenience, making whatever changes he feels necessary on the errata sheets, along with his reason for making same. Have him sign the original signature page and eratta sheets before any notary, and return the original signature page and eratta sheets to me at the above address so that I may file the original transcript in Court and notify opposing counsel of the changes.

Thank you for your cooperation in this regard.

Sincerely,

MARK D. CONCANNON

MDC:mk
encls.

WATER_PCB-SD0000073885

WILLIAM B. PAPAGEORGE

- DEPOSITION CORRECTION SHEET -

In Re: NEVADA POWER Vs. MONSANTO

Upon reading his deposition transcript and before subscribing thereto, the deponent indicated the following:

Page Line should read:

Reason assigned for change:

Page Line should read:

Reason assigned for change:

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Reason assigned for change:

Page Line should read:

WILLIAM B. PAPAGEORGE

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ROUGH DRAFT - 11/10/69

OUTLINE

PCB ENVIRONMENTAL POLLUTION ABATEMENT PLAN

I. Introduction

II. Problem

III. Extensiveness

IV. Nature of the Problem

~~Research and medical input~~

V. Effect on Monsanto

VI. Effect on Customer

VII. Involvement with other producers

VIII. Sources of Contamination

~~A. Indirect Pollution~~

IX. Recent technical changes which have bearing on the contamination

X. Courses of Action

XI. Recommended Course of Action

XII. Implementation of the Recommended Course of Action

A. Immediate Action (12-1-69)

B. Interim 1-3 months

C. Short term - 3-6 months

D. Long term (1-3 years)

1. Research medical
2. Manufacturing
3. Engineering
4. Market
5. Patent
6. Environmental Control
7. Legal
8. Public Relations
9. Others

PLAINTIFF'S EXHIBIT 422

STR 021938

84144

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XIII. Probability of Success

XIV. Cost of Program

$220,000 and bio with max. at $20-25M

XV. Future

STR 021939

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PCB ENVIRONMENTAL POLLUTION ABATEMENT PLAN

Introduction

On 15 October the "AD HOC" Committee consisting of Messrs. M. Farrar, P. Hodges, E. John, W. Richard, and E. Wheeler issued a report summarizing the polychlorinated biphenyl (PCB) pollution problems from the known available information to date. Out of this report came considerable information, conclusions, and recommendations which we have attempted to tie together into a plan of action in this document. Our objective has been to take a reasonable and responsible approach to the entire problem. Before we get into the problem, we should clarify the meaning of PCB, the nature of the entire line, and how these tie into our product line of Aroclors.

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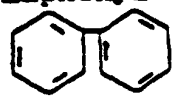
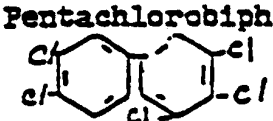
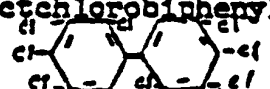
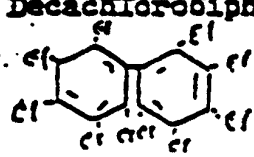
Monsanto entered the Aroclor market in 1930 by acquiring Swain Electrical Company or known today as our Anniston, Alabama plant. The first load of Aroclor which incidentally was Aroclor 1254 -- went out of Anniston, Alabama to GE in 1931. Since that time the market has grown to 170 to 200M worldwide.

Chemical	Monsanto Product Line	Nature of Material at Ambient
Biphenyl  Solid at Sublimes at		Solid
Monochlorobiphenyl 	Aroclor 1221	thin liquid (oil)
Dichlorobiphenyl 	Aroclor 1232	thin flush water
Trichlorobiphenyl 	Aroclor 1242	oily type fluid material
Quaterchlorobiphenyl 	Aroclor 1248	Thicker - transmission oil
Pentachlorobiphenyl 	Aroclor 1254	Heavy-Molasses
Hexachlorobiphenyl 	Aroclor 1260	Thick - tar
Heptachlorobiphenyl 	Aroclor 1262	Very thick - liquid
Octchlorobiphenyl 	Aroclor 1268	Solid
Decachlorobiphenyl 	Aroclor 12715	Solid

STR 021941

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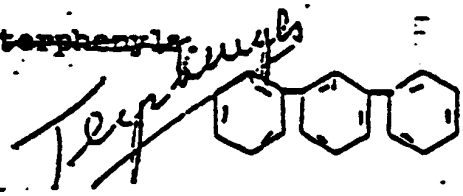
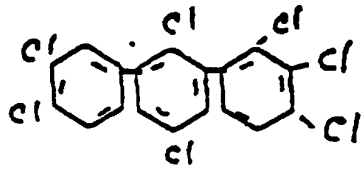
Total possibility are 210 theoretically possible chlorinated biphenyls'

~~terphenyls~~ Terphenyls



Santowax or terphenyl

Solid



Aroclor 5460

Solid

II. Problem

Damage to the ecological system by contamination from polychlorinated biphenyl (PCB).

III. Extensiveness

The problem involves the entire United States, Canada, and sections of Europe especially the United Kingdom and Sweden. As the investigation broadens other areas of Europe, Asia and Latin America will surely become involved. Evidence of contamination have been shown in some of the very remote parts of the world. The involvement could and most likely will follow the DDT investigations.

IV. Nature of the Problem

Professors Widmark and Jensen of the Institute of Analytical Chemistry at Stockholm, Sweden, in November 1966, announced and confirmed finding PCB in fish, birds, and eggs. Subsequent findings were made in 1967 in Great Britain. In February 1969, Professor Risebrough of the Universit of California published an article in the San Francisco Chronicle relaying his findings of PCB in the environment of the United States. Monsanto confirmed the presence of PCB's in mid-1969 and confirmed the adequacy of work by Widmark and Jensen and others; truly, the PCB's are a worldwide ecological problem.

STR 021942

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Analysis indicates the environmental presence of the 5 and higher chlorinated biphenyls which take the appearance of Aroclor 1254 and Aroclor 1260. We have strong indications that Aroclor 1242 or at least part of it degrades biologically. Since the Aroclor 1242 contains arou 7 percent of the 5 chlorine biphenyl or higher we cannot rule out the possibility that the observations may be a concentration affect of the higher chlorinated biphenyls of Aroclor 1242.

To date there have been no reports of finding Aroclor 1242 present in the environment (except outside the effluent of our plants where we kno Aroclor 1242 is present).

The seriousness of the problem can best be spelled out as follows:

1. Fish - Marine or aquatic species concentrate PCB in the fatty tissue. Toxic is small quantities (down to 5 ppb) to sensitive mar life such as shrimp.

2. Birds - Predatory species feeding on the marine or aquatic life can further concentrate PCB to possible harmful effects. Specifically in birds PCB can affect the calcium metabolism leading to egg shell imperfections which prevents proper hatch of the young. In fact, Monsanto has confirmed the eggshell by feeding chickens, a high order of the species, PCB's in controlled tests.

3. Man - There is no harmful effect known to man or other mammals afte 40 years of production. Investigations are underway by various sources.

STR 021943

4. Political and Public Emotion - PCB's are falsely linked with DDT because PCB's show up in the analysis for DDT. PCB's are linked w other permanent type chlorinated hydrocarbon pesticides. This becomes particularly serious since about every article of food in country is being examined for a trace of these materials.

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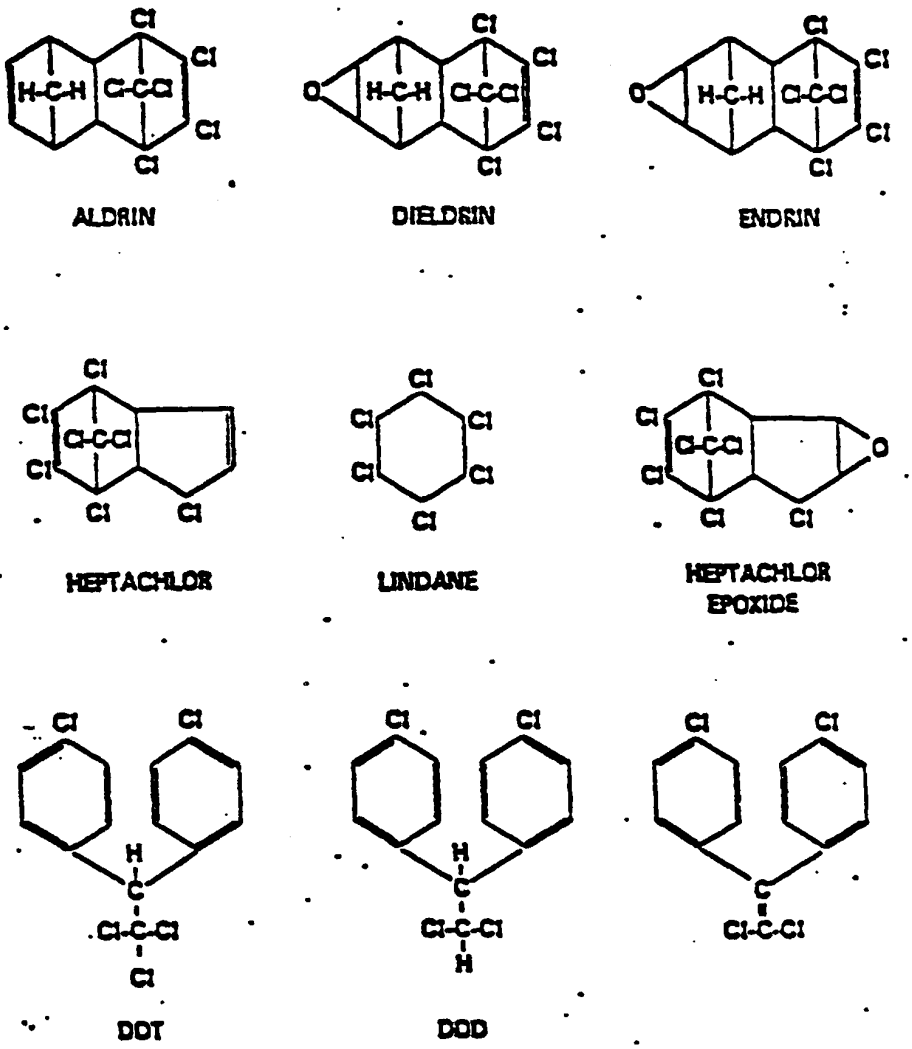

Fig 1 Structural Formulae of Nine Chlorinated-Hydrocarbon P.

STR 021944

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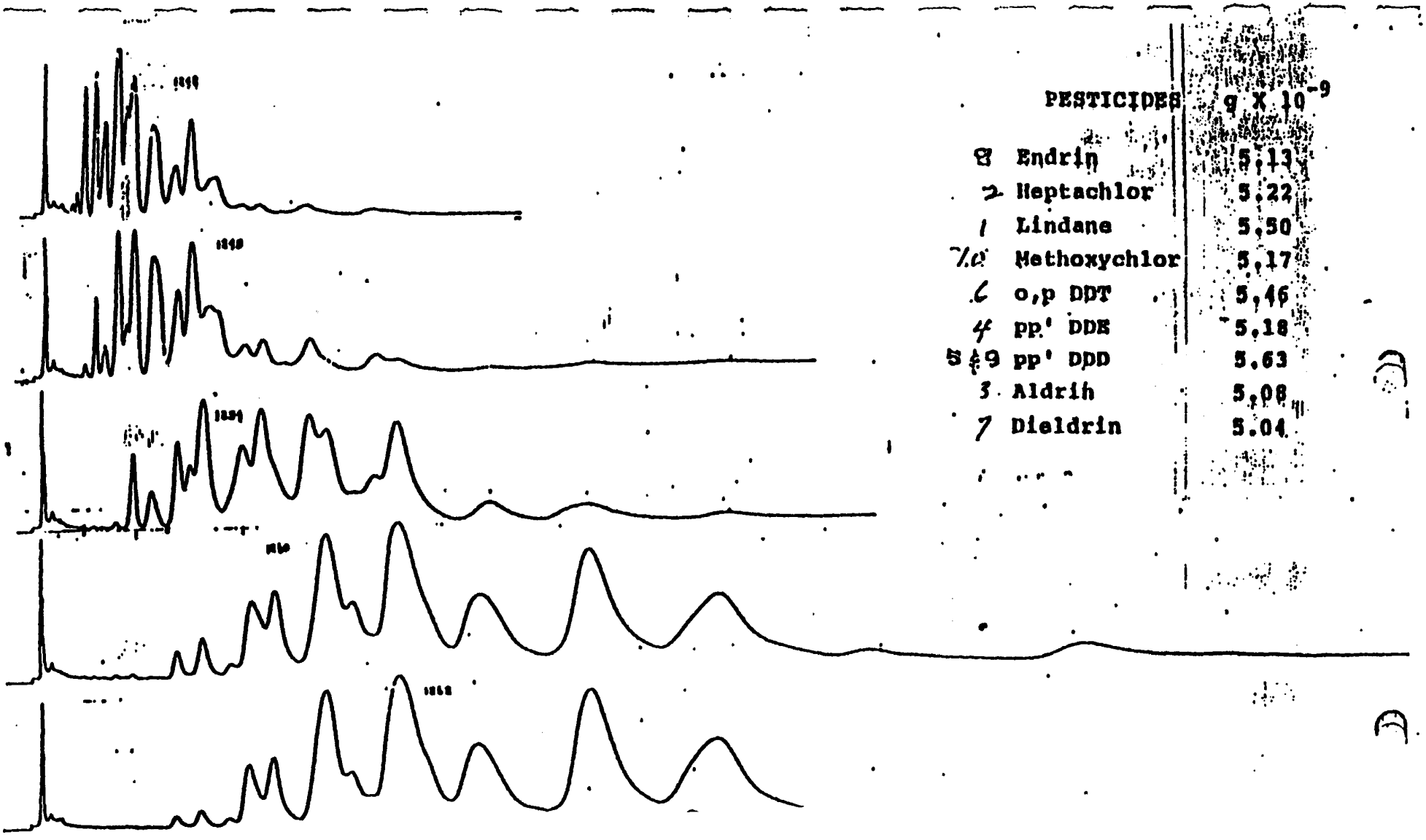

	PESTICIDES	q X 10^{-9}
8	Endrin	5,13
2	Heptachlor	5,22
1	Lindane	5,50
7a	Methoxychlor	5,17
6	o,p DDT	5,46
4	pp' DDE	5,18
5 & 9	pp' DDD	5,63
3	Aldrin	5,08
7	Dieldrin	5.04

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V. Effect on Monsanto

Business potential at stake on a worldwide basis:

Fluids	Plasticizers	Total/Year
70M lbs.	34M lbs.	104M lbs.
$16M	$6M	$22M
$6-8M G.P.	$2-3M G.P.	$8-11M G.P.

Already competition is using certain data against us in competitive situations.

A. Legal Liability

Direct lawsuits are possible. The materials are already present in nature having done their "alleged damage". All customers using thes products have not been officially notified about known effects nor d our labels carry this information. These are only a few of the possible legal implications which would best be covered by the legal department.

B. Public Image

The corporate image of Monsanto as a responsible member of the business world genuinely concerned with the welfare of our environment will be adversely affected with increased publicity.

The evidence proving the persistence of these compounds and their universal presence as residues in the environment is beyond questioning. This combined with certain scare publications is certa to give an adverse image. Guilty by association (with DDT) will prevail as the background while actual facts may be sparse.

C. Customer Relations

STR 021946

Some customers who presently use these materials will be "scared of to other competitive products. Products associated with the same name or "trademark" will be adversely affected ie., Therminol, Pydraul and Aroclor. Competitors will use the information for an

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influence on Monsanto products.

Customers will seek other "outs" rather than become involved.

VI. Effect on Customers and Ultimate Consumers

One of the unique features of PCB's is their fire resistance. Here the basic decision whether to risk lives due to fire or risk extinction of, some species of birds. In this case the PCB would probably be accepted as a necessary pollutant and tolerated under controlled conditions.

A. Electrical Industry - Capacitors and Transformers use Aroclor because it is the best inexpensive dielectric fluid available.

B. Food Processing - Bulk "deep frying" units for potato chips, fish, and doughnuts use the fire resistance fluid as an indirect heating medium.

C. Die Caster -- and other hot metal working industries fire resistance fluids to protect the workers.

Affects a wide range of plastics and adhesives because the PCB serves as the plasticizer.

A wide range of paints and coatings are affected. The "Carbonless" carbon paper used so widely would disappear.

VII. Involvement With Other Producers

Although Monsanto is most probably responsible for the U.S. contaminati and jointly responsible with MCL for the United Kingdom problem, we cannot accept responsibility for the world. There are five known producers in the free world, several possible producers behind the iron curtain and couple of additional companies making overtures about entering the business. Monsanto representatives have on one occasion discussed this problem with a couple of these producers but they expressed no great concern. In fact, it is highly possible that one of

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these manufacturers is dumping his waste into the Rhine River. Certainly any action taken by one producer will most assuredly affect the other. It is entirely possible that a joint plan of action could be developed but will most probably have to be spearheaded by Monsanto. It is also likely that producers of other chlorinated products used with PCB's will be dragged into the investigation.

VIII. Sources of Contamination

Although there may be some soil and air contamination involved, by far the most critical problem at present is water contamination. To our knowledge to date the contamination can be broken down into two general categories, open and indirect pollution.

A. Open Pollution - Our manufacturing facilities sewered a sizeable quantity of PCB's in a years time.

1. Fluids

Fluids are probably the most open source of pollution because of their mobility. They also may be the least serious because they are generally the lower chlorinated materials.

2. Electrical

Electrical customers have in the past sewered their wastes.

3. Heat Transfer

Heat transfer customers have sewered their objectionable and their spilled material.

4. Industrial

These fluids have generally been sprayed into drains, washed down sewers and generally regarded as very harmless.

All of the fluids have had the "pink" constituent dumped on dirt roads as a "dedusting agent" which inadvertently found its way back to the stream.

STR 021948

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5. Plastics

The plastics are not as mobile as the fluids so therefore they have not found and cannot find their way back to streams in op pollution.

B. Indirect

Shipping containers and the cleaning thereof for subsequent use a source of contamination.

1. Fluids

a. Electrical - Disposal of "burned out" transformer and capacitors may find its way back to streams. Scrap units (new) are generally disposed of in land fills but could possibly get back to the stream.

b. Heat Transfer - Leaks could contaminate.

c. Industrial - Cross product contamination carried out of an air compressor. Residual material carried on parts.

