4.3.3

REPORT ON THE DEGREE OF POLLUTION OF BOTTOM SEDIMENTS IN SHEBOYGAN HARBOR

April 17, 1963 ??

August 1969

Federal Water Pollution Control Administration
Great Lakes Region
Lake Michigan Basin Office

PLATE D-3

3

In accordance with an agreement between the Federal Water Pollution Control Administration and the United States Army Corps of Engineers that the Federal Water Pollution Control Administration would determine the degree of pollution of bottom sediments in harbors to be dredged by the Corps of Engineers, personnel of the Lake Michigan Basin Office surveillance staff made a sediment survey in Sheboygan Harbor on April 17, 1969. The points sampled are shown on the map on page 4 and are representative of the entire area of the Federal channel maintenance project.

Members of the sampling crew were:

Robert J. Bowden - Sanitary Engineer
Joseph V. Slovick - Hydraulic Technician
Daniel Chorowicki - Boat Operator-Sampler

CONCLUSIONS

1. The bottom sediment in the Sheboygan River and in the harbor east of stations SHEB 69-7, SHEB 69-8 and SHEB 69-9 are heavily polluted and should not be disposed of in Lake Michigan.

2. The bottom sediments in the outer harbor near the outer breakwater light, the south breakwater light and stations SHEB 69-5 and SHEB 69-6 consist primarily of sand and are only lightly polluted.

Discussion

Samples taken from stations SHEB 69-1 through SHEB 69-5 consisted of a tan sand with no odor and little or no benthic life. This material probably drifted into the channel from the bed of Lake Michigan. There is no evidence that it has been seriously contamin[illegible] by wastes from the inner harbor.

All of the other samples were dark brown or grey, had a sewage or petroleum odor and contained large sludgeworm populations. See Table 1, page 5. Three of these (SHEB 69-8, SHEB 69-12 and SHEB 69-16) were chemically analyzed and found to have high concentrations of phosp[illegible] nitrogen, COD, oil and grease and heavy metals indicating pollution by industrial and sanitary wastes. The concentration of chromium at station SHEB 69-16 is extremely heavy. See Table 2 page 6. The disposal of these sediments in Lake Michigan would constitute a significant sour[illegible] of nutrients and other pollutants to the lake.

Color photographs of all of the samples collected were taken and are on file at the Lake Michigan Basin Office.

D-15

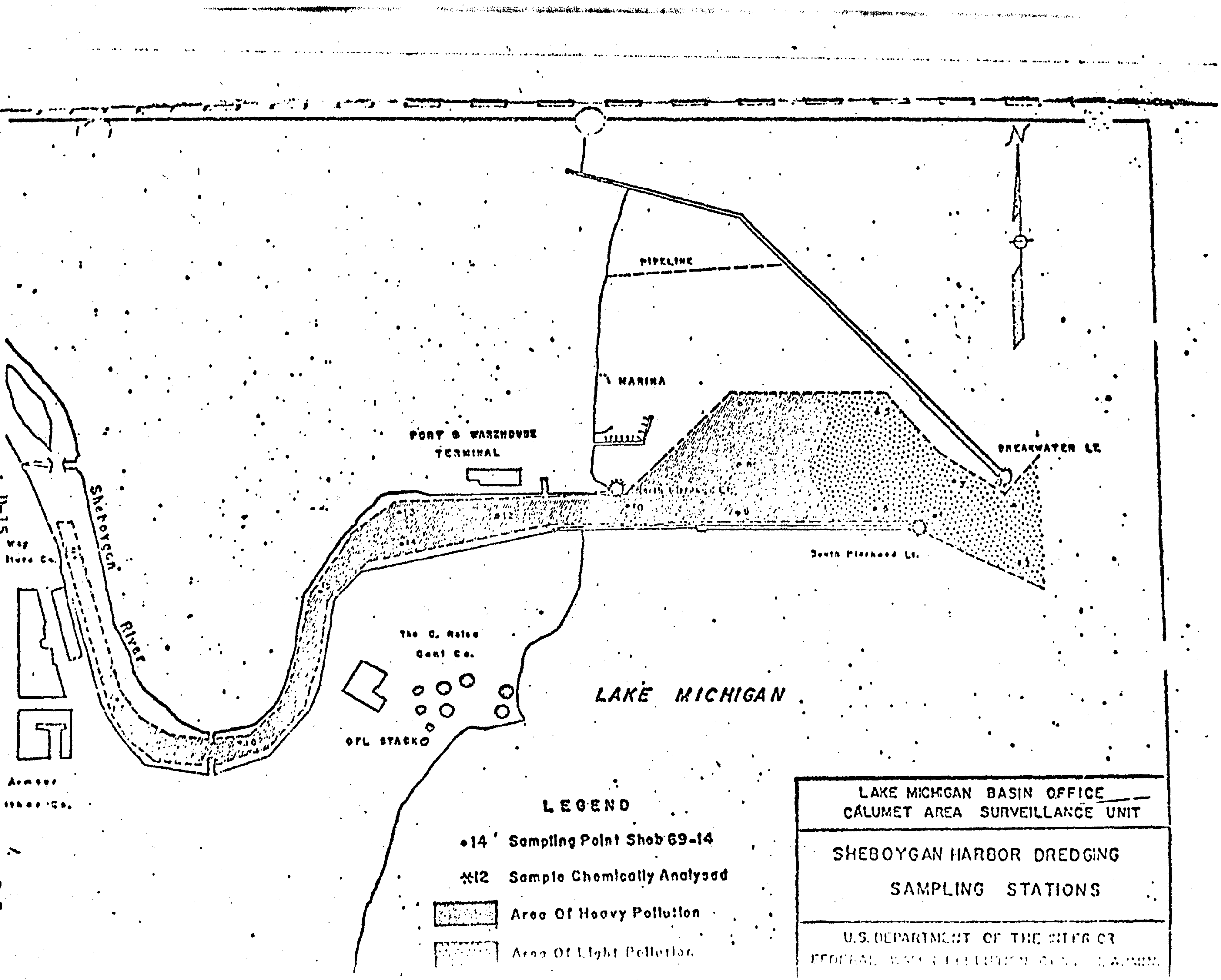
N
PIPELINE
MARINA
PORT & WAREHOUSE
TERMINAL
BREAKWATER LT.
South Pierhead Lt.
Sheboygan
River
The C. Reiss
Coal Co.
OIL STACKS
LAKE MICHIGAN
Armour
LEGEND
•14 Sampling Point Sheb 69-14
✱12 Sample Chemically Analysed
Area Of Heavy Pollution
Area Of Light Pollution
LAKE MICHIGAN BASIN OFFICE
CALUMET AREA SURVEILLANCE UNIT
SHEBOYGAN HARBOR DREDGING
SAMPLING STATIONS

PLATE D-7

TABLE 1

FIELD OBSERVATIONS OF BOTTOM SEDIMENTS
SHEBOYGAN HARBOR
APRIL 17, 1969

Sta. Sheb. 69-1	Depth 28' - Tan sand, no odor, no benthic life
Sta. Sheb. 69-2	Depth 24' - Tan sand, no odor, no benthic life
Sta. Sheb. 69-3	Depth 26' - Tan sand, no odor, no benthic life
Sta. Sheb. 69-4	Depth 28' - Tan sand, gravel, no odor, no benthic life
Sta. Sheb. 69-5	Depth 24' - Tan sand, no odor, no benthic life
Sta. Sheb. 69-6	Depth 28' - Hard bottom, no samples, 3 dips
Sta. Sheb. 69-7	Depth 20' - Gray sandy clay, slight sewage odor, many sludg-
Sta. Sheb. 69-8	Depth 22' - Graybrown sandy clay, slight sewage odor, many sludgeworms
Sta. Sheb. 69-9	No sample collected
Sta. Sheb. 69-10	Depth 26' - Gray sandy clay, sewage odor, sludgeworms, weed:
Sta. Sheb. 69-11	No sample collected
Sta. Sheb. 69-12	Depth 26' - Brown clay, sewage odor, sludgeworms, vegetation
Sta. Sheb. 69-13	Depth 24' - Dark brown clay, sewage odor, many sludgeworms
Sta. Sheb. 69-14	Depth 24' - Gray clay, coal, little odor, few sludgeworms
Sta. Sheb. 69-15	Depth 26' - Gray clay, some coal, sewage odor, few sludgewor
Sta. Sheb. 69-16	Depth 24' - Black-brown clay, strong sewage and petroleum o- sludgeworms, oil
Sta. Sheb. 69-17	Depth 15' - Dark gray brown clay, sewage and petroleum odor, sludgeworms, oily
Sta. Sheb. 69-18	Depth 12' - Dark brown clay, strong petroleum and sewage odor, sludgeworms, very oily

TABLE 2

RESULTS OF ANALYSIS OF BOTTOM SEDIMENT SAMPLES
COLLECTED IN SHEBOYGAN HARBOR APRIL 17, 1969

Station	Sheb. 69-8 mg/kg	Sheb. 69-12 mg/kg	Sheb. 69-16 mg/kg
Parameter			
% Total Solids	53.8	42.8	39.4
% Volatile Solids	6.4	16.7	6.6
Specific Gravity	1.4598	1.2928	1.2688
COD	89,060	203,940	135,150
Total Phosphorus	962	1058	1642
NH_3-N ammonium	134	250	393
NO_3-N nitrate	7.6	11	9.1
Organic N	2466	4506	4988
Hexane Solubles	3459	5615	11.637
Total Iron	9240	13,330	14,800
Copper	45	105	175
Cadmium	NF	NF	NF
Nickel	20	20	20
Zinc	110	275	420
Lead	80	260	335
Chromium	170	350	1400

All results reported on "DRY" basis

NF - None detected within sensitivity of test

DISCUSSION OF RESULTS

Samples SHE-1, SHE-1A, and SHE-1B consist of silt and/or sand, and had low sludgeworm populations. Sediments at the other stations consisted of muck with a pudding-like consistency, and had high sludgeworm populations (Field Report).

The bulk sediment analysis data (Sediment Pollution Evaluation) indicate moderate organic and lead pollution at stations SHE-1B and SHE-2. Samples from the remaining stations indicate high organic and lead pollution and moderate to high zinc pollution. Moderate arsenic pollution and moderate to high chromium pollution is present at all the stations analyzed.

Considering the data collected, the pollutional classifications of the sediments are indicated on the attached map. Sediments from the area indicated as "Not polluted" are suitable for open lake disposal. Sediments from the areas designated "Moderately polluted" and "Heavily polluted" are unsuitable for open lake disposal.

The survey conducted 17 April 1969 found the eastern half of the area presently indicated as moderately polluted to be unpolluted, and the western half of this area to be heavily polluted. The classifications of the two surveys agree in other areas of the harbor.

Comparison of the two surveys indicates no substantial change in pollutional levels in the interim.

FIELD REPORT

Harbor : Sheboygan
State : Wisconsin
Sampled: October 7, 1974

Sample or Station No.	Location	Depth	Observations
SHE-1	43° 44' 55.2" 87° 41' 35.8"	8.0 meters	Light brown beach sand material. No odor, no detritus, and no organisms observed.
SHE-1A	43° 44' 55.6" 87° 41' 42.7"	9.0 meters	Brown material with pebbles, sand and silt. [illegible] odor. No detritus. Some organisms observed; sludgeworms.
SHE-1B	43° 44' 57.7" 87° 41' 42.7"	8.5 meters	Dark tan colored material. Mostly silt with some fine sand. No detritus. Mild musty [illegible] detected. Some benthos observed; sludge[illegible]
SHE-2	43° 44' 55.6" 87° 42' 00.8"	7.5 meters	Dark brown material. Mostly silt with so[illegible] pudding-like consistency. Some detritus. [illegible] odor detected. Numerous sludgeworms observ[illegible] Oil present on sample.
SHE-3	43° 44' 55.5" 87° 42' 00.8"	7.5 meters	Dark brown material. Mostly silt with so[illegible] (grit). Mucky pudding-like consistency. [illegible] organic detritus. No odor detected. Numer[illegible] sludgeworms observed. Oil sheen on sample.
SHE-4	43° 44' 57.7" 87° 42' 00.8"	7.5 meters	Dark brown material. Mostly silt with mucky consistency. Some detritus. No odor detect- Numerous sludgeworms observed. Some oil on sample.
SHE-5	43° 44' 56.7" 87° 42' 09.0"	7.5 meters	Dark brown material. Silt with some fine sa[illegible] (grit). Mucky consistency. Mild earthy odor. Organisms; fingernail clam, numerous sludge[illegible]
SHE-6	43° 44' 54.5" 87° 42' 32.5"	7.0 meters	Dark brown material. Silt with mucky puddin[illegible] like consistency. Very little detritus. [illegible] earthy odor. Many sludgeworms observed.
SHE-7	43° 44' 41.3" 87° 42' 40.2"	7.0 meters	Dark brown material. Silt with mucky pudding-like consistency. Some detritus. Mild orga[illegible] odor. Numerous sludgeworms observed.

SEDIMENT POLLUTION EVALUATION

Harbor: Sheboygan

State: Wisconsin

Sampled: October 2, 1974

EVALUATION PARAMETERS	VALUE AT EACH STATION AS A PER CENT OF DRY WEIGHT					
	SHE-1B	SHE-2	SHE-4	SHE-5	SHE-6	SHE-7
Volatile Solids	6.49	5.04	8.90	10.43	12.34	11.99
Chem. Oxy. Demand	6.00	3.90	8.30	11.00	12.00	14.00
T. Kjel. Nitrogen	0.2300	0.1000	0.2900	0.4000	0.4500	0.4300
Oil-Grease	0.0500	0.0700	0.0950	0.0600	0.0900	0.2700
Mercury	<0.00002	<0.00002	<0.00002	<0.00002	<0.00003	0.00005
Lead	0.0050	0.0045	0.0115	0.0125	0.0145	0.0220
Zinc	0.0082	0.0068	0.0151	0.0170	0.0185	0.0265
Supplementary:						
Arsenic	0.00036	0.0032	0.00036	0.00048	0.00037	0.0003[illegible]
Cadmium	0.0003	0.00008	0.00026	0.00034	0.00035	0.[illegible]45
Chromium	0.0068	0.0044	0.0056	0.0100	0.0100	0.0350