2. Plasticizers

a. Process Contamination from Washing

(1.) Environment Contamination

Swimming pool paints

Incineration of wax coatings

Traffic paints

(2.) Product Contamination

STR 021949

Coating for tank lining

Painting inks and paper coatings

Certain adhesives

IX. Recent Technical Changes Which Have Bearing on the Contamination

A. Fluids

The sources of pollution were pointed out as they have been in th past because we are dealing with that quantity of material in the

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environment today which was deposited over the past forty years. We must state that responsible people throughout the industry have taken corrective action to reduce contamination in the last two years. There have also been technical advances which have brought about the use of lower chlorinated biphenyls which may be an advantage because to date t: low chlorinated ones have not been identified present in nature.

1. Electrical - The large customers have established collect systems a: the waste is recovered. Incinerators are being investigated and built for the disposal of the materials. There has been a shift away from the higher chlorinated types products and could probably shift almost entirely away from those products.
2. Heat Transfer - System have been tightened up and redesigned to confine the contents Here, too, the trend has been to shift away from the higher chlorinated materials.
3. Industrial - Settling ponds have been built by the large manufacture to catch the material and decant off the PCB for reprocessing. The trend here as the other fluid areas has been towards the lower chlorinated materials.
4. Plants - The plants effluent has been passed through limestone whi: provides surface to catch some of the material. But high concentrations can be found in our effluent (that is relative to those findings in nature causing the problem).

B. Plasticizer

Quite opposite to fluids the trend in plasticizer Aroclor has been to higher chlorinated biphenyls. In plasticizers the lower chlorinated biphenyl will not be an acceptable solution however, the lower chlorin terphenyl could offer a possible solution.

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X. Courses of Action

A. Do Nothing

We cannot deny the findings and the acquisitions by the various agencies. If we took no action we would likely face numerous suits. We would let government tolerances be based on public and political pressure along with any experimental or developed data which they may generate. We would most likely be forced out of this business. Other product areas would be adversely affected. We would project an image as an irresponsible member of the business world. Project poor customer relations. The only advantage to this technique offers is it reduces the cost but this too must be weighed against potential loss of business.

B. Discontinue Manufacture of All Polychlorinated Biphenyls (PCB)

Although we all realize this could be an eventually unfortunately the solution is not this simple. Assuming we did stop manufacture immediately, the pollutants are present in the environment, the liability is present and possibly by the shifting to the lower chlorinated materials and the recovery techniques the contamination may already be reduced to an acceptable level. Obviously the entire business would be lost without any or very few substitutes to be offered. Other product areas would be affected. Financial loss could be considered due to raw material contracts, customer contracts and royalty -- secrecy contracts. Competition would take advantage on all fronts. We would be admitting guilt by our actions. Loss of capitol investment in the plant, associated utilities, and associated processes. We would possibly gain a little public image on this action.

STR 021951

C. Respond responsibly, admitting that there is growing evidence of environmental contamination by the higher chlorinated biphenyls and take action as new data is generated to correct the problem.

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This approach would enable us to phase out the higher chlorinated materials in many applications where they are no longer necessary or really desired. Wecould maximize the corporate image by publicizing this act. We would reduce a known pollutant. Additionally we could gain precious time needed to develop new products and investigate further the lower chlorinated materials. As new research data is generated our course may be altered considerably. Certain limited actions may reduce or limit the problem.

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XI. Recommended Course of Action

Based on the information available today the only recommendation we can honestly make is respond responsibly admitting that there is growing evidence of environmental contamination by the higher chlorinated biphenyls and take action as new data is generated to correct the problem.

XII. Implementation of the Recommended Course of Action

A. Immediate (By 12-1-69)

1. Set up a task force under a project manager or the equivalent responsible for initiating, directing and implementing all action that Monsanto decides to take. This includes sufficient budget necessary to cope with the immediate problems. This task force should include representatives from Medical, Legal, Research and the two involved Marketing Groups and Public Relations and must conduct liaison with MCL and other locations involved in the problem.

2. Decide on timing and content of any public and/or customer notification of PCB problem.

B. Interim (Within 3 months)

Fluids	Plasticizers
1. Confirm Aroclor 1254/Aroclor 1260 are found in the environment.	1. Announce differential between fluids/plasticizer uses.
2. Publicize the difficult anal. tasks.	2. Announce safety of other PCB's chlorinated terphenyl.
3. Protect other PCB/chl. terph.	3. Educate customers on control o effluent for all products.
4. Announce plans to reformulate certain Therminols and Pydraul where control of the product is difficult.	4. Initiate program to develop A/ 1254 & 1260 substitutes

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5. Emphasize better control over other Aroclor 1254 & 1260 uses.

5. Investigate with manufacturers the feasibility of alternate products.

6. Initiate customer education on need for effluent control of all products.

6. ~~Analyze 1242~~

7. Determine composition of all PCB's.

Develop a comprehensive Program

C. Short Term (within the next 12 months)

1. Research - Expand program for more meaningful biodegradation studies and confirming analytical results. Expand toxicity studies. Follow developments concerning publicity and those developments covering political implications of PCB contamination.

Medical

2. Marketing - Discontinue or substitute replacement products for those applications of Aroclors 1254 and 1260 where the Aroclor remains mobile.

Work with customers to clean up plants on other Aroclors. Report the habitual violators or "do nothings" to the product group.

Reclaim or safely dispose of fluids. STR 021954

Consider renaming products that do not contain PCB. Follow and report market developments such as customer disposal systems. Follow and report any political or public feedback which may affect the contamination problems and must be coordinated with Medical, Research and Legal.

3. Production - Clean up plants and stop gross contamination.

4. Legal - Define our present position, recommend reasonable action that will not unduely alarm the market but reduce the exposure in terms of liability. Coordinate recommendations with Marketi

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5. Public Relations - Publicize actions where believed advantageous

Certainly discussions should be held with other producers within same period to determine their planned course of action, if any.

D. Long Range Tentative Outline (From 1 year to 3 years)

Realizing that the comprehensive program must be outlined the "Long Range Tentative Outline" is meant to serve as a guide: All aspects of this program should be reviewed quarterly by Organic Management.

1. Research-Medical

Continue biodegradation studies and analytical support

Isomer distribution

Toxicity and metabolism studies

Water soluble removal

Incineration analytical support

Confirmation analytical

Contract academic research for reference

Develop new and improved formulations

2. Manufacturing

a. Process Research and Development

(1.) Identification of typical Aroclor isomers

(2.) Develop control for effluent composition

(3.) Test substitute formulations, etc.

(4.) Develop new processes

b. Clean Up Plants

c. Modify processes to meet market needs

3. Engineering

a. Develop and set up on plant locations incineration systems

b. Design new processing equipment as necessary

4. Marketing

a. Specify alternates or changes

b. Customer-liaison

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c. Set reclaim or disposal of fluids

d. Work on name association problems

5. Patent

Investigate trademarks registered

Cover with patents any work felt patentable

6. Environmental Control

Develop cheap disposal systems for customers

a. Incineration or pyrolysis

b. Biodegradation unit etc.

c. Consultants in pollution control

7. Legal

Investigate and define our position on Royalty secrecy agreements.

Contracts - Raw Material and Customer

8. Public Relations

Portray to public positive actions at correcting the contamination problem. Release periodical statements covering our position.

XIII. Probability of Success

STR 021956

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XIV. Cost of Program

Neither the program nor the costs have been clearly defined at this tim
However, a cost estimate of $220,000 for toxicological work alone has
been presented. Tentative figures indicated under the worst conditions
the entire program could run as high as $2.0-2.5M. At this stage it is
very difficult if not impossible to develop a reasonable cost figure bu
one point is clear it will be larger than the normal research budget ca
handle. For this reason, assuming the approach is acceptable, we shall
be forced to ask for additional appropriations to fund the program.

XV. Future

Follow developments on the problem as they unfold.

Develop an aggressive research program to confirm or deny findings and
better understand the problem.

Develop costs for the duplementation of the Recommended course of
action.

Develop specific actions with each department involved

Submit the actions with costs for approval

Develop a timetable to solve the overall problem.

Prepare for "precipitious pullout" or drastic legislative action althc
we do not feel this is a likely possibility.

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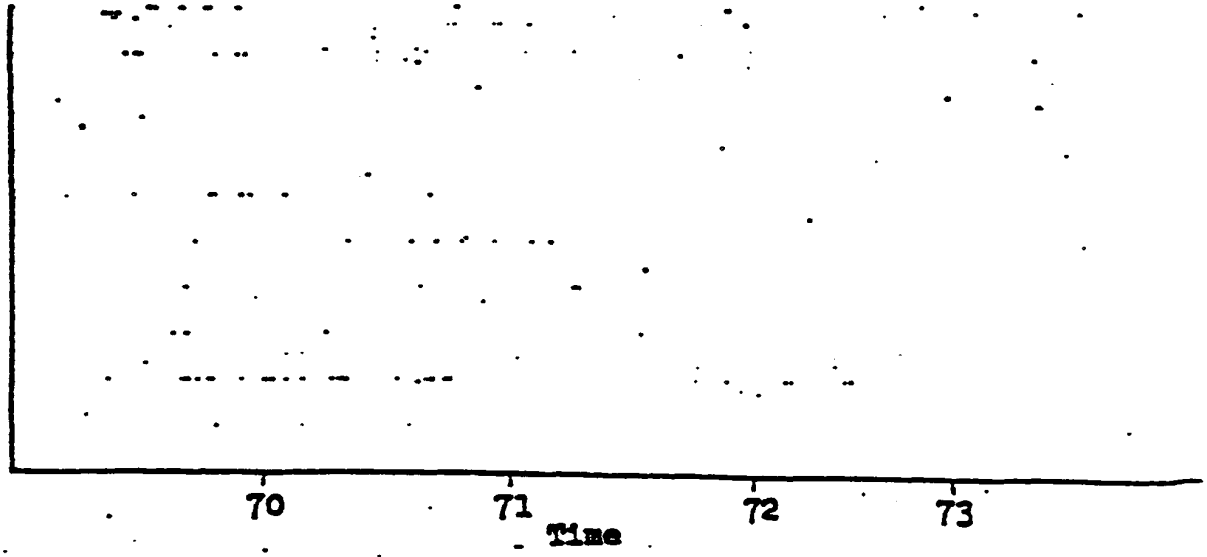
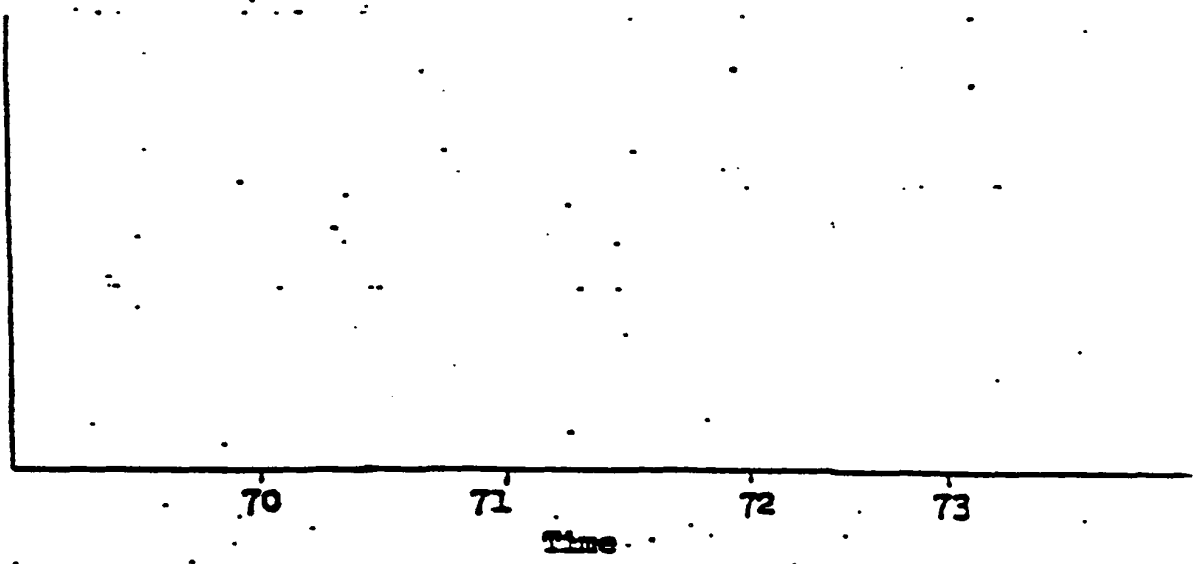
PROFIT AND LIABILITY VS. TIME

CTION

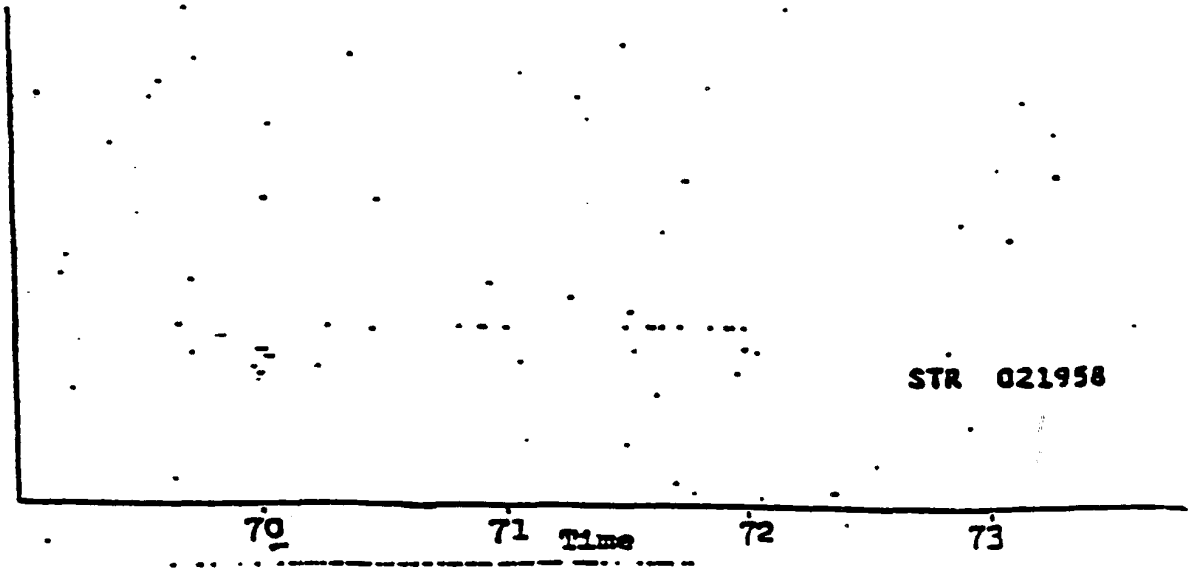
DO NOTHING



DISCONTINUE MANUFACTURE OF PCB



RESPONSIBLE APPROACH



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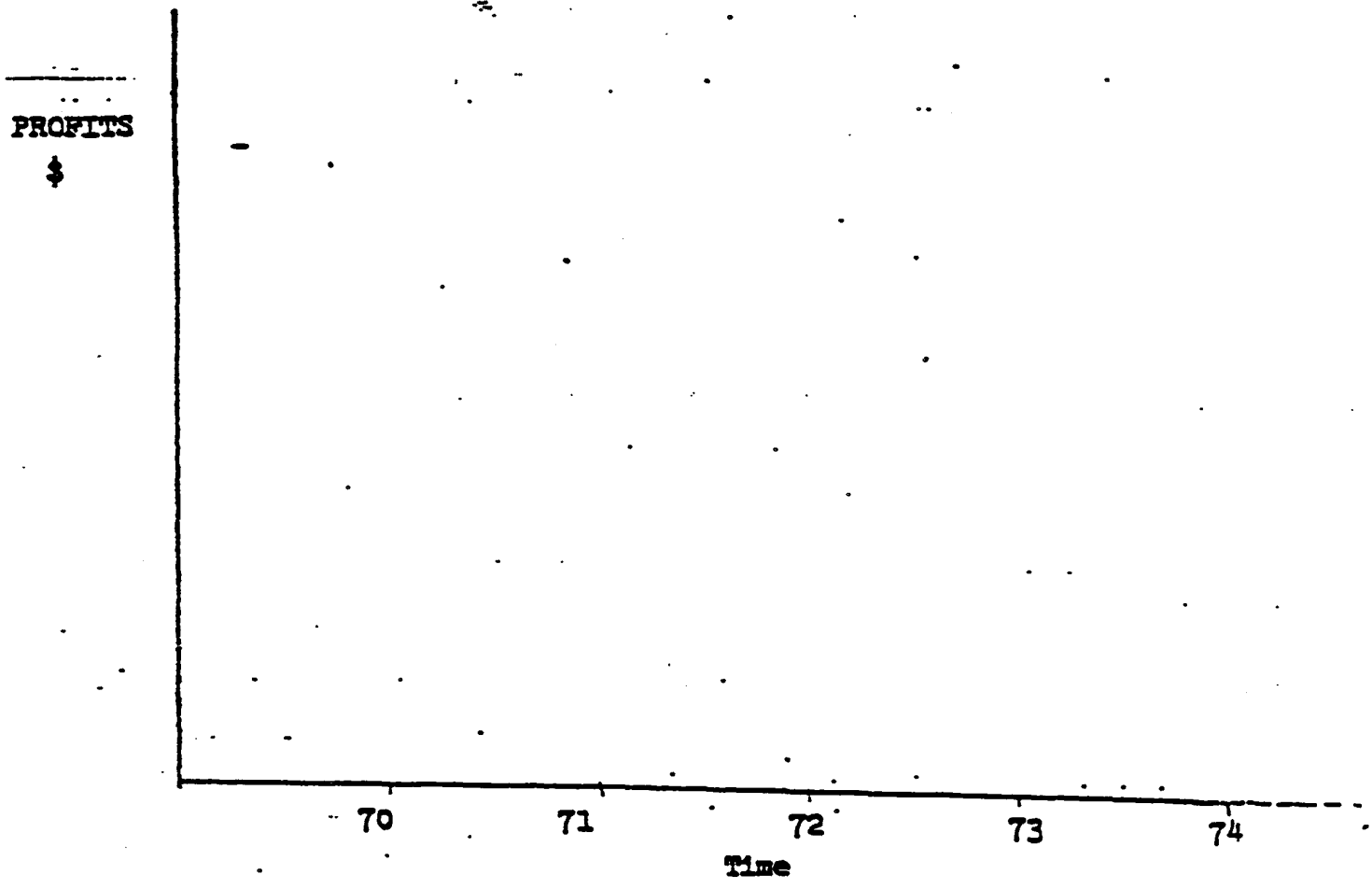
PROBABILITY OF SUCCESS