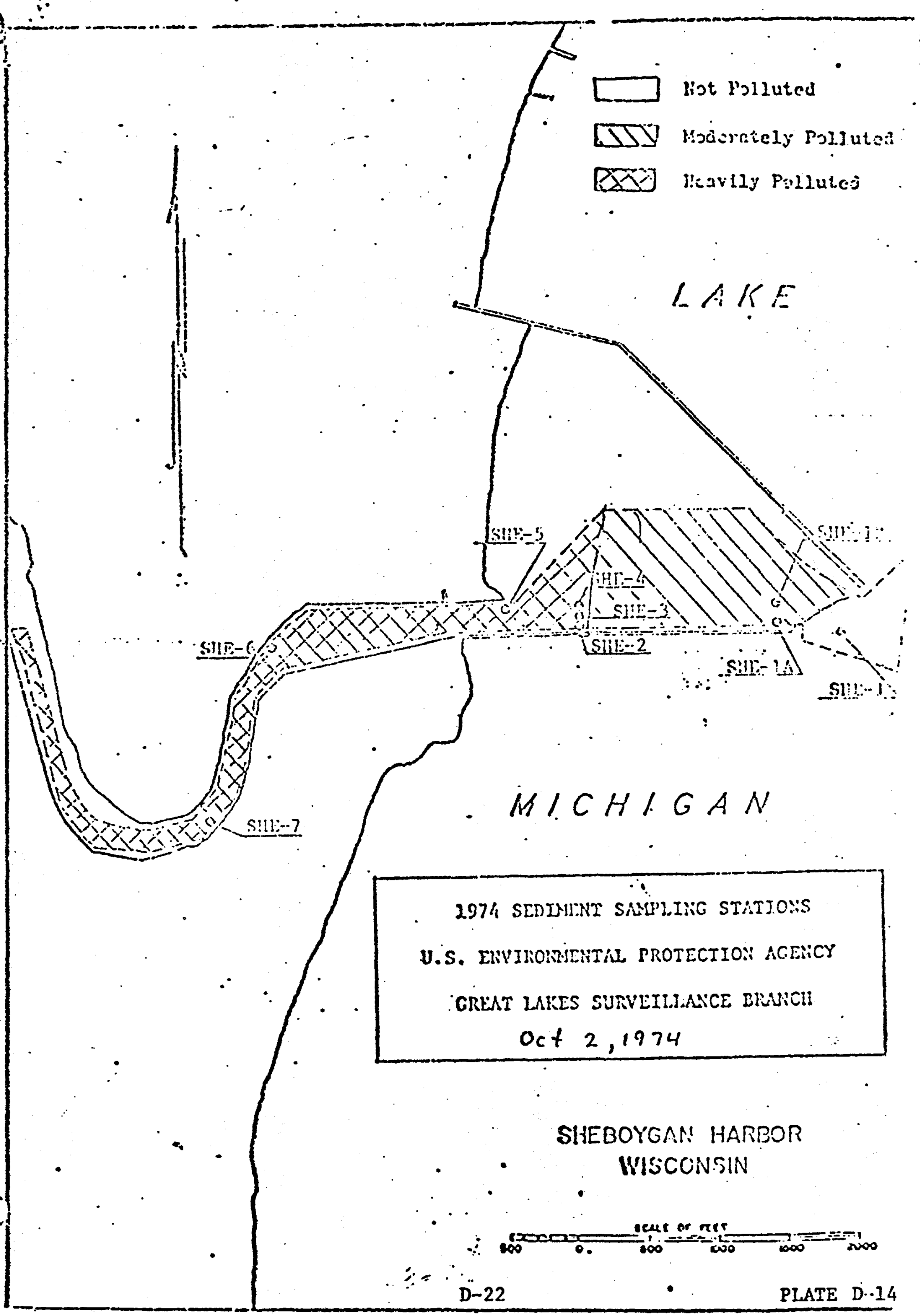
Not Polluted
Moderately Polluted
Heavily Polluted
LAKE
MICHIGAN
SHE-5
SHE-4
SHE-3
SHE-2
SHE-1A
SHE-6
SHE-7
1974 SEDIMENT SAMPLING STATIONS
U.S. ENVIRONMENTAL PROTECTION AGENCY
GREAT LAKES SURVEILLANCE BRANCH
Oct 2, 1974
SHEBOYGAN HARBOR
WISCONSIN
SCALE OF FEET

PLATE D-14

JAN 1 3 1985

DEPARTMENT OF THE ARMY
DETROIT DISTRICT, CORPS OF ENGINEERS
BOX 1027
DETROIT, MICHIGAN 48231-1027

December 14, 1984

IN REPLY REFER TO

Planning Division - PF

Ms. Joan Calabrese
U.S. Environmental Protection Agency
230 South Dearborn Street
Chicago, Illinois 60604

Dear Ms. Calabrese:

As promised by Mr. Jeff Groska in a December 11, 1984, telephone conversation, I am providing the following information concerning the PCB contamination problems in the Federal navigation channel at Sheboygan Harbor, Wisconsin:

a. Copies of drawings showing the limits of the Federal channel and locations of sediment samples taken from the harbor in 1979 and 1982;

b. A photocopy of the March 1980 report; "Sheboygan Harbor, WI - PCB Investigations and Results"; and

c. A draft copy of an ongoing study on bioaccumulation of PCB's in certain organisms.

I hope this information is useful to you in designing your Remedial Investigation - Feasibility Study for the Sheboygan River and Harbor. We look forward to close cooperative effort between our agencies in addressing this problem. If you have any questions concerning this information, please contact Mr. Jeff Groska of my staff at 8-226-2205.

Sincerely,

C. Argiroff

C. ARGIROFF
Chief, Planning Division

Enclosures

JAN 16 1985

December 14, 1984

Planning Division - PF

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U.S. Environmental Protection Agency
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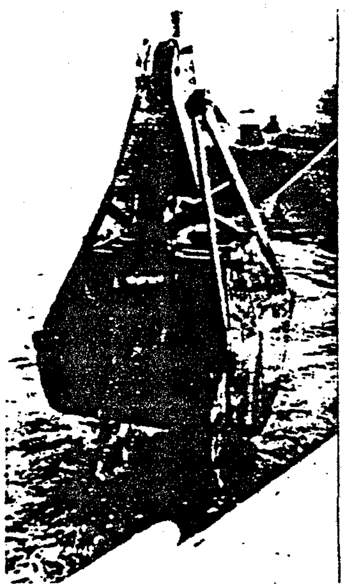
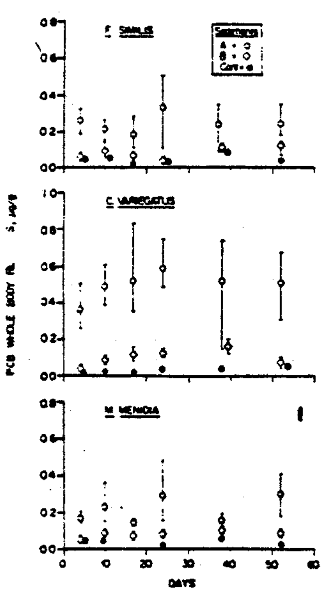
Sincerely,

Enclosures

US Army Corps of Engineers
Waterways Experiment Station





ENVIRONMENTAL LABORATORY

DRAFT FINAL REPORT

BIOACCUMULATION OF POLYCHLORINATED BIPHENYLS (PCB) FROM SHEBOYGAN HARBOR SEDIMENTS IN LABORATORY EXPOSURES

by

Victor A. McFarland, Joan U. Clarke, Alfreda B. Gibson

Environmental Laboratory

DEPARTMENT OF THE ARMY
Waterways Experiment Station, Corps of Engineers
PO Box 631
Vicksburg, Mississippi 39180-0631

October 1984

86·84·0083

Prepared for DEPARTMENT OF THE ARMY
US Army Engineer Division, North Central
US Army Engineer District, Detroit

Enclosure 3

20. ABSTRACT (Continued).

sediment PCB concentrations. Uptake occurred regardless of whether organisms were in direct contact with the sediments.

Time-sequenced sampling over the 30-day exposure period enabled calculation of steady-state tissue residues (C_{ss}), and bioaccumulation factors (BAF) for uptake of PCB from both sediment and water. Comparison of C_{ss} levels with the thermodynamically defined bioaccumulation potential (TBP) of the sediments showed that the proportion of TBP actually achieved declined with increasing sediment PCB content. Sediment BAF declined similarly. Whole water BAF increased with degree of chlorination of the PCB isomer groups, but did not vary with sediment PCB content.

Executive Summary

Three species of freshwater fish and two species of bivalve mollusks were exposed to PCB-contaminated sediments from Sheboygan Harbor under flowing water for periods lasting up to 30 days. Concentrations of PCB in four homogenates (reference, low, medium, and high) of the dredged sediments ranged from 0.45-44 μg g^{-1} on a dry weight basis. Exposures of organisms to these four homogenates were duplicated at constant water temperatures of 4° C and 20° C. Residues in pooled whole-organism samples taken at time intervals up to 30 days were fitted by a first-order kinetic model to project steady-state PCB concentrations. Results showed that bioaccumulation was minimal in all organisms at 4° C, but was enhanced by higher temperatures and increased lipoidicity of organisms. Highest steady-state total PCB residues were projected at 8.9 μg g^{-1} at 20° C in medaka, the organism with highest lipid content.

Direct contact with contaminated sediment was not necessary for bioaccumulation to occur. Most PCB bioaccumulated was in the isomer groups tetrachlorobiphenyl through hexachlorobiphenyl with a trend toward higher levels with increasing chlorination. Sediment PCB was nearly 50 percent tetrachlorobiphenyls. Some uptake of PCB in all isomer groups was observed including those which were highest in molecular weight and lowest in absolute concentration in sediments.

Levels of PCB in all organisms increased with increasing contamination of the sediments. However, for deposited sediments, high PCB concentrations did not result in similarly high residues in the tissues of exposed organisms. Organisms exposed to sediment containing 33 or 44 μg g^{-1} total PCB often bioaccumulated to projected steady-state concentrations similar to those of organisms exposed to sediments containing 4 μg g^{-1} total PCB.

Both sediment bioaccumulation factors (sediment BAF) and the proportion (p) of thermodynamically defined bioaccumulation potential (TBP) achieved decreased as PCB content of Sheboygan Harbor sediments increased. Whole water BAF were unrelated to sediment PCB concentrations, but increased with increasing chlorination of the PCB isomer groups di- through hexachlorobiphenyl.

Total PCB residues at steady state (C_{ss}) ranged from 0.028 μg g^{-1} in mussels exposed to the benthic surface sediment (R) to almost 9 μg g^{-1} in the lipoidal fish, medaka, exposed to the most highly contaminated sediment (H) taken at depths of 6 to 12 ft below the sediment-water interface.

Preface

This report describes work performed for US Army Engineer Division, North Central, US Army Engineer District, Detroit, in fulfillment of Intra-Army Order for Reimbursable Services No. NCE-IA-84-0083WB dated 3 May 1984.

The work was performed by the Environmental Laboratory (EL) of the US Army Engineer Waterways Experiment Station (WES). Principal Investigator was Victor Alan McFarland of the Ecosystems Research and Simulation Division (ERSD), EL. The work was contracted and generally supervised by Dr. Richard K. Peddicord, Team Leader, Biological Evaluation and Criteria Team, ERSD. Dr. C. R. Lee was group leader and Mr. D. L. Robey was Chief of ERSD. Dr. John Harrison was Chief of EL. The contract was monitored by Mr. Les Weigum, Chief of the Environmental Analysis Branch, and by Mr. Frank Snitz, Contract Manager, in the Planning Division, Detroit District. Mr. C. Argiroff was Chief of the Division. COL Raymond T. Beurket, Jr. was District Engineer, Detroit, at the time of this work.

Commander and Director of WES at the time of this work was COL Tilford C. Creel, CE, and at the time of its completion, COL Robert C. Lee, CE. Technical Director was Mr. Fred R. Brown.

Contents

Conversion Factors, US Customary to Metric (SI) Units of Measurement

US customary units of measurement used in this report can be converted to metric (SI) units as follows:

Multiply	By	To Obtain
Fahrenheit degrees	5/9	Celsius degrees or Kelvins*
gallons	3.785	litres
inches	25.4	millimetres
ounces	28.35	grams
square feet	0.0929	square metres

Equivalents

parts per million (ppm) = mg ℓ^{-1} = µg g^{-1}

parts per billion (ppb) = µg ℓ^{-1} = ng g^{-1}

parts per trillion (ppt) = ng ℓ^{-1}

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* To obtain Celsius (C) temperature readings from Fahrenheit (F) readings, use the following formula: C = (5/9)(F - 32). To obtain Kelvin (K) readings, use: K = (5/9)(F - 32) + 273.5.

Sediment collection

5. Sites chosen by Detroit District for sample collection are shown in Figure 1. The samples were collected by clamshell dredge supplied and operated by US Corps of Engineers Kewaunee Project Office. Pits were dug underwater to the depths indicated in Table 1. When the indicated depth was reached a full grab was taken and deposited on deck. Up to twelve four-gallon* glass jars were filled from each grab sample and an 8-ounce aliquot was taken from each jar for PCB analysis. Concentrations of total PCB in the sediment subsamples are shown in Table 1.

6. The collected sediments were shipped at once by air freight to WES where they were maintained in storage at 3-5° C until further use. All collections were completed on 2 April 1984. At this time acquisition and acclimation of experimental organisms was also begun.

Organisms

7. Two species each of bivalve mollusk and fish were collected or purchased from cultured stock during the first two weeks of April 1984. Holding facilities were adjusted to approximate collection temperatures (12-18° C) and organisms were gradually acclimated from these temperatures to either 4° C or 20° C. Accumulation occurred over a period of three weeks immediately prior to start of exposures.

8. Northern mussels, *Lampsilis silicoidea ventriculata*, were field-collected and furnished by Detroit District. These ranged from 36-40 mm in length, were 15-48 g whole-organism weight, and contained 10-37 g soft tissue, fresh weight. Very few mortalities were observed.

9. Asiatic clams, *Corbicula fluminea*, were collected by hand in the Sacramento River Delta, Calif., from a previously studied population (McFarland, 1982). The size range of adult organisms used was 21-29 mm from umbo to ventral edge, longest dimension. Whole organism weight ranged from 4.9-10 g and soft tissue, fresh weight was 1.7-5.6 g. Clams underwent a typical postcollection die-off lasting about one week, after which the population stabilized and no further mortalities occurred. All bivalves were maintained during holding and acclimation on brewer's yeast and cultured monoclonal alga, *Selenastrum capricornutun*.

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* A table of factors for converting US customary units of measurement to metric (SI) units is presented on page 4.

10. Japanese killifish or medaka, *Oryzias latipes*, juveniles and young adults were obtained from a cultured stock. Medaka ranged from 20-31 mm and 0.04-0.27 g whole body, fresh weight. All fish were disease-free and no mortalities were observed during holding and acclimation.