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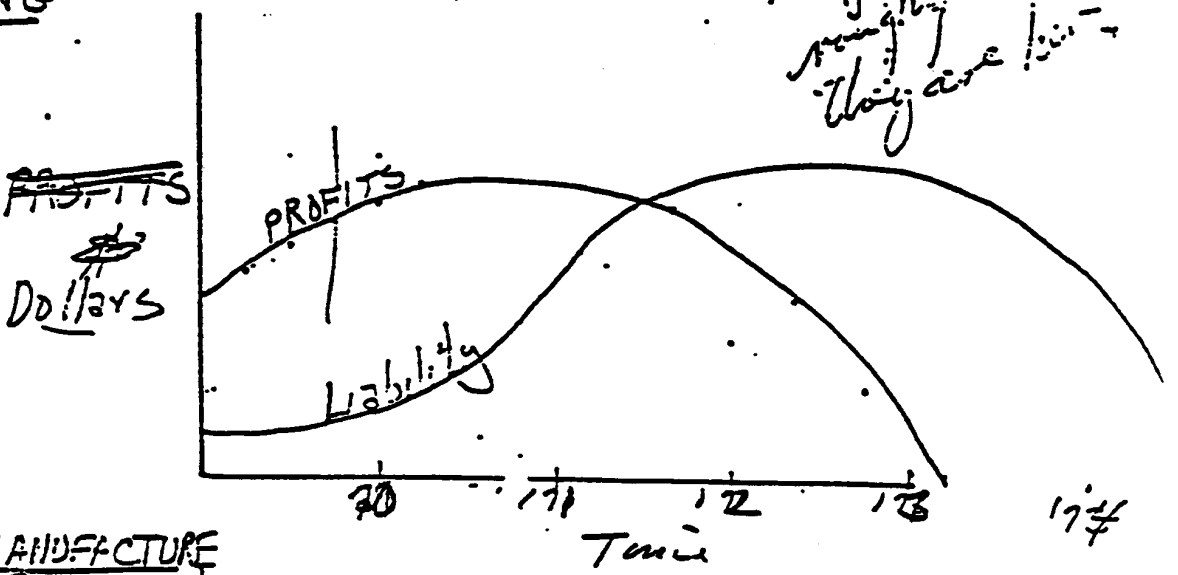
PROFIT AND LIABILITY VS TIME

ACTION

DO NOTHING



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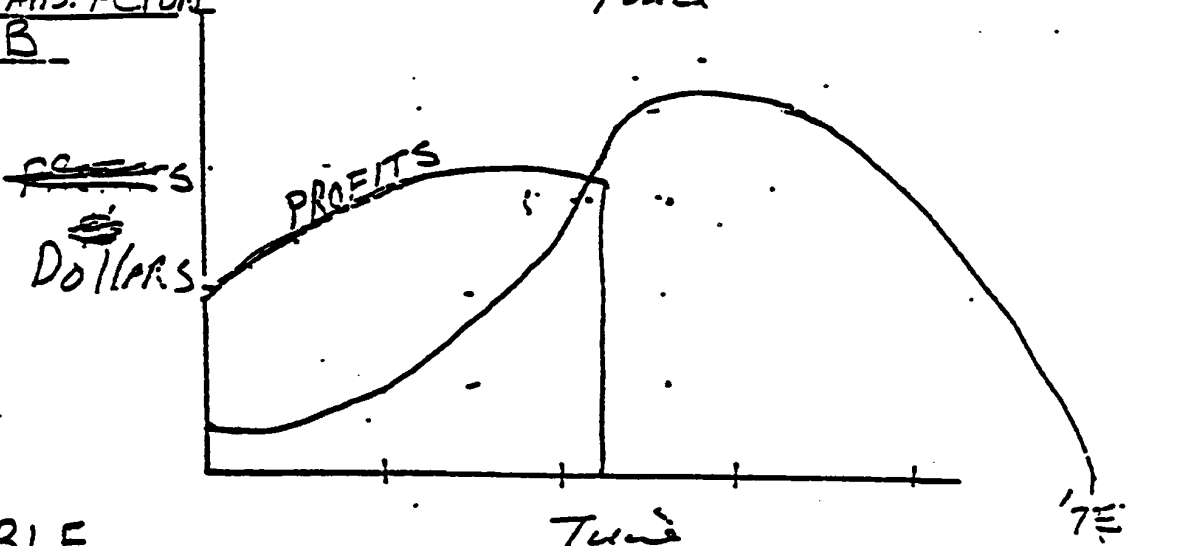

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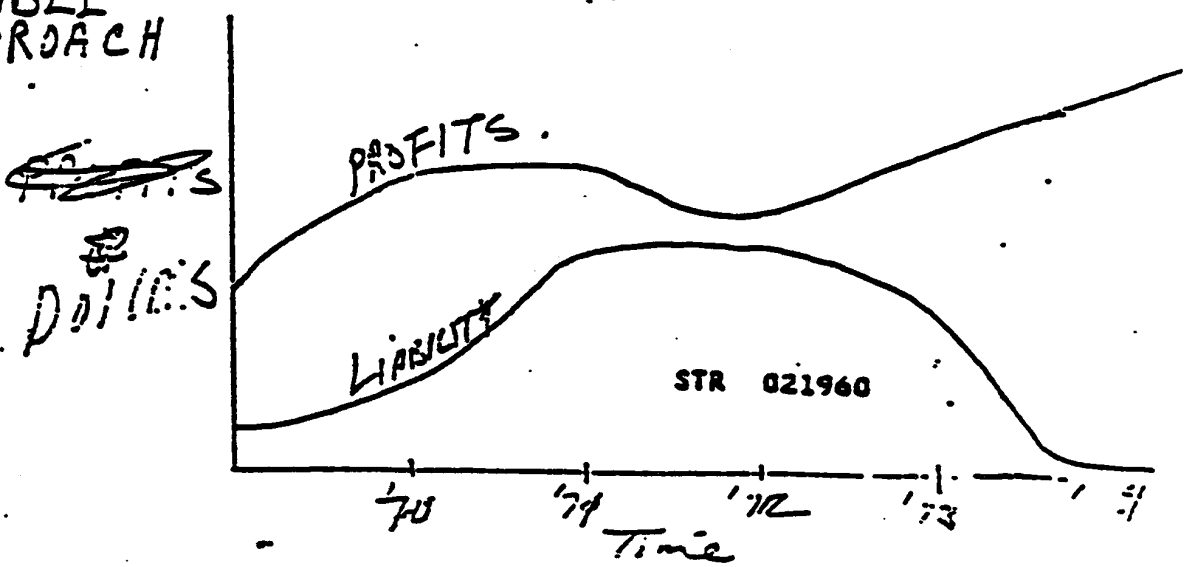

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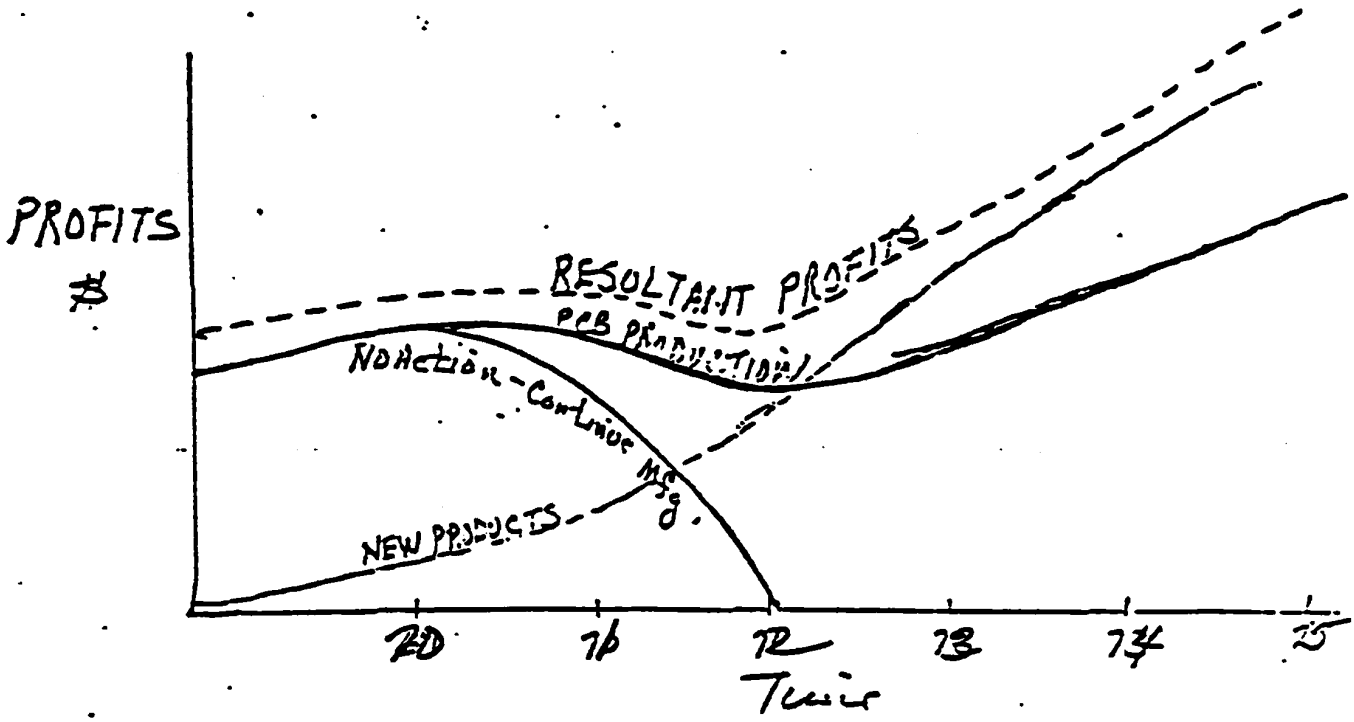
PROBABILITY OF SUCCESS



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PRE-1972 KNOWLEDGE OF NONHUMAN EFFECTS OF POLYCHLORINATED BIPHENYLS

Charles R. Walker*

Abstract

Research conducted worldwide on the effects of PCB on aquatic organisms, birds, and mammals is herein summarized. The ecological effects of PCB are still not fully understood, nor is the long-term impact of PCB on animal populations. It is known that PCB are highly persistent contaminants that bioaccumulate in the food chain. They produce both chronic and acute effects on the growth, reproduction, and behavior of fish, birds, and mammals. Of these, freshwater fish accumulate PCB to the greatest extent. The birds and mammals that feed on freshwater fish in turn take in hazardous amounts of PCB residues and become subject to their serious toxicological effects.

INTRODUCTION

Polychlorinated biphenyls were under investigative development as early as 1881 (Schmidt and Schultz) and yet very little knowledge of their toxic effects was evident until they had gained wide use during the 1930's and pathological studies on laboratory animals were conducted (refs. 5,41). These polychlorinated biphenyls, napthlenes, terpenes, etc., were marketed under a variety of trade names—Aroclor, Chlorphen, Kanechlor, Phenochlor—and a series of numerical synonyms such as we have become familiar with in Aroclors—1221, 1232, 1242, 1248, 1254, 1260, 1268, etc. (refs. 8, 33, 51).

Almost 20 years lapsed until McLaughlin et al. reported that Aroclor 1242 was highly toxic and produced teratogenic effects in chick embryo at low dosage levels (ref. 44). Many studies were initiated at about this time, when analytical chemists monitoring environmental components observed a number of unidentified peaks in gas chromatographic analysis that were most frequently associated with aquatic species of birds and fishes (refs. 3, 19, 20, 21, 22, 24, 25, 26, 27, 32, 33, 34, 45, 46, 48, 53, 54, 55, 56, 58, 59, 61, 64, 66, 67, 68, 83, 84, 85, 86, 88, 93, 94). The annual research reports by the U.S. Fish and Wildlife Service since 1969 gave technical details in the developments of our work on the toxicity of PCB and chlorinated hydrocarbon pesticides, which coincided with monitoring investigations of persistent chemicals such as DDT (refs. 3, 12, 16, 17, 38, 39, 40, 47, 52, 57, 71, 77, 78, 79, 80, 81, 82, 89, 90, 91, 92). The development of the silicic acid method allowed for the separation of PCB from other pesticide components and permitted detailed investigation of these environmental contaminants (refs. 1,71).

The December 1971 conference on polychlorinated biphenyls sponsored by the National Institute of Environmental Sciences at the Quail Roost Conference in Rougemont, North Carolina, provided full array of the effect of PCB on experimental animals, fish, and wildlife. The Fish and Wildlife Service National Pesticide Monitoring Program discussed at this conference concentrations of PCB in fish samples (ref. 89). These residue levels were confirmed in the cross-check analysis by the Fish Pesticide Research Laboratory, which in turn has spurred more toxicological research into the significance of these residues (refs. 18, 40, 71, 74, 75, 76, 80).

EFFECTS ON AQUATIC ORGANISMS

Chronic and acute toxicity studies on aquatic organisms were conducted in which 96-hour LC_{50} values were determined for eight of the Aroclor series from 1221 through 1268 (refs. 40,71). The 96-hour LC values ranged from 1,170 to 50,000 mg/l for cutthroat trout (table 1) (refs. 40,71). In another test, the acute oral toxicities of Aroclors 1242, 1248, 1254, and 1260 were found to be greater than 1500 mg/kg in rainbow trout. Intermittent flow for Aroclors 1242, 1248, and 1254 indicated that these compounds were much more toxic at high temperatures and at longer exposure periods. Comparable results were obtained on channel catfish and rainbow trout (table 1) (refs. 40,71).

The effect of Aroclors on invertebrate forms gave an even wider distribution of effects (table 2) (refs. 40,69,71), with Aroclor 1248 being the most toxic to *Daphnia magna* and levels above 5 mg/l causing inhibition in reproduction (ref. 45). Similar results were obtained on *Gammarus pseudolimnaeus* (ref. 45). The 96-hour LC_{50} values for Aroclors 1248 and 1254 were 52 and 2400 mg/l respectively (ref. 40). Another species of scud (*Gammarus fasciatus*) was found to concentrate PCB by 27,000 times the exposure level compared to the *Daphnia*, which concentrated Aroclor 1254 by 48,000 times (figure 1) (ref. 40).

Both crayfish and the scud were found to be much more sensitive to Aroclor 1242, with the uptake being

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NOTE: Scientific names for fish and wildlife listed in text are given at the end of the paper.

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PLAINTIFF'S EXHIBIT 514

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Table 1. Toxicity of PCB to fish (refs. 40,71)

PCB	Invertebrate (species)	Bioassay method[1/]	Exposure time	LC_{50} (µg/g)
Aroclor 1242	Scud (Gammarus faciatus)	C	4	10.0
	Scud (Gammarus faciatus)	C	10	5.0
	Crayfish (Orconectes nais)	A	7	30.0
	Damselfly (Ischnura verticalis)	A	4	400.0
	Dragonfly (Macromia sp.)	A	7	800.0
Aroclor 1248	Scud (Gammarus faciatus)	A	4	52.0
Aroclor 1254	Scud (Gammarus faciatus)	A	4	2400.0
	Glass shrimp (Palaemonetes kadiakensis)	C	7	3.0
	Crayfish (Orconectes nais)	C	7	80.0
	Damselfly (Ischnura verticalis)	C	4	200.0
	Dragonfly (Macromia sp.)	A	7	100.0
2,4'-Dichloro-biphenyl	Scud (Gammarus pseudolimnaeus)	A	4	120.0
4,4'-Dichloro-biphenyl	Scud (Gammarus pseudolimnaeus)	A	4	100.0
2,3,4'-Trichloro-biphenyl	Scud (Gammarus pseudolimnaeus)	A	4	70.0
2,4,5,2',5'-Penta-chlorobiphenyl	Scud (Gammarus pseudolimnaeus)	A	4	210.0
2,4,6,2',4',6'-Hexa-chlorobiphenyl	Scud (Gammarus pseudolimnaeus)	A	4	150.0

1/ A = Acute toxicity by static test procedure
C = Chronic toxicity by flow-through procedure

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Table 2. Toxicity of PCB to aquatic invertebrates (refs. 40,69,71)

PCB (Aroclor)	Fish	Temp (°C)	Bioassay method[1/]	LC_{50} value in µg/l at exposure time of						
				4d	5d	10d	15d	20d	25d	30d
1221	Cutthroat trout	8.9	A	1170	--	--	--	--	--	--
1232	Cutthroat trout	8.9	A	2500	--	--	--	--	--	--
1242	Cutthroat trout	8.9	A	4530	--	--	--	--	--	--
	Rainbow trout	17.0	C	--	67	48	18	10	12	--
	Bluegill	20.0	C	--	154	72	54	--	--	--
	Bluegill	17.0	C	--	--	--	164	125	120	84
	Channel catfish	20.0	C	--	--	174	107	--	--	--
	Channel catfish	17.0	C	--	--	--	219	150	132	87
1248	Cutthroat trout	8.9	A	5750	--	--	--	--	--	--
	Rainbow trout	17.0	C	--	54	38	16	6.4	3.4	--
	Bluegill	18.3	A	278	--	--	--	--	--	--
	Bluegill	20.0	C	--	307	160	76	10	--	--
	Bluegill	17	C	--	136	115	111	106	100	78
	Channel catfish	18.3	A	6000	--	--	--	--	--	--
	Channel catfish	27.0	C	--	--	94	57	--	--	--
	Channel catfish	20.0	C	--	--	225	127	--	--	--
	Channel catfish	17.0	C	--	--	121	121	115	104	75
1254	Cutthroat trout	8.9	A	42500	--	--	--	--	--	--
	Rainbow trout	20.0	C	--	156	8	--	--	--	--
	Rainbow trout	17.0	C	--	--	160	64	39	27	--
	Bluegill	18.3	A	2740	--	--	--	--	--	--
	Bluegill	20.0	C	--	--	443	204	135	54	--
	Bluegill	17.0	C	--	--	--	303	260	239	177
	Channel catfish	18.3	A	12000	--	--	--	--	--	--
	Channel catfish	20.0	C	--	--	--	741	300	113	--
	Channel catfish	17.0	C	--	--	303	286	293	181	139
1260	Cutthroat trout	8.9	A	60900	--	--	--	--	--	--
	Rainbow trout	20.0	C	--	156	5	--	--	--	--
	Rainbow trout	17.0	C	--	--	326	143	78	49	51
	Bluegill	20.0	C	--	--	--	--	245	212	151
	Bluegill	17.0	C	--	--	--	--	--	--	400
	Channel catfish	20.0	C	--	--	--	--	296	166	137
	Channel catfish	17.0	C	--	--	535	482	512	465	433
1262	Cutthroat trout	8.9	A	50000	--	--	--	--	--	--
1268	Cutthroat trout	8.9	A	50000	--	--	--	--	--	--

1/ A= Acute toxicity by static test procedure.
C= Chronic toxicity by flow-through procedure.