11. Fathead minnows, *Pimephales promelas*, were also obtained from cultured stock. These fish ranged from 38-46 mm and 0.27-0.87 g fresh weight. A fungal infection was endemic in the culture and caused persistent die-off of up to 10 percent per day. Cold acclimation arrested development of the disease.

12. Fingerling rainbow trout, *Salmo gairdneri*, were obtained from a hatchery in northern California one month later than all other organisms and were acclimated and exposed to the Sheboygan sediments separately.

Sediment homogenates

13. Chemical analyses of PCB content of the sediment field samples were used to select the individual four-gallon portions to be combined for each homogenate. Only sediments from the benthic surface at Sta 6+00 were used to prepare the reference sediment homogenate (R). Up to 15 four gallon portions were individually seived to remove large debris and combined in a polyethylene barrel using a motorized mixer to prepare each homogenate.

14. The homogenate R was prepared first and distributed in the exposure aquaria. The remainder of R after distribution served as the basis for preparation of the next higher level of contamination, i.e., "low" PCB-content at a nominal concentration of 5 $\mu g\ g^{-1}$ and designated "L". This procedure was followed for "medium"-PCB (M) and "high"-PCB (H) homogenates as well. The nominal PCB contents of M and H were 25 and 50 $\mu g\ g^{-1}$, respectively.

Exposure system

15. The exposure system consisted of 24, 75-ℓ hemispherical aquaria (Figure 2). Each set of 12 aquaria was temperature-controlled by circulating aquarium water continuously through a separate heat-exchanger system. An 8-ton chiller unit was dedicated to temperature control of the 12 4° C aquaria. Temperature was invariant at either set point, i.e. 4° C or 20° C as determined by twice daily monitoring.

16. Each of the four sediment homogenates was randomly assigned to three replicate 20° C aquaria or to three 4° C aquaria with the exception of R which was replicated twice at each temperature. The two free aquaria in which washed gravel was substituted for sediment homogenate served as laboratory controls, one at each temperature.

17. Twenty-five litres of sediment (or gravel) were placed in each aquarium and had a planar surface area at the sediment-water interface of 0.17 m^2.

18. Stainless-steel mesh floors were placed 5 cm above the sediment surface. Water was withdrawn through a screened port in the side of each aquarium, passed through a heat-exchanger and discharged through a disperser mounted above the mesh floor at the aquarium center.

19. Make-up water was supplied at a pulsed rate (4 min between pulses) equivalent to 95 percent replacement in 24 hr by programmed operation of solenoid valves. Excess water overflowed to a drain maintaining a constant water volume of 50 ℓ in each aquarium.

20. All components of the exposure system in contact with water were made of noncontaminating materials such as stainless steel, titanium, PVC, polyethylene, or epoxy-coated fiberglass. Each aquarium was covered with a transparent plexiglass lid and a diurnal light-cycle was maintained at a constant period of 10 hr light, 14 hr dark.

Experimental design

21. Distribution of sediments, organisms, and temperatures among the 24 aquaria is shown in Table 2. Clams were included in all mussel and in all fish exposures. Except for controls, all mussels (and clams exposed with them) were exposed by placement in glass crystallizing dishes containing a sediment homogenate. Six dishes containing six mussels each (or clams) were arranged in an aquarium. By this means clams and mussels were brought into direct contact with sediments. Clams exposed with fish were placed loosely on the aquarium floors and were not in direct contact with the sediments.

Sampling

22. Sediments were sampled at the time of homogenization and placement in the aquaria (Appendix Table A1, Trt. A(1) and A(2)) for PCB, total organic carbon (TOC), and particle size distribution (PSD). After completion of the first 30-day organism exposure period the aquaria were drained, the mesh floors removed, and the surficial layer (≅ 0.5 cm) of sediment taken. All samples of each treatment (R, L, M, and H) at 20° C were composited and are identified as Trt. B in Table A1. Surface sediments at 4° C were similarly composited and are identified as Trt. C.

23. Following exposure of trout the surficial sediments were again sampled and are identified as Trt. D. All Trt. D samples were taken from 4° C aquaria and had been under flowing water for 60 days.

24. Water samples (unfiltered) were taken once from each 20° C aquarium during the first 30-day exposure period and once from each 4° C aquarium during the trout exposures that followed. Baker-10 C-18 extraction columns fitted to vacuum apparatus were placed in an aquarium and up to 10-ℓ samples were withdrawn over a period of several hours.

25. Tissue samples of all organisms were taken for background PCB residues prior to the start of temperature acclimation (-17 days) and again after acclimation and before placement in exposure aquaria (day zero). Subsequently, tissue sampling was done on a schedule of +2, 4, 10, 17, and 30 days of exposure. Tissues were analyzed for PCB and lipid content.

Chemical analyses

26. Sediment samples were prepared for PCB and total organic carbon (TOC) analyses by air drying, grinding, and sieving to uniformity.

27. Dry oxidation for TOC analysis was accomplished by an ampule method using cupric oxide as the oxidant. After treatment with HCl to remove inorganic carbon, excess CuO was added, the ampule was purged with O_2, flame-sealed and combusted at 550° C for 4-5 hours in a furnace. Total organic carbon was measured by purging evolved CO_2 through a nondispersive infrared (IR) analyzer. The equipment and adapted method used was by Oceanographic International. The method is described in Plumb (1981) and elsewhere.

28. A 10 g portion of the sediment mass as prepared above was extracted for PCB analysis with 200 mℓ of hexane using an ultrasonic cell disrupter. A portion was cleaned up with sulfuric acid (Murphy 1972) and taken to the gas chromatograph (GC) for analysis.

29. Unfiltered (whole) water samples concentrated on Baker-10 SPE columns were eluted with 1 mℓ hexane for direct injection in the GC.

30. Tissue samples were prepared for PCB and lipid analyses by FDA Method 211.13f (FDA 1977). Frozen samples were macerated with dry ice and extracted using a Polytron. The extracts were concentrated to 10 mℓ using Kuderna-Danish (KD) apparatus. An aliquot was removed and evaporated to dryness for percent lipid determination. The remainder of the extract was given cleanup by the method of Murphy (1972) and taken to the GC for PCB analysis.

31. Seventy-eight pure isomer standards (Ultra Scientific) ranging from monochlorobiphenyl through decachlorobiphenyl were chromatographed individually to establish peak identification and retention time (RT). Detection was by electron capture (ECD) using an HP 5880 GC/ECD equipped with 30-m DB-5

fused silica capillary column. The column temperature was programmed at 10° C/min from 150° C to 280° C and held for 7 min.

32. Quantitative standard solutions were prepared by mixing all individual stock solutions of the 78 isomers and taking four dilutions. Of the 55 chromatographic peaks obtained under the established conditions, 18 were mixtures of two or three isomers. Isomer group concentrations were calculated by summation of all individual isomer peaks for each group. In the cases of overlapped isomers, the peaks were added to the appropriate group for the dominant isomer or to the lower-chlorinated group if a mixed pair. For example, if a peak consisted of two di-CBP isomers, it would be summed as di-CBP; if a di- and a tri-CBP, it would be also be summed as di-CBP; and if a di- and two tri-CBP, it would be counted as tri-CBP.

33. Concentrations were also reported as Aroclors when possible. Extracts were analyzed using an HP 5840 GC/ECD with column and conditions as described above, but standardized using A1242, 1248, 1254, or 1260 standards (EPA, RTP).