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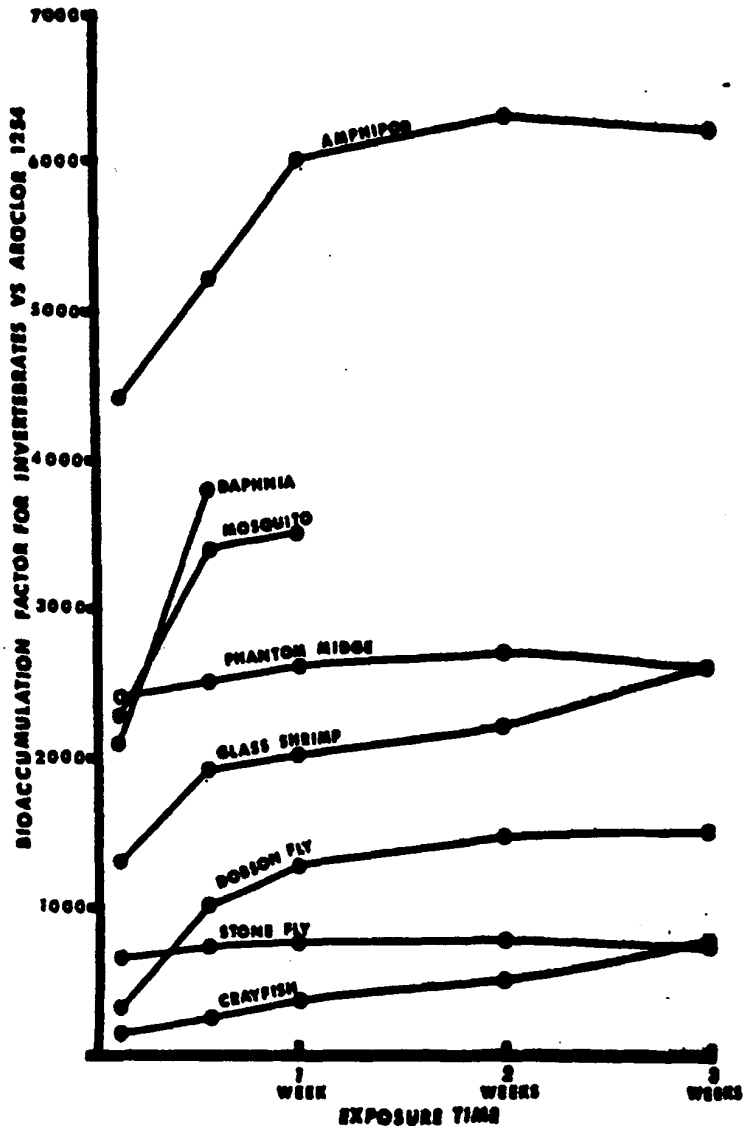

Figure 1. Bioaccumulation of Aroclor 1254 for various aquatic invertebrates exposed to water concentrations: 1.1 µg/l for *Daphnia magna*; 1.6 µg/l for *Gammarus pseudolimnaeus*; 1.2 µg/l for *Orconectes nais*; 1.3 µg/l for *Palaemontes kadiakensis*; 2.8 µg/l for *Pteronarcys dorsata*; 1.1 µg/l for *Corydalus cornutus*; 1.5 µg/l for *Culex tarsalis*; 1.3 µg/l for *Chaoborus punctipennis* (ref. 40).

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somewhat enhanced with time. Glass shrimp *(Palaemonetes kadiakensis)* were also found to be quite sensitive to Aroclor 1254, with an LC_{50} value of 3 mg/l in a 7-day exposure. On the other hand, dragon fly (*Macromia* species) and damsel fly (*Ischnura verticalis*) were a great deal more resistant to Aroclors 1254 and 1242 (table 1 and figure 1).

Aroclor 1254 was found to be extremely toxic to immature pink shrimp, of which more than 50 percent died within 15 days of continuous exposure to 0.94 mg/l (ref. 47). A similar concentration factor was noted for Aroclor 1254 in two estuarine fish species (*Lagondon rhomboides* and *Leiostomus xanthurus*). While between 14 and 45 days of exposure to 5 mg/l did product some mortality, the 1 mg/l during the same exposure time resulted in no mortality, but concentration of residues did occur at rates similar to those for freshwater fish—10,000 to 50,000 times the environmental levels (refs. 12,16).

In studies conducted in Sweden on salmon eggs, PCB residues on a lipid basis ranging from 7.7 to 34 μg/g caused mortalities between 16 to 100 percent (ref. 26). The regression analysis gave a coefficient of correlation of 0.85, with a significance of P = .001. PCB residues in these Atlantic salmon eggs on a wet weight basis were from 0.4 to 1.9 μg/g. This indicates that the threshold for egg mortality was about 0.5 μg/g PCB. Such residues would be comparable to whole fish residues of 2.5 to 5.0 μg/g or very close to those values found in many fish sampled in our National Pesticide Monitoring Program and in Sweden (refs. 6,89).

The oral toxicities of Aroclors 1242, 1248, 1254, and 1260 were found to be in excess of 1500 μg/kg for adult rainbow trout (ref. 40). However, trout fry from eggs containing 2.7 μg/g of Aroclor 1242 along with a DDT residue of 0.09 μg/g caused a 75 percent cumulative mortality 30 days after hatching (ref. 18). In five other groups of less contaminated eggs, 10 to 28 percent mortality was noted 30 days after hatching. About 60 to 70 percent of the fry that survived were deformed and teratology was evident. Generally speaking, the more chlorinated PCB were not as acutely toxic as the less chlorinated ones. For example, in cutthroat trout, Aroclors 1221, 1232, 1242, 1248, 1254, and 1260 had LC_{50} values for 96-hour exposure of 1.2, 2.5, 5.4, 5.7, 42, and 61 mg/l respectively.

In tests with individual homologs, toxicity decreases as the percentage of chlorine increases in amphipods against 5 PCB formulations (ref. 40). The dichlorobiphenyls and trichlorobiphenyls dominate the Aroclor 1242, whereas the trichlorobiphenyls and tetrachlorobiphenyls dominate in Aroclor 1248 and the pentachlorobiphenyls and hexachlorobiphenyls dominate in the Aroclor 1254. The most toxic PCB formulations appear to be those that contain 4 to 5 chlorine atoms; these predominated in Aroclor 1248, which was found to be the most toxic of all of the Aroclors tested on fish. A noticable shift in residue components following exposure to Aroclor 1254 was observed in experiments conducted on amphipods (ref. 71). An apparent twofold increase in concentration of less chlorinated isomers and homologs occurred in the trichlorobiphenyls and tetrachlorobiphenyls. The higher chlorinated pentachlorobiphenyls and hexachlorobiphenyls were decreased by half in experiments conducted on fish (ref. 40). Tests showed that residue accumulation of PCB in invertebrates ranged from 160 to 6,300 times that in water. In channel catfish, after 77 days of exposure, the concentration of Aroclors 1248 and 1254 accumulated in channel catfish to 56,270 and 61,190 times, respectively, than in water (figure 1). The more chlorinated components accumulated more than the less chlorinated ones, and upon termination of the exposure, PCB elimination by fish was more rapid for the less chlorinated components (refs. 40,71). The researchers also found evidence that the actual uptake is less or the turnover rate is more rapid in the invertebrates. This is in agreement with observations by other investigators (refs. 48, 64, 65, 66, 67).

In other experiments conducted by our Fish Pesticide Research Laboratory, we found that inclusion of Aroclor 1254 in fish food at the rate of 0.448 μg/g resulted in a 52 percent increase in fish thyroid activity. In a high-treatment group that received 480 μg/g, thyroid stimulation was 119 percent over that of the control group (figure 2) (ref. 40). In these tests we found that the lowest detectable stimulation thyroid activity occurred in salmon dosed at 1/1,000th the dosage that would cause mortality. This test was further duplicated in channel catfish with comparable results, which suggests that the laboratory studies may be realistic indicators of the physiological effects of PCB on fish and the aquatic environment (figure 3) (refs. 40,71). The true effects of thyroid stimulation, however, on respiration, carbohydrate metabolism, oxygen consumption, ammonia metabolism, osmoregulation, growth, oxidative phosphorylation, central nervous system function, and behavior of fish are yet to be determined. Nevertheless, we can postulate that these must be important and interrelated factors in the physiological and biochemical function of fish and any alteration of this normal function could effect fishes' ability to adapt to stress or such changes in the environment as salinity and temperature. The effect of environmental stress on the health of fish is very well illustrated by Snieszko (figure 4) (ref. 70). Subtle effects

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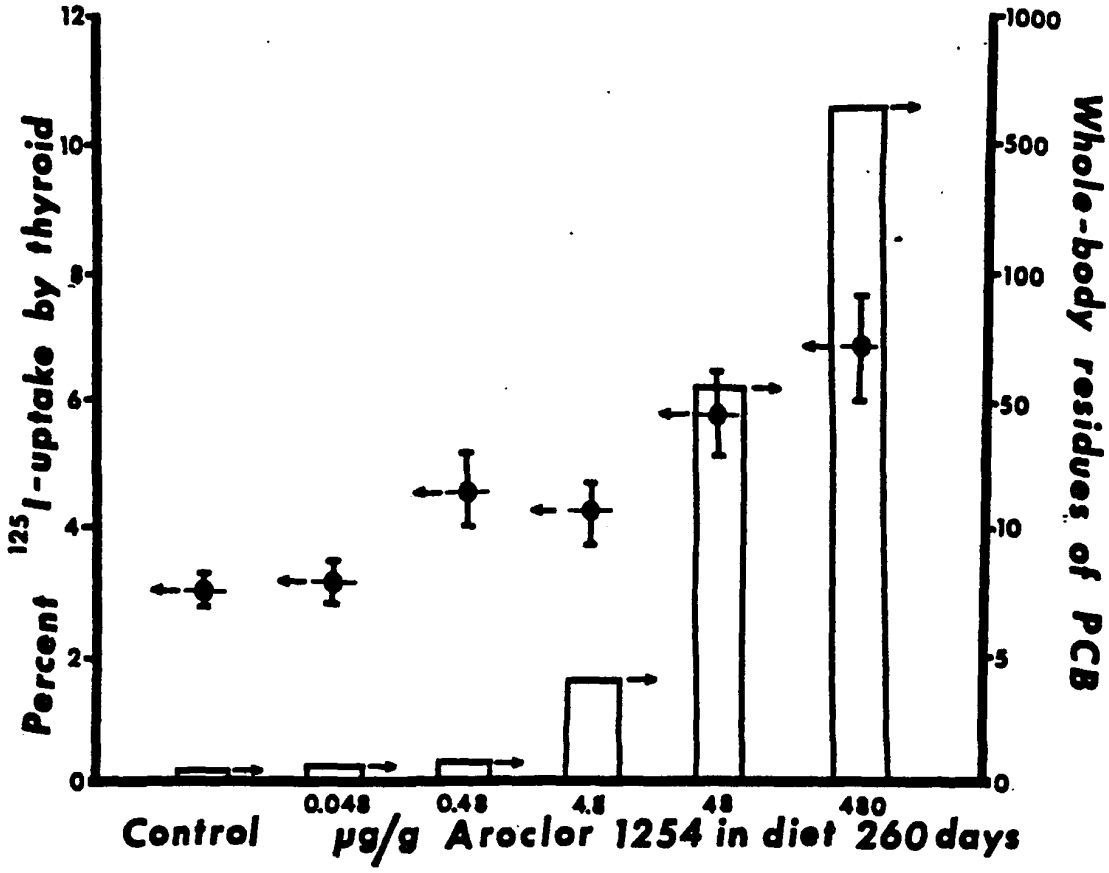

Figure 2. Whole-body residues and thyroidal uptake of ^{125}I in coho salmon fed diets containing Aroclor 1254 for 260 days (ref. 40).

on microflora, fauna, and plankton must also be investigated for potential impacts on trophic level ecology (refs. 29,30).

Enzymatic and compositional changes of the microsomes occur where possible lipids are concentrated in the membrane and manifestation of enzyme malfunction is suspect in the proximity of hydrophobic chlorinated aromatic hydrocarbons such as PCB, DDT, and other organochlorine pesticides that would accumulate (ref. 50). Meyer, Mehrle, and Sanders conducted experiments with incorporation of Aroclor 1248 into the diet of juvenile lake trout in concentrations of 0.2 to 6 mg/kg of food (ref. 40). These levels, comparable to those found in natural food, suppressed growth and serium cortisol levels, but stimulated thyroid activity during the first 180 days of the experiment (ref. 40). After 320 days, however, control and treated fish were similar.

Histopathological examination of fish exposed to Aroclor and chlordane showed a very high incidence of gill lesions after 6 months exposure; 6 percent of the PCB-treated fish were affected, compared to 15 percent after 9 months (refs. 76-78). Progressive and diffuse degeneration changes in liver were noted in 80 percent of the fish after 4 to 6 months exposure to the chlordane or PCB diet. A nonspecific degeneration of liver pyranchema and cytoplastic vaculation of liver cells occurred in addition to pleomorphism. The severity of liver tissue degeneration throughout the 6- to 9-month exposure period exceeded the controls by at least threefold. After this, we noted that focal areas in liver degeneration decreased in size and by the following year no liver lesions could be observed in this lot of fish. This observation was complemented by the decrease in severity of gill lesions in PCB-treated fish. The gill lesions also improved after 9 to 12 months of exposure and no significant difference between treated and control fish could be detected the following year.

In parallel experiments, whole-body residues had

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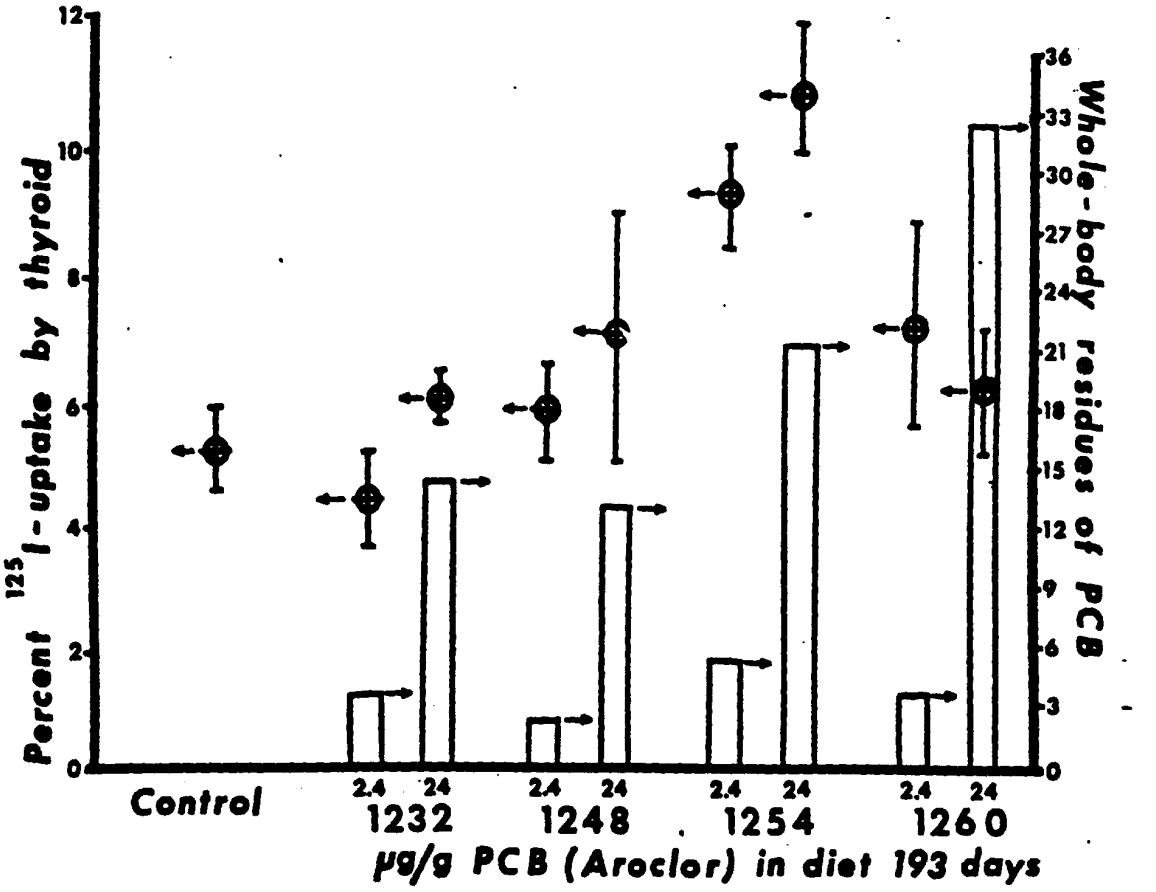

Figure 3. Whole-body residues and thyroidal uptake of ^{125}I in channel catfish fed diets containing Aroclors 1232, 1248, 1253, and 1260 for 193 days (ref. 40).

increased from 0.13 mg/kg at the lower dosage of 0.1 mg/kg in the food to a residue of 9.7 mg/kg at the higher food dosage 6 mg/kg after 320 days (ref. 40). After the trout were fed uncontaminated food for 60 days, the residues declined an average of 31 percent, 15 percent, and 12 percent in the 0.6-, 1.8-, and 6.0-mg/kg treatments respectively. Lake trout growth was retarded by the dietary intake of Aroclor 1248. These results suggest that although fish have a remarkable ability to recuperate and regenerate tissue, the extent and lethality of damage through intoxication by PCB are not clear. However, precise toxicological implication of Aroclors on the general well being and health of fish is certainly suspect (ref. 70).

EFFECTS ON BIRDS AND MAMMALS

Behavioral effects of organochlorine pesticides and PCB have been noted in the studies conducted on Japanese or coturnix quail fed sublethal concentrations and subjected to a simultaneous test for avoidance behavior by rapidly moving away from strange objects (refs. 79,82). This behavior appears in the very early stage of development of galinaceous chicks and is almost certainly essential to their survival in the wild. Seven-day-old coturnix chicks were given Aroclor 1254 in their diet for 8 days and in untreated food for 6 more days. Avoidance behavior was measured daily, and a group avoidance response was significantly suppressed by chlordane,

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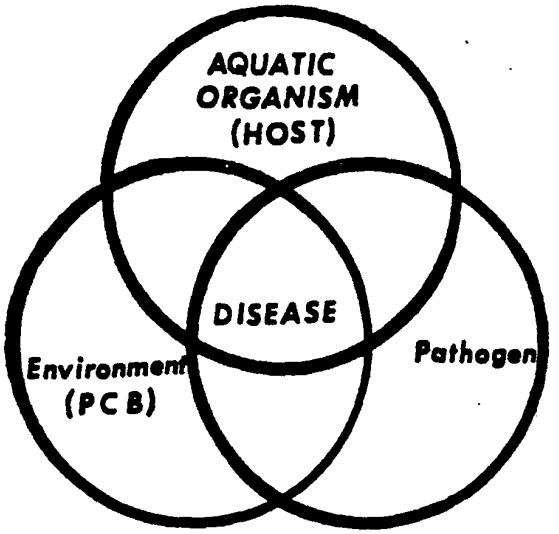

Figure 4. Relationship between environmental stress imposed by PCB and pesticides, susceptible host, and the disease organism as suggested by Sniezko (ref. 70).

dieldrin, and Aroclor 1254, although DDE had no apparent effect. Whereas the behavior of untreated birds returned to normal after 2 days on untreated feed, the response of chicks that were on dieldrin- and chlordane-treated feed improved somewhat during the 6 days of untreated food. However, the response of birds treated with Aroclor 1254 showed no improvement during the period.

Investigative monitoring for pesticide and PCB residues indicated that the highest residues occur in or near urban and industrialized areas. If these data are transferable to many other species of birds, we would expect to see the avoidance reaction suppressed, mortalities would increase from accidents, and predation would be maximized through the encroachment of man on the habitat of the species. The causes of mortality were subjected to autopsy study plus chemical analysis in studies conducted from 1969 through 1970 on 39 bald eagles found dead in various areas in the United States (refs. 42, 57, 79-82). The median residues of DDE in carcuses were 7 ppm in 1969 and 19 ppm in 1970, and mean residues of dieldrin were 0.4 ppm in 1969 and 0.7 ppm in 1970. Six of the eagles had dieldrin residues in the brain of 4.6 to 11 ppm, which is within the lethal range. One eagle contained 385 ppm of DDE and 235 ppm of PCB. In summary, environmental poisons were credited with 18 percent of the deaths, illegal shooting with 46 percent, accidents with 15 percent, natural disease with 8 percent, and miscellaneous and unknown causes with the remaining 13 percent.

In a survey to determine the degree of eggshell thinning and the extent of chemical contamination in aquatic birds in the Texas Coast area, eggs from 21 species were collected in 1971 (refs. 52, 78-80). Chemical analysis completed for 14 species showed that DDT in metabolites existed in all samples, whereas dieldrin residues were found in the Texas Rice Belt and the highest PCB residues were near urban and industrial areas again (ref. 79). The most noticably high PCB residues were found in some eggs of inland feeding species, including: double-crested cormorant (*Phalacrocorax auritus*), which contained 32 ppm; Caspian terns (*Hydroprogne caspia*), 16.5 ppm; and Foster terns (*Sterna forsteri*), 12.5 ppm (ref. 80). However, PCB were present in only 66 percent of the 158 eggs that were analyzed in another study conducted on ospreys (*Pandion haliaetus*) in the Gulf of California. During 1971, the residues of DDT were found to be generally low compared to those in osprey populations showing poor reproductive success in other parts of the range. PCB residues were detected in four of eight eggs and when present were higher than DDE residues; however, eggshell thinning was minor (averaging -3 percent), as expected from their low residues.

An experimental study on the absorption and metabolism of the PCB mixture Aroclor 1254 showed that all the components in the mixture were absorbed in essentially equal proportions from encapsulated dosages (ref. 81). The dietary dosage for quail of 300 ppm of Aroclor 1254 for 14 days followed by 14 or 42 days of untreated food showed that the various components of the Aroclor were excreted at greatly different rates. At the end of the 42 days of clean food, the PCB components changed entirely from the proportions of compounds that were originally fed to birds. Changes in patterns of gas chromatographic peaks that were detected militate against the dependable measurement of the quantities of PCB by gas chromatographic methods that can be related to the environmental or diet intake of the birds.

In another study, the combined effects of p,p'–DDE, and PCB were measured in mallard ducks. The ducks were fed diets containing 40 ppm of each chemical in the diet for 2 months prior to breeding and throughout the reproductive season (ref. 81). Average decreases in eggshell thickness were almost identical between the two compounds, with -17.5 percent for DDT only and -17.0 percent for DDE plus PCB in the diet (refs. 38, 79-80). No eggshell thinning occurred in birds fed PCB alone or in untreated diets except for a

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slight decrease in shell thickness near the end of the egg laying period. However, the birds fed the DDE-plus-PCB diet layed fewer eggs and egg production dropped off significantly 8 weeks before that of birds that were receiving other treatments. Egg breakage and egg eating were also highest in the DDE-plus-PCB groups and the combination of the chemicals seemed to increase the amount of egg loss through some effect—possibly on behavior. Therefore, overall production problems were most severe when PCB were fed in addition to the DDE.

In the Upper Great Lake States, 9 of 13 species of fish-eating birds were investigated in 1969-1970, and were found to sustain statistically significant decreases in eggshell thickness since 1946 (ref. 82). Maximum changes in thickness index occurred in great blue herons (-25 percent), red breasted mergansers (-23 percent), common mergansers (-15 percent) and double-crested comorants (-15 percent). Great blue heron eggs taken from Louisiana generally displayed smaller changes since 1946 than herons in the Midwest. On a lipid basis, mean PCB and DDE residue levels exceeded 100 ppm in seven of these species in the Lake States and one of seven species in Louisiana. The average DDE:PCB ratios in the two regions were 1.25:1 and 3.9:1 respectively. These ratios contrast with some around 0.3:1 previously reported in oceanic birds in the Bay of Fundy and with ratios of roughly 5:1 and 10:1 that were reported by others on the Pacific Coast. The relationship between shell thinning and DDE content of eggs was apparent for most species, but for herons DDE was the only compound correlated (ref. 52).

Partial correlation carried out on a somewhat questionable family basis showed that PCB also correlated with shell thinning in mergansers, in a study of chlorobiphenyl poisoning with formation of myelin figures in both mouse and monkey liver (ref. 49). Mice were subjected to daily dosages of .001 ml for 12-26 weeks and cornification of smooth surface membranes of the cytoplasmic reticulum was observed (ref. 50). This was also accompanied by a displacement of rough surface membranes and endoplasmic proliferation and an increase in microbodies, lyosomes, and lipid content. Similar observations were made in the squirrel monkey from dosages of 320 mg given over 46 days. Liver enlargement was noted but the main cause of death was attributed to penumonia or diarrhea (ref. 49). A similar experiment was run on the cynomolgus monkey, which received 641 mg in 40 days to 348 mg in 239 days with very similar results (ref. 49). Sublethal effects of hepatic enzyme induction were correlated with the breakdown of estradiol and the increase in cytoplasmic RNA in kestrels fed 0.5 to 5.0 ppm of Aroclors 1254 or 1262 for 6 months (ref. 53).

The effects of polychlorinated biphenyls and organochlorine pesticides appear to be manifested in the alteration of enzyme and hormone biochemistry. In unpublished work by Street and his coworkers, Vos reported that in inductions of hepatic microsomal enzymes, the sleeping time of experimental animals was decreased after treatment with hexobarbitol. An enhancement of in vitro rates of aniline hydroxylation and para-nitroanisole demethylations occurred in direct proportion to an increase to chlorine content of different PCB isomers in Aroclors 1221 through 1268 (ref. 86). PCB preparation of Aroclor 1221 and Aroclor 1254 at 1 and 10 mg/kg for 28 days in pregnant rabbits resulted in liver enlargement with increased activity of drug metabolizing enzymes aniline hydroxylase and aminopyrine n-demethylase at the rate of 10 mg/kg of Aroclor 1254, while no effects could be measured at the other levels and with the other levels and with the other Aroclors (ref. 86).

Vos conducted an extensive review of toxicity of PCB for mammals and birds (ref. 86). He concluded that PCB's have several sublethal effects, such as microsomal enzyme induction, porphyrogenic action, estrogenic activity, and immunosuppression. Aroclor 1254 administered to rabbits during the first 28 days of gestation had embryo-toxic effects at levels of 12.5, 25, and 50 mg/kg of body weight, which demonstrates the direct effects on microsomal enzyme activity in pregnant rabbits (ref. 77). In previously cited work by McLaughlin (ref. 44), edema and beak deformities in chicken embryos have been described after yoke sac-injection of 10 and 25 mg of Aroclor 1242 resulted in a 95 and 100 percent embryonic mortality respectively. PCB have also been found to cause neural pathology in rats when administered at a rate of 0.3 to 0.5 ml/kg per day for 14 or 21 days. The pathology is characterized by impairment of motor function and decreased motor velocity with loss of large nerve fibers (ref. 76).

A high dose of Aroclor was required before liver necrosis developed in chickens (ref. 88). Moderate dosages in rabbits produce mottled liver with subacute yellow atrophy and fatty degeneration with marked necrosis at dosage rates of 0.3 and 0.6 g/day, but 0.9 g/day caused death before liver pathology developed (refs. 86,87). Miller (1944) observed 100 percent mortality between 17 and 96 days with similar skin applications of 34.5 mg during an 11-day period caused 100 percent mortality within 28 days while on treatment (ref. 41). Central atrophy of liver cells occurred, with perinuclear basophilic granulation and focal necrosis occurring in a few of the animals.

Nichizumi (1970) utilized light and electron microscopy to confirm the formation of so-called myelin figures in mouse liver associated with a minimum effec-

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tive dose of 5 mg/kg of a 48% chlorine PCB (refs. 73,88). Japanese quail demonstrated porphyrogenic action when dosed with PCB for 7 days at dosage rates of 1 to 100 mg/kg of Aroclor 1260 (ref. 86). Nichizumi measured the formation of aminoevulinic acid by liver mitochondria; significant increases of greater than 10.5 to 120 m/moles ALA per gram of liver per hour were found. PCB concentrations in the liver ranged from 1.4 to 478 ppm between the 1 mg/kg and 100 mg/kg dosage rates. The most marked effect was noted at the 100 mg/kg dosage rate, in which microscopic tissue fluorescence was seen in three out of five cases and two out of five cases respectively.

Domestic chickens demonstrate an acute susceptibility to Aroclor intoxification; liver enlargement occurs at dosages ranging from 100-1,000 ppm of Aroclor 1242 and mortality occurs at rates above 200 ppm (ref. 88). However, Aroclor 1258 causes mortality at dosages above 100 ppm and partial mortalitites at dosages above 30 ppm when fed in a diet for 4 to 5 weeks. One hundred percent mortality occurs in chickens fed Aroclor 1254 above 250 ppm. Pathologically, clinical observations demonstrate that general edema occurs at all toxic dosages (refs. 7, 10, 35, 43, 55, 56). Internal haemorrhaging and tubular dilatation in kidneys are accompanied by enlargement of the kidneys, in addition to defeathering and dermatitis (refs. 86,88). Depression and secondary sexual characteristics occurred at levels as low as 30 ppm of Aroclor 1248 (ref. 7).

Sublethal effects caused by enzyme induction and increased steroid metabolism have been demonstrated in pigeons. American kestrels fed Aroclor 1254 and 1262 at levels of 0.5 and 5 ppm for 5 months affected hormone metabolism (refs. 53, 66, 67). In an interaction of polychlorinated biphenyls and duck hepatitis virus, 10-day-old ducklings fed Aroclor 1254 at levels of 25, 50 and 100 ppm had significantly higher mortality than those birds not exposed to PCB (ref. 13). Vos and Koeman (1970) found direct effects on the lymphoid system in chickens (ref. 88). Peakall and Lincer (1972) observed embryonic mortality and chromosomal aberrations in ring doves fed Aroclor 1254 at 10 ppm over two generations (ref. 54). They found that 13 of 17 PCB-treated embryos had aberration rates exceeding the mean control. Results thus indicate possible clastogenic (i.e., chromosome-breaking) action of PCB in dove embryos. Eggshell thinning was not observed in either the first or second generation. Dahlgren et al. observed that pheasant fertility and eggshell thickness were not affected by PCB exposure (ref. 10). The chief effects on reproduction occurred through PCB taken in by the hen but not by the cock. In laying pheasant hens, the major effects were observed in egg production, hatchability, and viability of the embryo. There also was a subtle effect on behavior, as the visual cliff and ability of offspring to avoid hand capture was adversely affected.

Among the most profound demonstrations of the adverse effects of PCB was the inhibition of mink reproduction that was caused by feeding them coho salmon containing PCB residues (refs. 2, 62, 63).

CONCLUSIONS

Polychlorinated biphenyls are highly persistent environmental contaminants that bioaccumulate in food chains and produce direct acute and chronic effects as well as subtle impact on the growth, reproduction, behavior, and health of fish, birds, and mammals. Freshwater fish are particularly susceptible to chronic effects since PCB residues concentrate at high levels that are known to elicit serious toxicological effects. Fish-eating birds and mammals are thus subject to hazardous levels of residues. However, the actual mode of action and ecological effects are poorly understood, as is the long-term impact of PCB on animal populations.

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SCIENTIFIC NAMES

Cutthroat trout (*Salmo clarki*); rainbow trout (*Salmo gairdneri*); *Atlantic salmon* (*Salmo salar*); coho salmon (*Oncorhynchus kisutch*); lake trout (*Salvelinus namaycush*); Japanese or coturnix quail (*Coturnix cotumin*); bald eagle (*Haliaeetus leucocephalus*); double-crested cormorant (*Phalacrocorax auritus*); caspian tern (*Hydroprogne caspia*); Fosters tern (*Sterna fosteri*); osprey (*Pandion haliaetus*); mallard duck (*Anus platyrhynchos*); great blue herons (*Ardeo herodias*); red breasted merganser (*Mergus serratus*); common merganser (*Mergus merganser*); American kestrel (*Falco sparverius*); ring dove (*Staptopelia risoria*); pigeon (*Columba livia*); pheasant (*Phasianus colchicus*); squirrel monkey (*Saimiri*

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sciureus); cynomolgus monkey (*Macaca sp.*); mink (*Mustela vison*).

REFERENCES

1. J. A. Armour and J. A. Burke, "Method for Separating Polychlorinated Biphenyls From DDT and Its Analogs," *J. Assoc. Official Anal. Chem.*, Vol. 53, No. 4 (1970), pp. 761-768.
2. R. J. Aulerich, "Effects on Feeding Coho Salmon and Other Great Lakes Fish on Mink Reproduction," *Canadian Zool.*, Vol. 49 (1971), p. 611.
3. G. E. Bagley, W. I. Reichel, and E. Cromarie, "Identification of Polychlorinated Biphenyls in Two Bald Eagles by Combined Gas-Liquid Chromatography-Mass Spectrometry," *J. Assoc. Official Anal. Chem.*, Vol. 53 (1970), pp. 251-261.
4. S. Bailey and P. J. Bunyan, "Interpretation of Persistence and Effects of Polychlorinated Biphenyls in Birds," *Nature*, Vol. 236, No. 5340 (1972), pp. 34-36.
5. G. A. Bennett, C. K. Dinker, and M. F. Warren, "Morphological Changes in the Livers of Rats Resulting From Exposure to Certain Chlorinated Hydrocarbons," *J. Indust. Hyg.. Toxicol.*, Vol. 20 (1938), p. 97.
6. Fredrick Berglund, "Levels of Polychlorinated Biphenyls in Foods in Sweden," *Environ. Health Perspectives*, No. 1, DHEW, Nat. Inst. Environ. Health Sci., (1972), pp. 67-72.
7. Joel Bitman, Helene C. Cecil, and S. J. Harris, "Biological Effects of Polychlorinated Biphenyls in Rats and Quail," *Environ. Health Perspectives*, No. 1, DHEW, Nat. Inst. Environ. Health Sci., (1972), pp. 145-149.
8. J. William Cook, "Some Chemical Aspects of Polychlorinated Biphenyls (PCB)," *Environ. Health Perspectives*, No. 1, DHEW, Nat. Inst. Environ. Health Sci., (1972), pp. 165-168.
9. L. K. Cutkomp, H. H. Yap, D. Desaiah, and R. B. Koch, "The Sensitivity of Fish ATPase to Polychlorinated Biphenyls," *Environ. Health Perspectives*, No. 1, DHEW, Nat. Inst. Environ. Health Sci., (1972), pp. 165-168.
10. Robert B. Dahlgren, Raymond L. Linder, and C. W. Carlson, "Polychlorinated Biphenyls: Their Effects on Penned Pheasants," *Environ. Health Perspectives*, No. 1, DHEW, Nat. Inst. Environ. Health Sci., (1972), pp. 89-101.
11. E. J. Duda, "The Use of Chlorinated Polyphenyls to Increase the Effective Insecticidal Life of Lindane," *J. Econ. Entomol.*, Vol. 50 (1957), pp. 218-219.
12. T. W. Duke, J. I. Lowe, and A. J. Wilson, Jr., "A Polychlorinated Biphenyl (Aroclor 1254®) in the Water, Sediment, and Biota of Escambia Bay, Florida," *Bull. Environ. Contam. Toxicol.*, Vol. 5, No. 2 (1970), pp. 171-180.
13. M. Friend, and D. O. Trainer, "Polychlorinated Phenyl: Interaction With Duck Hepatitis Virus," *Science*, Vol. 170 (1970), p. 1314.
14. G. F. Fries "Polychlorinated Biphenyl Residues in Milk of Environmentally and Experimentally Contaminated Cows," *Environ. Health Perspectives*, No. 1, DHEW, Nat. Inst. Environ. Health Sci., (1972), pp. 55-59.
15. D. L. Grant, W. E. J. Phillips, and D. C. Villeneuve, "Metabolism of a Polychlorinated Biphenyl (Aroclor 1254) Mixture in the Rat," *Bull. Environ. Contam. Toxicol.*, Vol. 6 (1971), p. 102.
16. D. J. Hansen, J. I. Lowe, A. J. Wilson, Jr., and P. D. Wilson, "Chronic Toxicity, Uptake, and Retention of Aroclor® 1254 in Two Estuarine Fishes," *Bull. Environ. Contam. Toxicol.*, Vol. 6, No. 2 (1971), pp. 113-119.
17. D. J. Hansen, P. R. Parrish, and J. Forester, "Aroclor® 1016: Toxicity to and Uptake by Estuarine Animals," *Environ. Res.*, Vol. 7, No. 3 (1974), pp. 363-373.
18. J. W. Hogan and J. L. Brauhn, "Abnormal Rainbow Trout Fry From Eggs Containing High Residues of a PCB (Aroclor 1242)," *Progessive Fish Culturist*, 1974 (in press).
19. A. V. Holden, "Ineternational Cooperative Study of Organochlorine Pesticide Residues in Terrestrial and Aquatic Wildlife, 1967/1968," *Pesticides Monitoring J.*, Vol. 4, No. 3 (1970), pp. 117-135.
20. A. V. Holden and K. Marsden, "Organochlorine Pesticides in Seals and Porpoises," *Nature*, Vol. 216, No. 5122 (1967), pp. 1274-1276.
21. A. V. Holden and G. Topping, "Occurrence of Specific Pollutants in Fish in the Forth and Tay Estuaries," *Proc. R.S.E.* (B), Vol. 71, No. 14 (1972), pp. 189-194.
22. D. C. Holmes, J. H. Simmon, and J. O. G. Tatton, "Chlorinated Hydrocarbons in British Wildlife," *Nature*, Vol. 216 (1967), pp. 227-229.
23. I. Hornstein and W. N. Sullivan, "The Role of Chlorinated Polyphenyls in Improving Lindane Residues," *J. Econ. Entomol.*, Vol. 46 (1953), pp. 937-940.
24. S. Jensen, "A New Chemical Hazard," *New Sci.*, Vol. 32 (1966), p. 612.
25. S. Jensen, "Chlorinated Hydrocarbons in Fauna and Flora," *Grundfoerbattring*, Vol. 23, Special-nummer 5 (1970), pp. 81-84.
26. S. Jensen, N. Johansson, and M. Olsson, "PCB-