Physical analyses

34. Aquaria at 20° C containing mussels and clams were monitored by gravimetric methods for suspended particulates (SP) until SP concentrations caused by activity of the clams fell below the measurement threshold of about 5 μg ℓ^{-1}. Particle size distribution (PSD) of the sediment homogenates was determined by a modified hydrometer method (Patrick 1958).

Curve fitting and statistics

35. All summary statistics, analysis of variance, regression, correlation, and data reduction were done on the Digital VAX computer using Statistical Analysis System (SAS) programs. All time-sequenced exposure data for each organism in each sediment and temperature treatment were fitted using the Marquardt algorithm in the SAS NLIN program.

36. All chemical analysis data are tabulated and included as Appendix A. Data tabulated in the body of the text are calculated from Appendix A. In cases where PCB concentration was below the analytical detection limit, the value was set equal to the detection limit for subsequent calculations. This was judged to be the most conservative approach from an environmentally protective standpoint.

Results and Discussion

Isomers and Aroclors

37. The fact that PCB is not a discrete chemical substance, but rather a complex mixture of differing amounts of 209 possible isomers, vastly complicates measurement and interpretation of data resulting from environmental samples. The approach taken in this investigation has been to quantitate PCB in sediment, water, and tissue as the total present in the individual PCB isomer groups dichlorobiphenyl (two chlorine atoms per molecule) through decachlorobiphenyl (ten chlorine atoms per molecule). The total PCB reported is then the sum of PCB in these isomer groups. Wherever a sufficient correspondence between Aroclor standards and an environmental sample was found in the chromatographic patterns, the sample was also quantitated as the Aroclor mixture. The most frequent correspondence was with A1242 which is predominantly tetrachlorobiphenyl. Other Aroclors (A1254 and A1260) could sometimes be matched with the chromatographs of tissue samples and are reported in Appendix A.

38. Monochlorobiphenyls are not included in the data because of their poor chromatographic response. These isomers are relatively water soluble and do not tend to bioaccumulate as do the higher chlorinated compounds. The groups heptachlorobiphenyl (7-Cℓ) through decachlorobiphenyl were present in low concentrations in all sample matrices and are reported in Appendix A. These highly chlorinated isomers are extremely insoluble in water and account for a small proportion of the total PCB bioaccumulated.

39. The most abundant and most biologically available isomers are those in groups di-CBP through hexa-CBP (2 to 6 chlorines per molecule). These are considered separately in Tables 5-9 in which steady state (C_{ss}) and related data are given on a fresh weight basis in organisms, and in Tables 12-16 in which C_{ss} and related data are lipid-normalized. Data are treated similarly for total PCB in Tables 10 and 17 and for A1242 in Tables 11 and 18.

Sediments

40. The data of Table A1 were subjected to analysis of variance and no treatment effects were found within a sediment homogenate block, i.e., R, L, M, or H. Concentrations of PCB and TOC in the original homogenates were not different than concentrations in any surface sample including that taken after 60 days under flowing water. Neither was there a difference attributable to temperature regime. There were, of course, differences in PCB concentration

among the homogenates. Since no time or temperature differences were found, the sediment samples within each homogenate block were treated as replicates and the means and standard deviations are reported in Table 3.

41. Organic carbon content, PSD, and moisture are also reported. It can be seen that TOC content is highly constant in all the sediments. Relative proportions of sand and clay, however, differ substantially. Clay and silt + clay correlate with trichlorobiphenyl through hexachlorobiphenyl, octachlorobiphenyl, total PCB, and A1242 at $r = 0.96$ to 0.99, $n = 5$, and $P = 0.0087$ to 0.0001.

42. Although organic carbon content of sediment indicates a capacity for PCB sorption it does not necessarily follow that such capacity will be reached. In the case of Sheboygan Harbor sediments the fine-grained mineral fraction appears to be a better correlate of PCB contamination than is organic carbon content.

Water

43. Unfiltered water data in Table A2 were compared for treatment (R, L, M, and H) and temperature (4° C, 20° C) effects by analysis of variance. No differences were found among treatment means for the isomer groups di- through decachlorobiphenyl, total PCB, or A1242. All groups except octachlorobiphenyl showed significantly lower concentrations at 4° C than at 20° C. Although some effect of temperature on PCB solubility can be expected, the sampling and extraction techniques did not distinguish between solution-phase PCB and PCB associated with fine particulate or colloidal material or otherwise in a sorbed state. It is likely that the difference in PCB in water samples at high and at low temperature is due largely to a higher level of organism activity in the 20° C aquaria altering the patterns of water movement over the sediments and affecting the deposition and resuspension dynamics in the tanks.

44. Unfiltered or whole-water PCB concentrations (C_w) are given in Tables 12 through 18 and are mean values for the exposures reported in Table A2.

Lipid content

45. The percent total extractable lipid was determined on all tissue samples for two reasons. First, alterations in lipoidicity may take place over an exposure period lasting several weeks. If loss of lipid occurs, the rate of uptake and observed and projected fresh weight tissue concentrations of PCB will be reduced, increasing the difficulty of interpretation of results.

Second, lipid-nomalization of data is a means of reducing interspecific variability and can be related to estimations of a thermodynamically defined "bioaccumulation potential" (TBP) calculated from sediment chemistry data (McFarland 1984).

46. Regressions of organism lipid content over time resulted in the data of Table 4. It can be seen that there was a nearly twenty-fold range in organism mean lipid content between mussels and medaka. Also, the slopes of the regressions for medaka and trout were significant at $P = 0.0001$ and $P = 0.0225$, respectively, whereas slopes of regressions for all other organisms were not significant. In calculations involving lipid-normalized data, the means of all values were used for mussels, clams, and fatheads because the lipid content of these organisms did not change significantly during the 30 days of exposure. In calculations on the medaka and trout data, the Y-intercept was taken as most representative of organism lipid content since it was the best estimate of pre-exposure condition.

Observations on the raw data

47. Fresh weight data reported in Tables of Appendix A in units of ng g^{-1} (ppb) are expressed in units of μg g^{-1} (ppm) and plotted over time in Figures 3-6 for total PCB at 4° C and at 20° C. An effect of temperature on PCB uptake is evident for all organisms contrasted. Mussels (Figure 3) show uptake after 30 days of exposure at 4° C only for organisms in sediment H. At 20° C, however, total PCB uptake was progressive and substantially increased for sediments L , M, and H while PCB content of organisms exposed to the reference sediment, R , remained at control levels.

48. The response of clams under the same conditions of exposure is shown in Figure 4. The pattern of uptake and influence of temperature is similar to that of mussels. The initial residues are higher in clams than in mussels and the magnitude of response is about twice that of the mussels. The higher initial residues in the clams may be metabolites of DDT or may reflect PCB contamination in the environment from which they were collected. The higher levels of PCB uptake of the clams are commensurate with their nearly eightfold-greater lipid content as compared with the mussels.

49. Of the three species of fish, none was completely compatible with the exposure conditions at both 4° C and 20° C despite acclimation prior to exposure. Fatheads and trout were subject to disease at 20° C and medaka, because of their small size and the immobilizing effect on them of low

temperature, were unable to adapt to the high currents generated by water circulation in the 4° C aquaria.