ADM 000574

WATER_PCB-SD0000073921

Indications of Effects on Salmon," *Swedish Salmon Research Institute. Report LFI MEDD*, July 19, 1970, p. 9.
27. S. Jensen, A. G. Johnels, M. Olsson, and G. Otterlind, "DDT and PCB in Marine Animals From Swedish Waters," *Nature*, Vol. 224 (1969), pp. 247-250.
28. S. Jensen and L. Renberg, "Contaminants in Pentachlorophenol: Chlorinated Dioxins and Predioxines (Chlorinated Hydroxy-Diphenylethers)," *Ambio.*, Vol. 1, No. 2 (1972), pp. 62-65.
29. Julian E. Keil, Charles D. Graber, Lamar E. Priester, and Samuel H. Sandiefer, "Polychlorinated Biphenyls (Aroclor 1242): Effects of Uptake on *E. coli* Growth," *Environ. Health Perspectives*, No. 1, DHEW, Nat. Inst. Environ. Health Sci., (1972), pp. 175-177.
30 J. E. Keil, L. E. Priester, and S. H. Sandifer, "Polychlorinated Biphenyl (Aroclor 1242): Effects of Uptake on Growth, Nucleic Acids, and Chlorophyll of a Marine Diatom," *Bull. Environmental Contam. Toxicol.*, Vol. 6 (1971), pp. 156-159.
31. W. B. Kinter, L. S. Merkens, Roth Janick, and A. M. Guarino, "Studies on the Mechanism of Toxicity of DDT and Polychlorinated Biphenyls (PCB's): Distruption of Osmoregulation in Marine Fish," *Environ. Health Perspectives*, No. 1, DHEW, Nat. Inst. Environ. Health Sci. (1972), pp. 169-173.
32. J. H. Koeman, A. A. G. Oskamp, J. Veen, E. Brouwer, J. Rooth, P. Zwart, E. V. D. Brock, and H. Van Genderen, "Insecticides as a Factor in the Mortality of the Sandwich Tern (*Sterna sandvicensis*)," preliminary communication *Meded. Rijksfac. Landbouwwetensch.*, Vol. 32 (1967), pp. 841-853.
33. J. H. Koeman, M. C. TenNoever de Brauw, and R. H. deVos, "Chlorinated Biphenyls in Fish, Mussels, and Birds From the River Rhine and the Netherlands Coastal Area," *Nature*, Vol. 221 (1969), pp. 1126-1128.
34. J. H. Koeman, J. A. J. Vink, and J. J. M. de Gocij, "Causes of Mortality in Birds of Prey and Owls in the Netherlands in the Winter of 1968-1969," *Ardea*, Vol. 57 (1969), pp. 67-76.
35. M. Kohanawa, "Poisoning Due to an Oily By-Product of Ricebran Similar to Chick Edema Disease. II. Tetrachlorodiphenyl as Toxic Substance," *Nat. Inst. Animal Health Quart.*, Vol. 9 (1969), p. 220.
36. Massanori Kuratsune and Yoshito Masuda, "Polychlorinated Biphenyls in Non-Carbon Copy Paper," *Environ. Health Perspective*, No. 1, DHEW, Nat. Inst. Environ. Health Sci., (1972), pp. 61-65.
37. Masanori Kuratsune, "An Abstract of Results of Laboratory Examinations of Patients With Yusho and of Animals Experiments," *Environ. Health Perspectives*, No. 1, DHEW, Nat. Inst. Environ. Health Sci., (1975), p. 129.
38. J. R. Longcore and B. M. Mulhern, "Organochlorine Pesticides and Polychlorinated Biphenyls in Black Duck Eggs From the United States and Canada—1971," *Pesticides Monitoring J.*, Vol. 7, No. 1 (1973), pp. 62-66.
39. J. I. Lowe, P. R. Parrish, J. M. Patrich, Jr., and J. Forester, "Effects of the Polychlorinated Biphenyl Aroclor® 1254 on the American Oyster *Crassostrea virginica*," *Mar. Biol.* (Berl.), Vol. 17, No. 3 (1972), pp. 209-214.
40. F. L. Meyer, P. M. Mehrle, and H. O. Sanders, "Residue Dynamics and Biological Effects of Polychlorinated Biphenyls in Aquatic Organisms," Proceedings of the 164th National Meeting of American Chemical Society, New York, N.Y., 1972.
41. J. W. Miller, "Pathologic Changes in Animals Exposed to a Commercial Chlorinated Diphenyl," *Public Health Rts.*, Vol. 54 (1944), p. 1085.
42. B. M. Mulhern, W. L. Reichel, L. N. Locke, T. G. Lamont, A. A. Belisle, E. Cromartie, G. E. Bagley, and R. M. Prouty, "Organochlorine Residues and Autopsy Data for Bald Eagles, 1969 and 1970," *Pesticides Monitoring J.*, Vol. 6, No. 3 (1970), pp. 133-138.
43. E. L. McCane, J. E. Savage, and B. L. O'Dell, "Hydropericardium and Ascites in Chicks Fed a Chlorinated Hydrocarbon," *Poultry Science*, Vol. 41 (1962), p. 295.
44. J. McLaughlin, Jr., G. P. Marliae, M. J. Verrett, M. K. Mutchler, and O. G. Fritzlaugh, "The Injection of Chemicals Into the Yolk Sac of Fertile Eggs Prior to Incubation as Toxicity Test," *Toxicol. Appl. Pharmacol.*, Vol. 5 (1963), pp. 760-771.
45. A. V. Nebeker and F. A. Puglisi, "Effect of Polychlorinated Biphenyls (PCB's) on Survival and Reproduction of *Daphnia, Gammarus*, and *Tanytarus*," *Trans. Amer. Fish. Soc.*, Vol. 103, No. 4 (1974), pp. 722-728.
46. A. V. Nebeker, F. A. Puglisi, and D. L. Defoe, "Effect of Polychlorinated Biphenyl Compounds on Survival and Reproduction of the Fathead Minnow and Flagfish," *Trans. Amer. Fish. Soc.*, Vol. 103, No. 3 (1974), pp. 567-568.
47. D. R. Nimmo, R. R. Blackman, A. J. Wilson, and J. Forester, "Toxicity and Distribution of Aroclor® 1254 in the Pink Shrimp, *Penaeus duorarum*," *Mar. Biol.* (Berl.), Vol. 11, No. 3 (1971), pp. 191-197.
48. Ian C. T. Nisbet and Adel F. Sarofim, "Rates and

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WATER_PCB-SD0000073922

Routes of Transport of PCB's in the Environment," *Environ. Health Perspectives*, No. 1, DHEW, Nat. Inst. Environ. Health Sci. (1972), pp. 21-38.

49. M. Nishizumi, "Light and Electron Microscope Study of Chlorobiphenyl Poisoning in Mouse and Monkey Liver," *Arch. Environ. Health*, Vol. 21 (1970), p. 620.
50. Norback and J. R. Allen, "Chlorinated Aromatic Hydrocarbon Induced Modifications of the Hepatic Endoplasmic Reticulum: Concentric Membrane Arrays," *Environ. Health Perspectives*, Experimental Issue No. 1, DHEW Pub. No. (NIH), DHEW, Nat. Inst. of Environ. Health Sci., Vols, 72-218 (1972), pp. 137-143.
51. M. Ogawa, "Electrophysiological and Histological Studies of Experimental Chlorobiphenyls Poisoning," *Fukuoka-Igaku-Zasshi (Acta Med.)*, Vol. 62 (1971), p. 74.
52. H. M. Ohlendorf, E. E. Klaas, and T. E. Kaiser, "Environmental Pollution in Relation to Estuarine Birds, *In* Survival in Toxic Environments," M. A. Q. Khan and J. P. Bederka, eds., Academic Press, New York, N.Y., (1974), pp. 53-81.
53. D. B. Peakall and J. L. Lincer, "Polychlorinated Biphenyls Another Long-Life Widespread Chemical in the Environment," *Bio. Science*, Vol. 20, No. 17 (1970), pp. 958-964.
54. David B. Peakall, Jeffery L. Lincer, and Stephen E. Bloom, "Embryonic Mortality and Chromosomal Alterations Caused by Aroclor 1254 in Ring Doves," *Environ. Health Perspectives*, No. 1, DHEW, Nat. Inst. Environ. Health Sci., (1972), pp. 103-104.
55. I. Prestt, "Organochlorine Pollution of Rivers and the Heron (*Ardea cinerea* L.)," IUCN Eleven Technical Meeting, Vol. I, pp. 95-102.
56. B. M. Rehfeld, R. L. Bradley, and M. L. Sunde, "Toxicity Studies on Polychlorinated Biphenyls in the Chick. I. Toxicity and Symptoms," *Poultry Science*, Vol. 50 (1971), p. 1090.
57. W. L. Reichel, E. Cromartie, T. G. Lamont, B. M. Mulhern, and R. M. Prouty, "Pesticide Residues in Eagles," *Pesticides Monitoring J.*, Vol. 3, No. 3 (1969), pp. 142-144.
58. L. M. Reynolds, "Polychlorinated Biphenyls (PCB's) and Their Interference With Pesticide Residue Analysis," *Bull. Environ. Contam. Toxicol.*, Vol. 4 (1969), pp. 128-143.
59. L. M. Reynolds, "Pesticide Residue Analysis in the Presence of Polychlorinated Biphenyls (PCB's) *In* Residues of Pesticides and Other Foreign Chemicals in Foods and Feeds," *Residue Reviews*, F. A. Gunther and J. D. Gunther, eds., Vol. 34 (1971), pp. 27-57.
60. K. S. Rhee and F. W. Plapp, Jr., "Polychlorinated Biphenyls (PCBs) as Inducers of Microsomal Enzyme Activity in the House Fly," *Archives of Environ. Contam. and Toxicol.*, Vol. 1, No. 2 (1973), pp. 182-192.
61. A. Richardson, J. Robinson, A. N. Crabtree, and M. K. Baldwin, "Residues of Polychlorinated Biphenyls in Biological Samples," *Pesticides Monitoring J.*, Vol. 4, No. 4 (1971), pp. 169-176.
62. R. K. Ringer, R. J. Aulerich, and M. Zabik, "Effect of Dietary Polychlorinated Biphenyls on Growth and Reproduction of Mink," Amer. Chem. Soc. Air, Water and Waste Division, New York, N.Y., Vol. 12 (1972), pp. 149-154.
63. R. Ringer, J. Johnson, and R. Hoopingarner, Interagency Meeting on PCBs, DHEW, 1971.
64. R. W. Risebrough, "Chlorinated Hydrocarbons in the Global Ecosystem," *Chemical Fallout*, G. G. Berg and M. W. Miller, eds., Charles C. Thomas, Springfield, Ill., 1969, p. 5-23.
65. Robert W. Risebrough and Brock DeLappe, "Accumulation of Polychlorinated Biphenyls in Ecosystems," *Environ. Health Perspectives*, No. 1, DHEW, Nat. Inst. Environ. Health Sci., (1972), pp. 39-45.
66. R. W. Risebrough, R. Reiche, D. B. Peakall, S. G. Herman, and M. N. Kirven, "Polychlorinated Biphenyls in the Global Ecosystem," *Nature*, Vol. 220 (1968), pp. 1098-1102.
67. R. W. Risebrough, P. Reiche, and H. S. Olcott, "Current Progress in the Determination of the Polychlorinated Biphenyls," *Bull. Environ. Contam. & Toxicol.*, Vol. 4, No. 4 (1969), pp. 192-201.
68. J. Roburn, "A Simple Concentration-Cell Technique for Determining Small Amounts of Halide Ions and Its Use in the Determination of Residues of Organochlorine Pesticides," *Analyst.*, Vol. 90 (1965), pp. 467-475.
69. H. O. Sanders and J. H. Chandler, "Biological Magnification of a Polychlorinated Biphenyl (Aroclor 1254) From Water by Aquatic Invertebrates," *Bull. Environ. Contam. & Toxicol.*, Vol. 7, No. 5 (1972), pp. 257-263.
70. S. F. Snieszko, "The Effects of Environmental Stress on Outbreaks of Infectious Diseases of Fishes," *J. Fish Biol.*, Vol. 6 (1974), pp. 197-208.
71. D. L. Stalling and F. L. Mayer, "Toxicities of PCB's to Fish and Environmental Residues," *Environ. Health Perspectives*, No. 1, DHEW, Nat. Inst. Environ. Health Sci., (1972), pp. 159-164.

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72. W. N. Sullivan and Hornstein "Chlorinated Polyphenyls to Improve Lindane Residues," *J. Econ. Entomol.*, Vol. 45 (1953), pp. 158-159.
73. K. Tanaka, "Experimental Subacute Poisoning by Chlorobiphenyls Particularly the Influence on the Serum Lipids in Rats," *Fukuoka-Igaku-Zasshi*, Vol. 60 (1969), p. 544.
74. G. H. Thomas and L. M. Reynolds, "Polychlorinated Biphenyls in Paperboard Samples," *Bull. Environ. Contam. and Toxicol.*, Vol. 10, No. 1 (1973), pp. 37-41.
75. Ching-Hsi Tsao, W. N. Sullivan, and I. Hornstein, "A Comparison of Evaporation Rates and Toxicity to House Flies of Lindane and Lindane-Chlorinated Polyphenyl Deposits," *J. Econ. Entomol.*, Vol. 46 (1953), pp. 882-884.
76. U.S.D.I., Bureau of Sport Fisheries and Wildlife, Div. of Fishery Research, *Progress in Sport Fishery Research, 1969*, U.S.D.I., B.S.F.W., Resource Publication 88, 1970, 284 pp.
77. U.S.D.I., Bureau of Sport Fisheries and Wildlife, Div. of Fishery Research, *Progress in Sport Fishery Research, 1970*, U.S.D.I., B.S.F.W., Resource Publication 106, 1971, 318 pp.
78. U.S.D.I., Bureau of Sport Fisheries and Wildlife, Div. of Fishery Research, *Progress in Sport Fishery Research, 1971*, U.S.D.I., B.S.F.W., Resource Publication 121, 1973, 157 pp.
79. U.S.D.I., Bureau of Sport Fisheries and Wildlife, Div. of Wildlife Research, *Wildlife Research 1969. Activities in the Division of Wildlife Research of the Bureau of Sport Fisheries and Wildlife for Calendar Year 1969*, U.S.D.I., B.S.F.W., Resource Publication 94, 1971, 104 pp.
80. U.S.D.I., Bureau of Sport Fisheries and Wildlife, Div. of Wildlife Research, *Wildlife Research Problems, Programs, Progress, 1970. Activities in the Division of Wildlife Research of the Bureau of Sport Fisheries and Wildlife for Calendar Year 1970*, U.S.D.I., B.S.F.W., Resource Publication 104, 1970.
81. U.S.D.I., Bureau of Sport Fisheries and Wildlife, Div. of Wildlife Research, *Wildlife Research, 1971. Activities in the Division of Wildlife Research of the Bureau of Sport Fisheries and Wildlife for Calendar Year 1971*, U.S.D.I., B.S.F.W., Resource Publication 111, 1972, 106 pp.
82. U.S.D.I., Bureau of Sport Fisheries and Wildlife, *Sport Fishery and Wildlife Research, 1972. Activities in the Division of Sport Fishery and Wildlife Research of the Bureau of Sport Fisheries and Wildlife for the Calendar Year 1972*, V. T. Harris and P. H. Eschmeyer, eds., 1974, 124 pp.
83. G. D. Veith, "Environmental Chemistry of the Chlorobiphenyls in the Milwaukee River," Univ. of Wis., Ph.D. thesis, 1970.
84. G. D. Veith and G. F. Lee, "A Review of Chlorinated Biphenyl Contamination in Natural Waters," *Water Research*, Vol. 4 (1970), pp. 265-269.
85. G. D. Veith, "Baseline Concentrations of Polychlorinated Biphenyls and DDT in Lake Michigan Fish, 1971," *Pesticides Monitoring J.*, Vol. 9, No. 1 (1975), pp. 21-29.
86. J. G. Vos, "Toxicology of PCBs for Mammals and for Birds," *Environ. Health Perspectives*, No. 1, DHEW, Nat. Inst. Environ. Health Sci., (1972), pp. 105-117.
87. J. G. Vos and R. B. Beems, "Dermal Toxicity Studies of Technical Polychlorinated Biphenyls and Fractions Thereof in Rabbits," *Toxicol. and Applied Pharmacol.*, Vol. 19 (1971), p. 617.
88. J. G. Vos and J. H. Koeman, "Comparative Toxicologic Study With Polychlorinated Biphenyl in Chickens With Special Reference to Porphyria, Edema Formation, Liver Necrosis, and Tissue Residues, *Toxicol. and Applied Pharmacol.*, Vol. 17 (1970), p. 656.
89. D. F. Walsh, "Organochlorine and Heavy Metals Detected in Fish—A Partial Review of the FWS Contribution to the National Pesticide Monitoring Program, 1967-1973," U.S.F.W.S. administrative report, Atlanta, Ga., 1975.
90. D. H. White and T. E. Kaiser, "Residues of Organochlorines and Heavy Metals in Ruddy Ducks From the Delaware River, 1973," Brief *Pesticides Monitoring J.* (in press).
91. D. H. White, "Nationwide Residues of Organochlorines in Starlings, 1972," *Pesticides Monitoring J.* (in press).
92. D. H. White and R. G. Heath, "Nationwide Residues of Organochlorines in Wings of Adult Mallards and Black Ducks" *Pesticides Monitoring J.* (in press).
93. G. Widmark, "Possible Interference by Chlorinated Biphenyls," *J. Assoc. Official Anal. Chem.*, Vol. 50 (1967), p. 1069.
94. V. Zitko, O. Hutzinger, and P. M. K. Choi, "Contamination of the Bay of Fundy-Gulf of Maine Area With Polychlorinated Biphenyls, Polychlorinated Terphenyls, Chlorinated Dibenzodioxins and Dibenzofurans," *Environ. Health Perspectives*, No. 1, DHEW, Nat. Inst. Environ. Health Sci., (1972), pp. 47-54.