50. Trout sampled beyond the 10th day of exposure at 20° C were not analyzed because of development of disease. Figure 5 contrasts the total PCB uptake in trout at 4° C, and at 20° C through the 10th day. Uptake is enhanced at the higher temperature during this period. Residues of PCB in organisms exposed to contaminated sediments at 4° C are somewhat higher than reference and controls at that temperature but the differences were not increasing with time.

51. This apparent lack of bioaccumulation at 4° C may be due to the fact that lipid content of the fish was constantly diminishing over the 30-day exposure period. Trout lipid content at each sample time is listed in Appendix Table A13. It can be seen that trout lipid diminishes from about 5-9 percent at the first sample time to 2-3 percent at the last in the 4° C fish. Normalizing the residue data on the basis of lipid content in trout shows a gradual net bioaccumulation at 4° C rather than the apparent lack of change with continuing exposure shown in the fresh weight data in Figure 5.

52. Medaka were the most lipoidal organism used in this investigation. As with the trout, both cold acclimation and the conditions of exposure caused medaka to mobilize lipid stores. High mortality occurred at the start of 4° C exposures due to physical impact. Fish that adapted to the aquarium conditions were not sufficient in number to provide time-sequenced tissue samples in the cold exposures. Medaka that did adapt remained in good condition throughout the 30-day exposures and furnished sufficient biomass for a single tissue sample from each exposure. The results are shown in Table A9. It can be seen that PCB residues in medaka after 30 days of exposure at 4° C are only slightly greater than background or controls on a fresh weight basis. As with the trout, medaka exposed at 20° C showed temperature and exposure PCB concentration-related responses. Figure 6 shows the increases in fresh weight total PCB residues in medaka at 20° C for the sediment homogenates R, L, M, and H and for controls over the 30-day exposures. The maximum tissue residue at 30 days was in sediment M (33 $\mu g\ g^{-1}$ total PCB) and was about ninefold greater than residue in controls.

53. The general tendencies of the two bivalves and three fish to bioaccumulate PCB are compared in Figure 7. The temperature pairs (4° C, 20° C) were matched by sediment homogenate and day in order to calculate mean total

PCB for each organism at each temperature. Overall means were calculated from all data points for each organism. The broadest confidence intervals (CI) were for the 20° C means for clams (no contact), medaka, and fatheads where the data consisted of only a few observations. In all other cases sufficient data were available to illustrate a consistent enhancement of bioaccumulation at the higher temperature. Again, the concentrations of total PCB in the organisms exposed closely parallels the relative lipoidicity of the organisms.

54. The data also show essentially no difference in PCB uptake between clams that were allowed to burrow in the sediments (contact) and those that had access only to PCB mediated through the water column (no contact). Clams in contact with sediments at 20° C caused some suspension of particulates (SP) during the first few days of exposure. In all sediments, R, L, M, and H, the maximum SP concentration was about 40 mg ℓ^{-1} (ppm) on the first day of exposure. In sediment treatments R, M, and H, the SP was below measurement levels (<5 mg ℓ^{-1}) by the fifth day. In sediment L, however, SP concentrations were consistently near 10 mg ℓ^{-1} throughout the first two weeks of exposure. Although no marked differences are evident in the contact-no contact comparison of clams, examination of Figures 3 and 4 shows a high response of clams (and of mussels exposed with them) to sediment L. It is probable that suspension of contaminated sediment facilitated uptake of PCB in this treatment for both filter-feeding bivalves.

55. It was beyond the scope of this investigation to assess the role of sediment suspension on bioavailability and bioaccumulation of PCB associated with sediment. The existence of mechanisms of chemical uptake facilitation by SP can be inferred (e.g., Voice et al. 1983; Voice and Weber, Jr. 1983), are probably of substantial importance in the field, and require further research.

Projections of C_{ss}

56. The concentration of a chemical contaminant in an organism is said to be at steady-state (C_{ss}) when rates of elimination and uptake are balanced such that the net change in body burden is zero. A C_{ss} requires that chemical concentration in the medium to which an organism is exposed be constant. The conditions of exposure in this investigation were designed so that time-sequenced tissue sampling would yield results that could be used to project C_{ss}. The value of C_{ss} is that it provides an estimate of bioaccumulation that is not an unknown proportion of potential response requiring reference to

a specific exposure duration, but is the maximum response for a given exposure. Thus, C_{ss} provides a consistent point on uptake curves at which body burden of all species can be compared, regardless of the slope of the curve.

57. The simple one-compartment kinetic model (Branson et al. 1975, Others) integrated for constant exposure is:

$$C_T = \frac{k_1 C_w}{k_2}\left(1 - e^{-k_2 t}\right) \tag{1}$$

where

C_T = PCB concentration in tissue
$k_1 C_w$ = a constant for rate of uptake
k_2 = elimination rate constant
t = time

C_{ss} was calculated as the ratio of the constants,

$$C_{ss} = \frac{k_1 C_w}{k_2} \tag{2}$$

58. Equation 1 fitted lipid-normalized data more often than fresh weight data. Fresh weight C_{ss} in $\mu g\ g^{-1}$ was calculated from the lipid-normalized estimates using the means or regression intercepts reported in Table 4. Fresh weight C_{ss} for each PCB isomer group, total PCB and Aroclor 1242 are given in Tables 5-11. Mean PCB concentration in corresponding sediment (C_s) and sediment bioaccumulation factor (BAF) calculated as:

$$\text{sediment BAF} = \frac{C_{ss}}{C_s} \tag{3}$$

are also given in the tables.

59. Tables 12-18 show the corresponding lipid-normalized values of C_{ss}, the bioaccumulation potential (TBP) calculated according to the method described in McFarland (1984), the proportion, p, of bioaccumulation potential reached as well as whole water concentration (C_w) and bioaccumulation factors using C_w as the exposure concentration.

60. Fitted regressions are shown for isomer groups di-hexa CBP, total PCB, and A1242 for the 20° C mussel exposures in Figures 8a, 8b, and 8c. Vertical dashed lines in the figures separate the interval over which observations were made (30 days) from projections beyond the data.

Potential versus
<u>projected bioaccumulation</u>

61. The thermodynamically defined TBP of a chemical in sediment is a hypothetical maximum concentration that would result in organism lipid at equilibrium with the sediment. The purpose of TBP is to provide an α ρθιοθι evaluation based on sediment chemistry that estimates the upper limit of potential bioaccumlation from sediment as the sole source of contaminant to organisms. TBP was estimated in terms of lipid equivalency for sediment homogenates R, L, M and H and the proportional relationship, p , was calculated as:

$$p = \frac{C_{ss}}{TBP} \tag{4}$$

The proportion, p , is an indicator of bioaccumulation potential achieved. The idealized maximum value of p is 1.00. Tables 12-18 show a consistently lower proportion of TBP projected for organisms at C_{ss} as the concentration of PCB in sediments increases.

62. In some cases involving mussels and clams the idealized maximum p is exceeded for sediment homogenate R . Sediment R contained a mean concentration of total PCB of only 0.45 μg g^{-1} which was essentially the background PCB level of the clams. Mussels had substantially lower lipid content than any other organism. Since a fundamental assumption in TBP calculation is the primacy of lipid as representing the absorptive capacity of organisms, the higher than unity p's for mussels exposed to sediment R may indicate the lower limits of applicability of TBP.

63. The very low values of p calculated for more highly contaminated sediments show clearly that for PCB in deposited sediments, high concentrations do not result in similarly high tissue concentrations in fish and bivalves exposed to them. Higher concentrations in sediment result in increased levels in organism tissue, but the increase is not of the same magnitude in sediment and tissue.