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PCB ENVIRONMENTAL POLLUTION ABATEMENT PLAN

Introduction

On 15 October the "AD HOC" Committee consisting of Messrs. M. Farrar, P. Hodges, E. John, W. Richard, and E. Wheeler issued a report summarizing the polychlorinated biphenyl (PCB) pollution problems from the known available information to date. Out of this report came considerable information, conclusions, and recommendations which we have attempted to tie together into a plan of action in this document. Our objective has been to take a reasonable and responsible approach to the entire problem. Before we get into the problem, we should clarify the meaning of PCB, the nature of the entire line, and how these tie into our product line of Aroclors.



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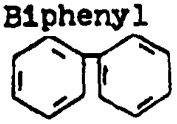
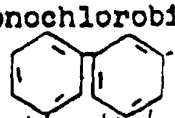
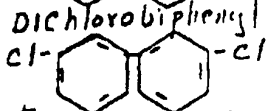
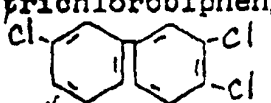
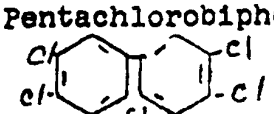
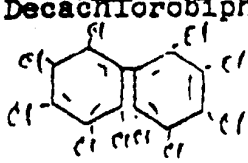
Monsanto entered the Aroclor market in 1930 by acquiring Swann Chemical ~~Electrical~~ Company or known today as our Anniston, Alabama plant. The first load of Aroclor which incidentally was Aroclor 1254 -- went out of Anniston, Alabama to GE in 1931: Since that time the market has grown to 170 to 200M# worldwide.

Chemical	Monsanto Product Line	Nature of Material at Ambient
Biphenyl  ~~Solid at~~ ~~Sublimes at~~		Solid
Monochlorobiphenyl 	Aroclor 1221	thin liquid (oil)
Dichlorobiphenyl 	Aroclor 1232	thin flush water
Trichlorobiphenyl 	Aroclor 1242	oily type fluid material
Quaterchlorobiphenyl 	Aroclor 1248	Thicker - transmissi oil
Pentachlorobiphenyl 	Aroclor 1254	Heavy-Molasses
Hexachlorobiphenyl 	Aroclor 1260	Thick - tar
Heptachlorobiphenyl 	Aroclor 1262	Very thick - liquid
Octchlorobiphenyl 	Aroclor 1268	Solid
Decachlorobiphenyl 	Aroclor 12715	Solid

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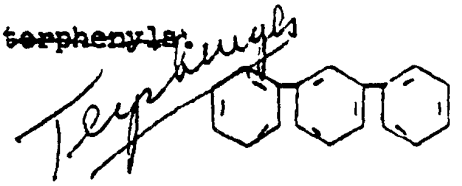
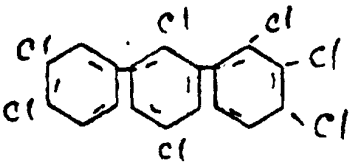
Total possibility are 210 theoretically possible chlorinated biphenyls

~~terphenyls~~



Santowax or terphenyl

Solid



Aroclor 5460

Solid

II. Problem

Damage to the ecological system by contamination from polychlorinated biphenyl (PCB).

III. Extensiveness

The problem involves the entire United States, Canada, and sections of Europe especially the United Kingdom and Sweden. As the investigation broadens other areas of Europe, Asia and Latin America will surely become involved. Evidence of contamination have been shown in some of the very remote parts of the world. The involvement could and most likely will follow the DDT investigations.

IV. Nature of the Problem

Professors Widmark and Jensen of the Institute of Analytical Chemistry at Stockholm, Sweden, in November 1966, announced and confirmed finding PCB in fish, birds, and eggs. Subsequent findings were made in 1967 in Great Britain. In February 1969, Professor Risebrough of the University of California published an article in the San Francisco Chronicle relaying his findings of PCB in the environment of the United States. Monsanto confirmed the presence of PCB's in mid-1969 and confirmed the adequacy of work by Widmark and Jensen and others; truly, the PCB's are a worldwide ecological problem.

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Analysis indicates the environmental presence of the 5 and higher chlorinated biphenyls which take the appearance of Aroclor 1254 and Aroclor 1260. We have strong indications that Aroclor 1242 or at le part of it degrades biologically. Since the Aroclor 1242 contains a 7 percent of the 5 chlorine biphenyl or higher we cannot rule out th possibility that the observations may be a concentration affect of t higher chlorinated biphenyls of Aroclor 1242.

4

To date ~~there~~ we have ~~been~~ no confirmed reports of finding Aroclor 1242 present i the environment (except ~~outside~~ in the effluent of our plants ~~where no Aroclor 1242 is present~~). streams and mud below our own plants at Anniston and Sauget

The seriousness of the problem can best be spelled out as follows:

1. Fish - Marine or aquatic species concentrate PCB in the fatty tissue. Toxic is small quantities (down to 5 ppb) to sensitive life such as shrimp.

2. Birds - Predatory species feeding on the marine or aquatic life further concentrate PCB to possible harmful effects. Specifical in birds PCB can affect the calcium metabolism leading to egg sh imperfections which prevents proper hatch of the young. In fact Monsanto has confirmed the eggshell by feeding chickens, a high order of the species, PCB's in controlled tests.

3. Man - There is no harmful effect known to man or other mammals af 40 years of production. Investigations are underway by various sources.

4. Political and Public Emotion - PCB's are falsely linked with DDT because PCB's show up in the analysis for DDT. PCB's are linked other permanent type chlorinated hydrocarbon pesticides. This becomes particularly serious since about every article of food in country is being examined for a trace of these materials.

5

More than 50 samples and [illegible]

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V. Effect on Monsanto

Business potential at stake on a worldwide basis:

Fluids	Plasticizers	Total/Year
70M lbs.	34M lbs.	104M lbs.
$16M	$6M	$22M
$6-8M G.P.	$2-3M G.P.	$8-11M G.P.

Already competition is using certain data against us in competitive situations.

A. Legal Liability

Direct lawsuits are possible. The materials are already present nature having done their "alleged damage". All customers using products have not been officially notified about known effects nc our labels carry this information. These are only a few of the possible legal implications which would best be covered by the legal department.

B. Public Image

The corporate image of Monsanto as a responsible member of the business world genuinely concerned with the welfare of our enviro ment will be adversely affected with increased publicity.

The evidence proving the persistence of these compounds and their universal presence as residues in the environment is beyond questioning. This combined with certain scare publications is ce to give an adverse image. Guilty association (with DDT) will pre- vail as the background while actual facts may be sparse.

C. Customer Relations

NEV 021440

Some customers who presently use these materials will be "scared c to other competitive products. Products associated with the same name or "trademark" will be adversely affected ie., Therminol, Pydraul and Aroclor. Competitors will use the information for an

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influence on Monsanto products.

Customers will seek other "outs" rather than become involved.

VI. Effect on Customers and Ultimate Consumers

One of the unique features of PCB's is their fire resistance. Here t basic decision whether to risk lives due to fire or risk extinction o some species of birds. In this case the PCB would probably be accept as a necessary pollutant and tolerated under controlled conditions.

A. Electrical Industry - Capacitors and Transformers use Aroclor because it is the best inexpensive dielectric fluid available.

B. Food Processing - Bulk "deep frying" units for potato chips, fish, and doughnuts use the fire resistance fluid as an indirect heatin medium.

C. Die Caster -- and other hot metal working industries fire resista fluids to protect the workers.

Affects a wide range of plastics and adhesives because the PCB serves as the plasticizer.

A wide range of paints and coatings are affected. The "Carbonles carbon paper used so widely would disappear.

VII. Involvement With Other Producers

Although Monsanto is most probably responsible for the U.S. contamina and jointly responsible with MCL for the United Kingdom problem, we cannot accept responsibility for the world. There are five known producers in the free world, several possible producers behind the ir curtain and couple of additional companies making overtures about entering the business. Monsanto representatives have on one occasion discussed this problem with a couple of these producers but they expressed no great concern. In fact, it is highly possible that one

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these manufacturers is dumping his waste into the Rhine River. Certa any action taken by one producer will most assuredly affect the other It is entirely possible that a joint plan of action could be develope but will most probably have to be spearheaded by Monsanto. It is als likely that producers of other chlorinated products used with PCB's will be dragged into the investigation.

VIII. Sources of Contamination

Although there may be some soil and air contamination involved, by fa the most critical problem at present is water contamination. To our knowledge to date the contamination can be broken down into two gener categories, open and indirect pollution.

A. Open Pollution - Our manufacturing facilities sewered a sizeable quantity of PCB's in a years time.

1. Fluids

Fluids are probably the most open source of pollution because their mobility. They also may be the least serious because t are generally the lower chlorinated materials.

2. Electrical

Electrical customers have in the past sewered their wastes.

3. Heat Transfer

Heat transfer customers have sewered their objectionable and their spilled material.

4. Industrial

These fluids have generally been sprayed into drains, washed down sewers and generally regarded as very harmless.

All of the fluids have had the "pink" constituent dumped on dirt roads a "dedusting agent" which inadvertently found its way back to the stream.

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5. Plastics

The plastics are not as mobile as the fluids so therefore th have not found and cannot find their way back to streams in pollution.

B. Indirect

Shipping containers and the cleaning thereof for subsequent use source of contamination.

1. Fluids

a. Electrical - Disposal of "burned out" transformer and capacitors may find its way back to streams. Scrap units (new) are generally disposed of in land fills but could possibly get back to the stream.

b. Heat Transfer - Leaks could contaminate.

c. Industrial - Cross product contamination carried out of a air compressor. Residual material carried on parts.

2. Plasticizers

a. Process Contamination from Washing

(1.) Environment Contamination

Swimming pool paints

Incineration of wax coatings

Traffic paints

(2.) Product Contamination

Coating for tank lining

Printing inks and paper coatings

Certain adhesives

NEV 021443

IX. Recent Technical Changes Which Have Bearing on the Contamination

A. Fluids

The sources of pollution were pointed out as they have been in the past because we are dealing with that quantity of material in the

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environment today which was deposited over the past forty years. We mustmust state that responsible people throughout the industry have taker corrective action to reduce contamination in the last two years. Ther have also been technical advances which have brought about the use of lower chlorinated biphenyls which may be an advantage because to date low chlorinated ones have not been identified present in nature.

1. Electrical - The large customers have established collect systems the waste is recovered. Incinerators are being investigated and built for the disposal of the materials. There has been a shift away from the higher chlorinated types products and could probabl shift almost entirely away from those products.
2. Heat Transfer - System have been tightened up and redesigned to confine the contents Here, too, the trend has been to shift away from the higher chlorinated materials.
3. Industrial - Settling ponds have been built by the large manufactu to catch the material and decant off the PCB for reprocessing. T trend here as the other fluid areas has been towards the lower chlorinated materials.
4. Plants - The plants effluent has been passed through limestone wh provides surface to catch some of the material. But high concentrations can be found in our effluent (that is relative to those findings in nature causing the problem).

B. Plasticizer

Quite opposite to fluids the trend in plasticizer Aroclor has been to higher chlorinated biphenyls. In plasticizers the lower chlorinated biphenyl will not be an acceptable solution however, the lower chlorir terphenyls could offer a possible solution.

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X. Courses of Action

A. Do Nothing

We cannot deny the findings and the acquisitions by the various agencies. If we took no action we would likely face numerous su: We would let government tolerances be based on public and political pressure along with any experimental or developed data which they may generate. We would most likely be forced out of this business. Other product areas would be adversely affected. We would project an image as an irresponsible member of the busir world. Project poor customer relations. The only advantage to t technique offers is it reduces the cost but this too must be weighed against potential loss of business.

B. Discontinue Manufacture of All Polychlorinated Biphenyls (PCB)

Although we all realize this could be an eventually unfortunately the solution is not this simple. Assuming we did stop manufactur immediately, the pollutants are present in the environment, the liability is present and possibly by the shifting to the lower chlorinated materials and the recovery techniques the contaminati may already be reduced to an acceptable level. Obviously the enti business would be lost without any or very few substitutes to be offered. Other product areas would be affected. Financial loss could be considered due to raw material contracts, customer contra and royalty -- secrecy contracts. Competition would take advantag on all fronts. We would be admitting guilt by our actions. Loss of capitol investment in the plant, associated utilities, and asse ciated processes. We would possibly gain a little public image on this action.

NEV 021445

C. Respond responsibly, admitting that there is growing evidence of environmental contamination by the higher chlorinated biphenyls anc take action as new data is generated to correct the problem.

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This approach would enable us to phase out the higher chlorinate materials in many applications where they are no longer necessar or really desired. Wecould maximize the corporate image by publicizing this act. We would reduce a known pollutant. Additionally we could gain precious time needed to develop new products and investigate further the lower chlorinated materials As new research data is generated our course may be altered considerably. Certain limited actions may reduce or limit the problem.

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XI. Recommended Course of Action

Based on the information available today the only recommendation we c honestly make is respond responsibly admitting that there is growing evidence of environmental contamination by the higher chlorinated biphenyls and take action as new data is generated to correct the problem.

XII. Implementation of the Recommended Course of Action

A. Immediate (By 12-1-69)

1. Set up a task force under a project manager or the equivalent responsible for initiating, directing and implementing all act that Monsanto decides to take. This includes sufficient budge necessary to cope with the immediate problems. This task forc should include representatives from Medical, Legal, Research and the two involved Marketing Groups and Public Relations and must conduct liaison with MCL and other locations involved in the problem.

2. Decide on timing and content of any public and/or customer not cation of PCB problem.

B. Interim (Within 3 months)

Fluids	Plasticizers
1. Confirm Aroclor 1254/Aroclor 1260 are found in the environment.	1. Announce differential betwee fluids/plasticizer uses.
2. Publicize the difficult anal. tasks.	2. Announce safety of other PCE chlorinated terphenyl.
3. Protect other PCB/chl. terph.	3. Educate customers on control effluent for all products.
4. Announce plans to reformulate certain Therminols and Pydraul where control of the product is difficult.	4. Initiate program to develop 1254 & 1260 substitutes

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5. Emphasize better control over other Aroclor 1254 & 1260 uses.

5. Investigate with manufact the feasibility of altern products.

6. Initiate customer education or need for effluent control of all products.

~~6. Analyze 1242~~

7. Determine composition of all PCB's.

Develop a comprehensive Program

C. Short Term (within the next 12 months)

1. Research - Expand program for more meaningful biodegradation Medical studies and confirming analytical results. Expand toxicity studies. Follow developments concerning publicity and those developments covering politica implications of PCB contamination.

2. Marketing - Discontinue or substitute replacement products fc those applications of Aroclors 1254 and 1260 where the Aroclc remains mobile.

Work with customers to clean up plants on other Aroclors. Report the habitual violators or "do nothings" to the product group.

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Reclaim or safely dispose of fluids.

Consider renaming products that do not contain PCB. Follow ar report market developments such as customer disposal systems. Follow and report any political or public feedback which may affect the contamination problems and must be coordinated with Medical, Research and Legal.

3. Production - Clean up plants and stop gross contamination.

4. Legal - Define our present position, recommend reasonable acti that will not unduely alarm the market but reduce the exposure in terms of liability. Coordinate recommendations with

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5. Public Relations - Publicize actions where believed advantage
Certainly discussions should be held with other producers wit
same period to determine their planned course of action, if a

D. Long Range Tentative Outline (From 1 year to 3 years)

Realizing that the comprehensive program must be outlined the "Lo
Range Tentative Outline" is meant to serve as a guide: All aspec
of this program should be reviewed quarterly by Organic Management.

1. Research-Medical

Continue biodegradation studies and analytical support

Isomer distribution

Toxicity and metabolism studies

Water soluble removal

Incineration analytical support

Confirmation analytical

Contract academic research for reference

Develop new and improved formulations

2. Manufacturing

a. Process Research and Development

(1.) Identification of typical Aroclor isomers

(2.) Develop control for effluent composition

(3.) Test substitute formulations, etc.

(4.) Develop new processes

b. Clean Up Plants

c. Modify processes to meet market needs

3. Engineering

a. Develop and set up on plant locations incineration syste-s

b. Design new processing equipment as necessary

4. Marketing

a. Specify alternates or changes

b. Customer liaison

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c. Set reclaim or disposal of fluids

d. Work on name association problems

5. Patent

Investigate trademarks registered

Cover with patents any work felt patentable

6. Environmental Control

Develop cheap disposal systems for customers

a. Incineration or pyrolysis

b. Biodegradation unit etc.

c. Consultants in pollution control

7. Legal

Investigate and define our position on Royalty secrecy agreements.

Contracts - Raw Material and Customer

8. Public Relations

Portray to public positive actions at correcting the contamination problem. Release periodical statements covering our position.

XIII. Probability of Success

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XIV. Cost of Program

Neither the program nor the costs have been clearly defined at this
However, a cost estimate of $220,000 for toxicological work alone ha
been presented. Tentative figures indicated under the worst conditi
the entire program could run as high as $2.0-2.5M. At this stage it
very difficult if not impossible to develop a reasonable cost figure
one point is clear it will be larger than the normal research budget
handle. For this reason, assuming the approach is acceptable, we sh
be forced to ask for additional appropriations to fund the program.

XV. Future

Follow developments on the problem as they unfold.

Develop an aggressive research program to confirm or deny findings a
better understand the problem.

Develop costs for the duplementation of the Recommended course of
action.

Develop specific actions with each department involved

Submit the actions with costs for approval

Develop a timetable to solve the overall problem.

Prepare for "precipitious pullout" or drastic legislative action alth
we do not feel this is a likely possibility.

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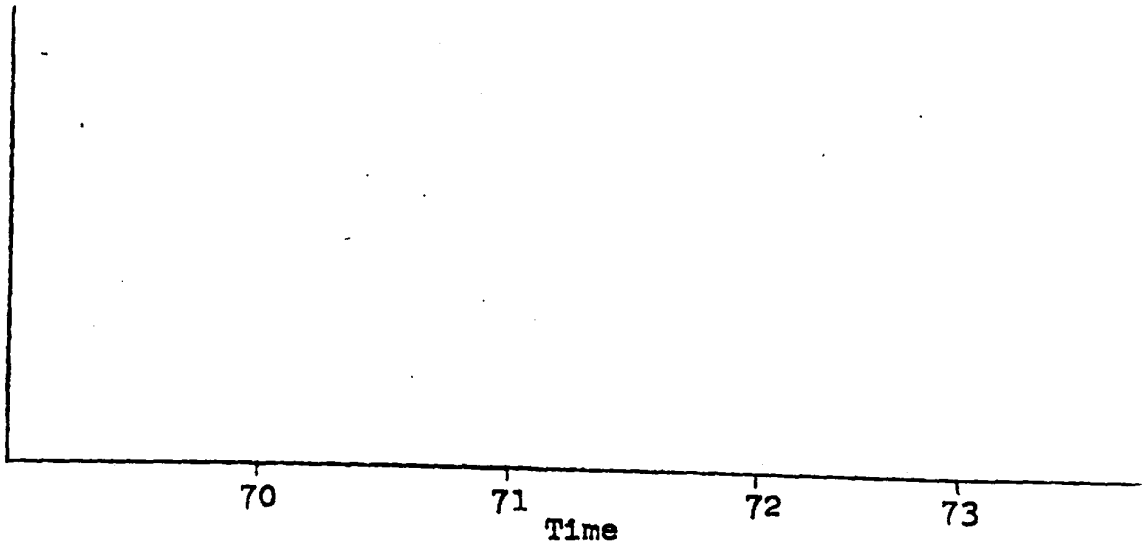
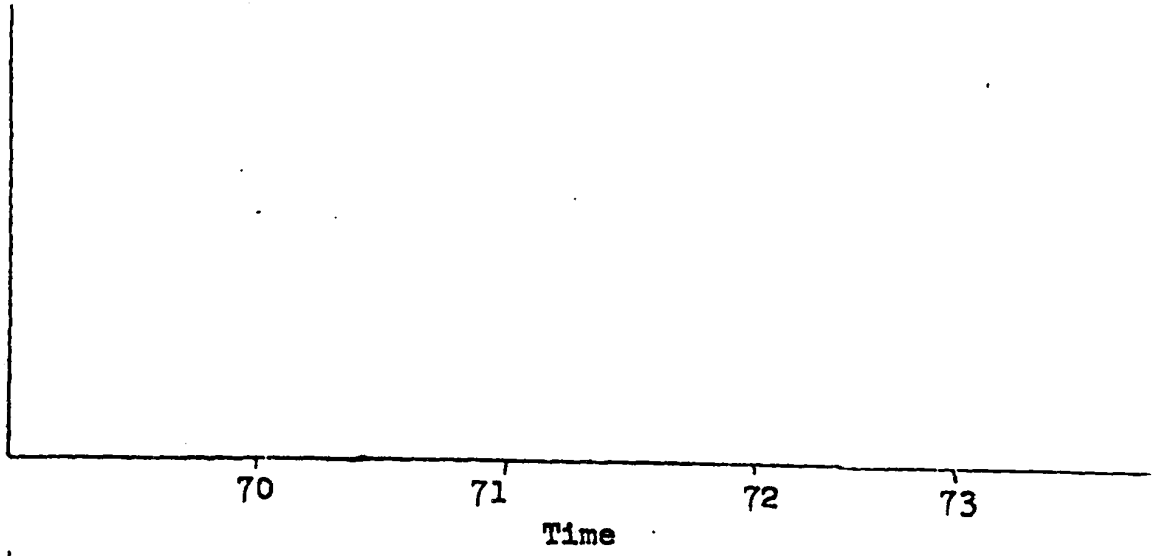
PROFIT AND LIABILITY VS. TIME

ACTION

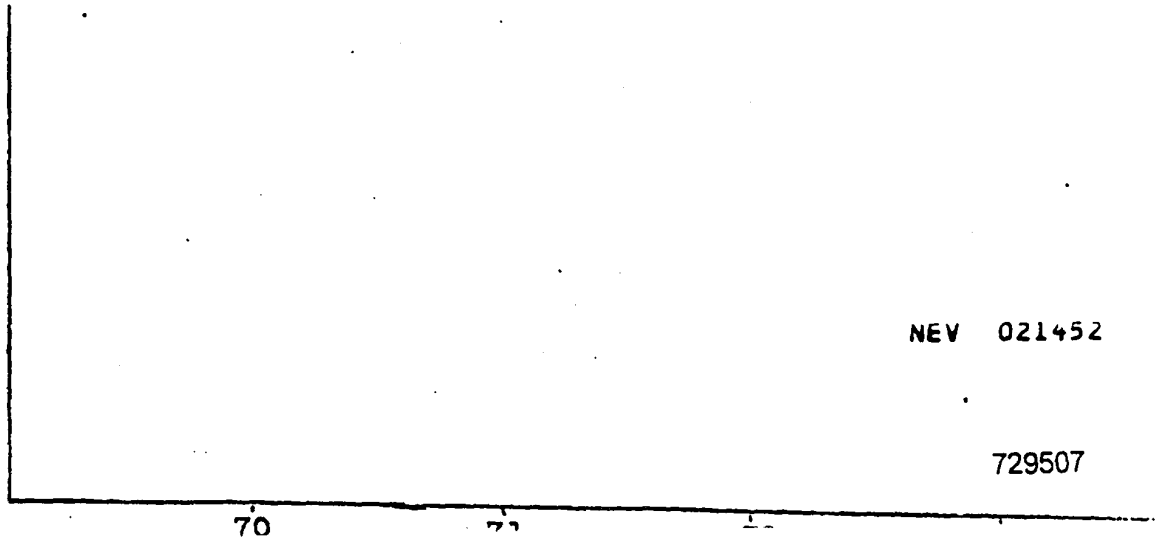
DO NOTHING



DISCONTINUE MANUFACTURE OF PCB



RESPONSIBLE APPROACH



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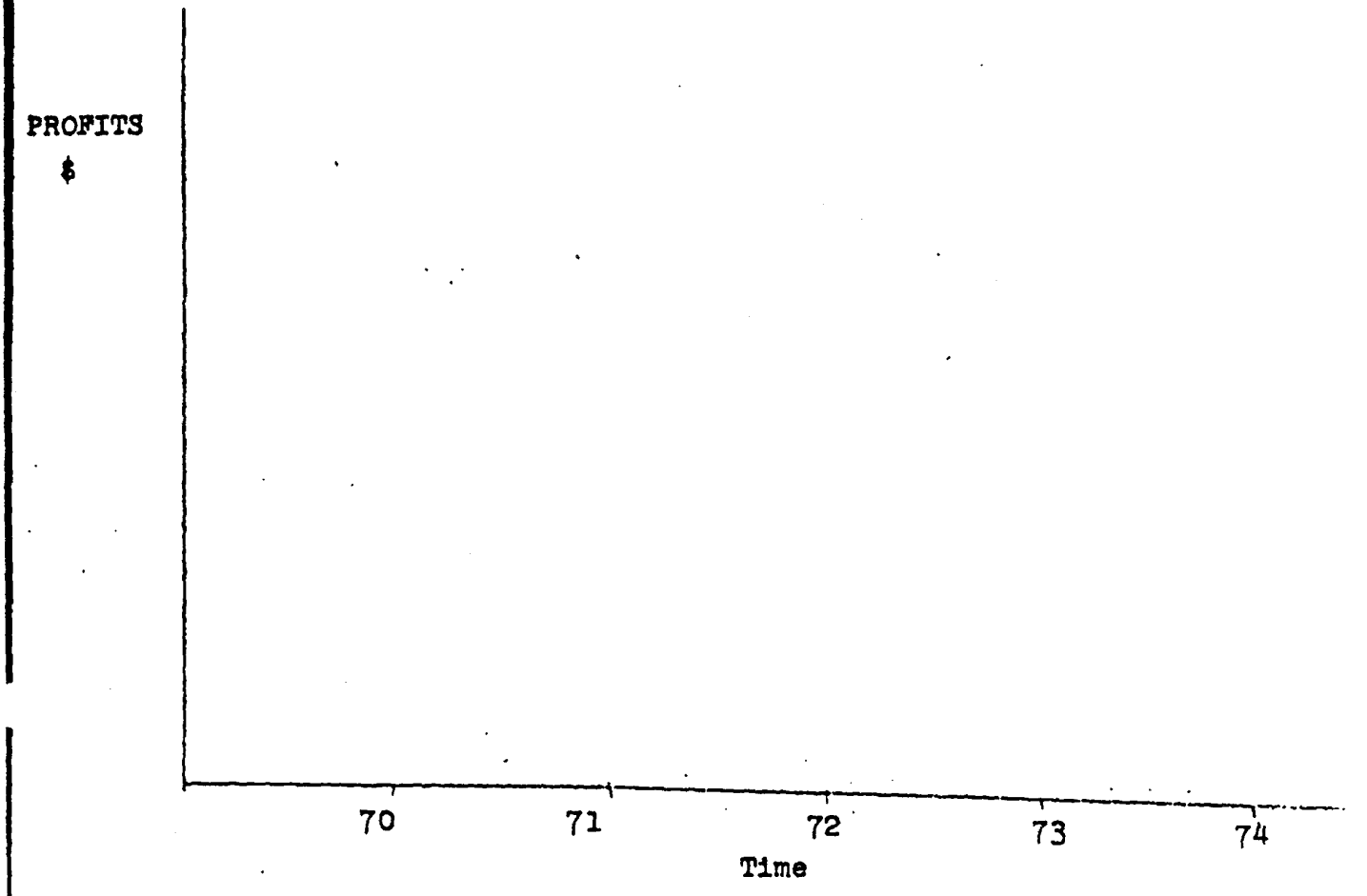
PROBABILITY OF SUCCESS



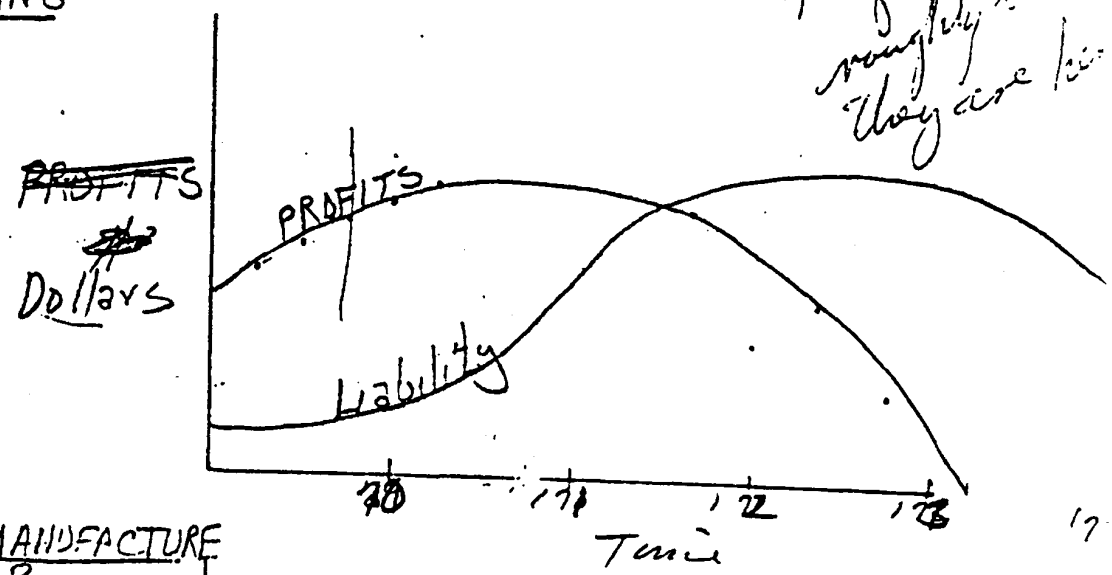
NEV 021453

WATER_PCB-SD0000073942

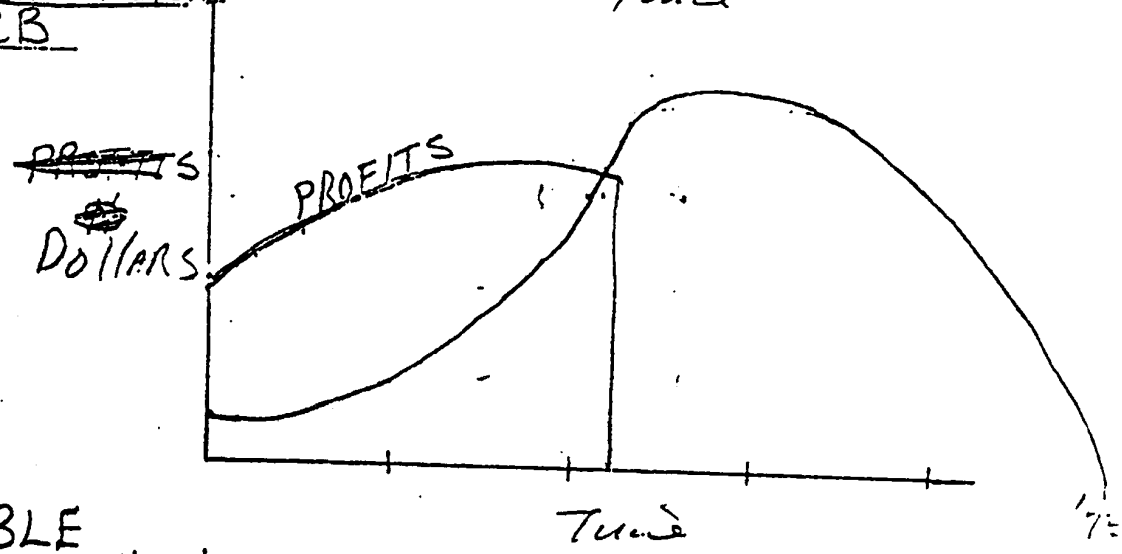
PROFIT AND LIABILITY VS TIME

ACTION

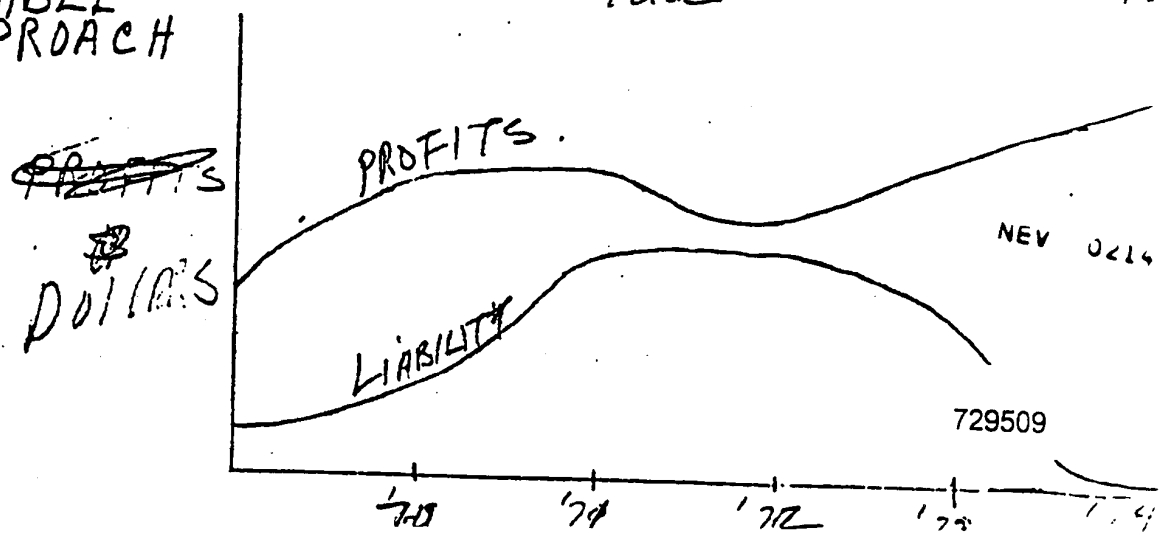
DO NOTHING



DISCONTINUE MANUFACTURE of PCB



RESPONSIBLE APPROACH



729509

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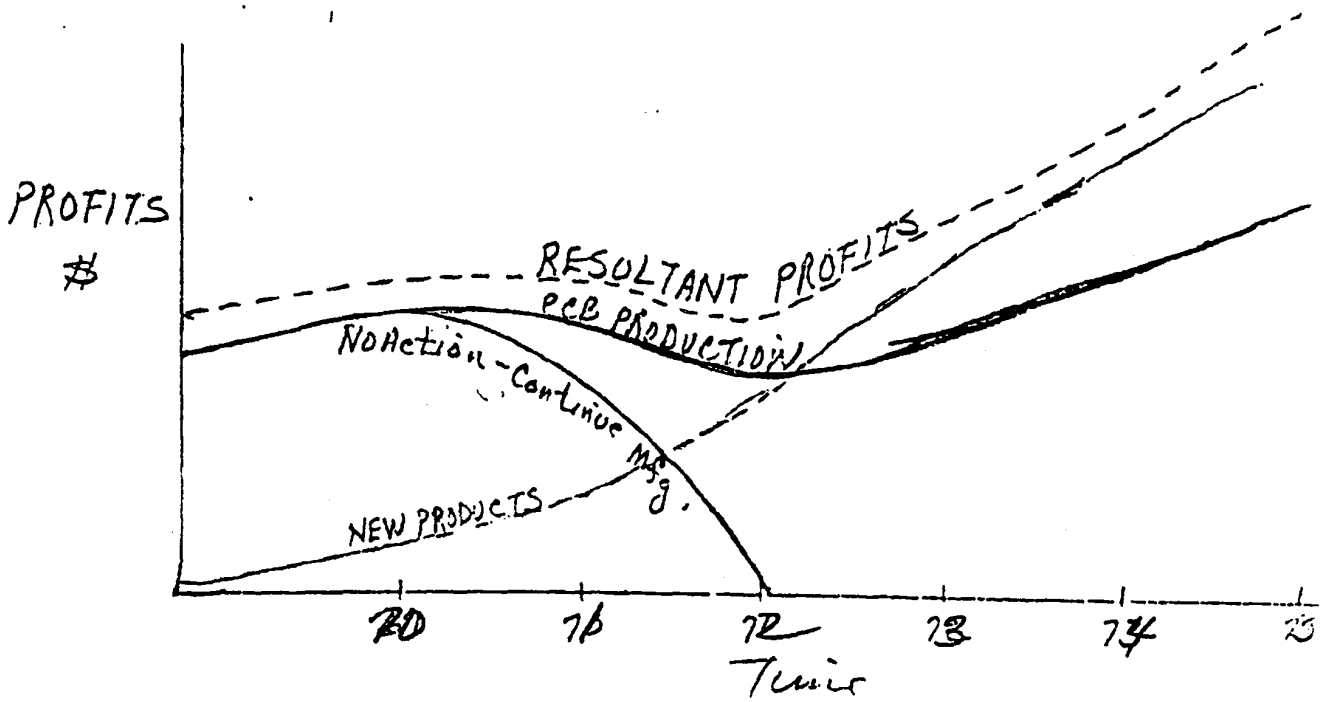
PROBABILITY OF SUCCESS



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XIII. Probability of Success

XIV. Cost of Program

$220,000 and bio with max. at $20-25M

XV. Future

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