64. The means of treatments (R, L, M, and H) and PCB isomer group

calculated data were compared by analysis of variance and the significant results are shown in Table 19. Over all organisms log-transformed p values were significantly lower for sediment treatment L than for R, and the treatments M and H were significantly lower than both L and R at $P < 0.0001$. Log-transformed sediment bioaccumulation factors varied similarly to p but did not show a significant difference between treatments L and R.

65. Whole water bioaccumulation factors (log BAF) showed increasing magnitude with increasing degree of PCB chlorination up to a point. For neutral chemicals, additional chlorination results mainly in increased molecular volume which increases structuring of water. Such structuring is negatively entropic and accounts for the diminishing water solubility of more massive neutral molecules. Significantly lower log BAF's were calculated for di- and trichlorobiphenyls but log BAF's of higher groups were not statistically differentiated. It is probable that virtually all highly chlorinated PCB is present in the water sorbed with organic or mineral material and not in true solution (Hiraizumi et al. 1979; Hassett and Anderson 1979; Means and Wijayaratne, 1982). If this is the case then the lack of increase in log BAF for whole water beyond the levels shown in Tables 14-16 appears consistent with their expected low activity in nonpolar media or at surfaces.

Summary and Conclusions

66. Two species of bivalve mollusk and three of fish were exposed under flowing water for up to 30 days to homogenates composed of sediments from Sheboygan Harbor, Wis. Exposures were duplicated simultaneously at constant temperatures of 4° C and 20° C following temperature acclimation of the organisms. Samples of tissue, water, and sediment were taken under various time schedules and analyzed for PCB as totals in isomer groups, total PCB and as Aroclor mixtures (where possible).

67. Concentrations of PCB in sediments were not detectably diminished after 60 days under flowing water. Time-sequenced sampling of organisms permitted use of curve-fitting techniques involving a simple one-compartment whole organism-water kinetic model. Steady-state (C_{ss}) residues in organisms in response to the several levels of exposure were projected. Bioaccumulation potential (TBP) calculated from sediment chemistry was compared with the

projections of bioaccumulation based on the experimental results. Several conclusions derive:

a. Bioaccumulation was minimal at 4° C and was enhanced at 20° C.

b. Organisms of higher lipid content bioaccumulated PCB to higher levels than those of low lipid content.

c. PCB of all degrees of chlorination was bioaccumulated from sediment by aquatic organisms.

d. Direct contact with contaminated sediment was not necessary for bioaccumulation to occur.

e. For deposited sediments, high PCB concentrations did not result in similarly high residues in the tissues of organisms. Higher concentrations in sediment tended to result in increased levels in organism tissue, but the increase was of a lower magnitude in tissue than in sediment.

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Table 1

Location, Depth, and PCB Content* of Sheboygan Harbor Sediment Samples

Gage = 2.5 ft, All Depths Given Without Gage

Sample	Location	Water Depth ft	Dug Down to ft	Sample Taken at ft	Dry Weight PCB, ppm,
S-1	Sta 52+00 12 ft south of north revetment	11.3	23.0	23.0-23.5	18, 9, 20, 12
S-2	Sta 52+00 122 ft north of south revetment	16.0	22.0	22.0-24.0	84, 81, 46, 85 75, 82, 140, 140, 130, 50, 47, 34
S-3	Sta 37+00 90 ft north of south revetment	18.7	24.5	24.5-25.0	34, 33, 37, 25, 9.4, 12, 11, 41
S-4	Sta 37+00 25 ft north of south revetment	18.0	24.0	24.0-25.0	23, 30, 48, 24, 24, 26, 32, 52
S-5	Sta 6+00 200 ft north of south breakwater	23.0	Sediment surface	23.0-24.5	1.0, 1.4, 2.3, 1.0

* PCB as total in isomer groups di-decachlorobiphenyl.

Table 2

Distribution of Organisms in Treatments

Temperature °C	Treatment	Aquarium No.	Organism[1]
4	Control	16	M, C, K, T
	Reference	15	C, K, T
		18	M, C*
	Low	13	C, K, T
		19	C, F
		21	M, C*
	Medium	14	C, K, T
		17	--
		24	M, C*
	High	20	C, K, T
		22	C, F
		23	M, C*
20	Control	1	M, C, K, T
	Reference	3	C, K, T
		6	M, C*
	Low	4	C, K, T
		7	C, F
		9	M, C*
	Medium	2	C, K, T
		5	C, F
		12	M, C*
	High	8	K, C, T
		10	C, F
		11	M, C*

[1] M = mussels, C = clams (not in contact with sediment), C* = clams (in contact with sediment), K = killifish (medaka), F = fatheads, T = trout.

Table 3

Characteristics of Sediment Homogenates: Means (Standard Deviations)

Sediment	Total PCB $\mu g\ g^{-1}$	A1242 $\mu g\ g^{-1}$	Moisture Percent	TOC Percent	Sand:Silt:Clay Percent
Reference R	0.45 (0.23)	0.10 (0.00)	24 (0.77)	1.5 (0.21)	62.1 : 18.8 : 19.2 (2.92):(2.62):(1.29)
Low PCB L	4.0 (0.89)	4.6 (1.3)	28 (0.20)	1.6 (0.18)	62.5 : 17.5 : 20.0 (0.00):(0.00):(0.00)
Medium PCB M	33.0 (4.3)	23.0 (5.1)	48 (0.12)	1.6 (0.18)	43.3 : 20.8 : 35.8 (1.44):(1.44):(1.44)
High PCB H	44.0 (10.0)	35.0 (3.7)	46 (0.22)	1.6 (0.21)	37.5 : 27.5 : 35.0 (0.00):(0.00):(0.00)

Table 4

Regressions of Percent Lipid over Time

Organism	Number of Observations	Regression Test of Significance F	P	Initial Percent Lipid (95 percent Confidence Interval) a*	Mean Percent Lipid (95 percent Confidence Internal) $\bar{x}$
Mussels	49	0.040	0.8419	0.26(0.040)	0.26(0.026)
Clams (contact)	40	0.044	0.8345	2.04(0.243)	2.02(0.150)
Clams (no contact)	33	0.033	0.8569	2.09(0.295)	2.07(0.199)
Clams (all)	73	0.069	0.7932	2.06(0.182)	2.04(0.119)
Medaka	31	33.210	0.0001	6.75(0.840)	5.00(0.814)
Fatheads	15	0.062	0.8070	1.04(0.160)	1.05(0.122)
Trout	39	5.674	0.0225	4.29(0.675)	3.76(0.532)

* Initial percent lipid is Y-intercept (a) from regression percent lipid = a + b(day).

Table 5

Calculated Data Using Time-Sequence Sampled Residues and Simple Kinetic Model for Fresh Weight Dichlorobiphenyls in Organisms Exposed to Sheboygan Harbor Sediments

Temperature, °C	Organism	Treatment*	C_{ss}** $\mu g\ g^{-1}$	± (Range†)	C_s $\mu g\ g^{-1}$	Sediment BAF
4	Mussels	R	0.0092	(0.00092)	0.016	0.58
		L	0.024	(0.0024)	0.37	0.065
		M	0.027	(0.0027)	8.8	0.0031
	Trout	M	0.28	(0.043)	8.8	0.032
		H	0.26	(0.040)	6.1	0.042
20	Mussels	R	0.016	(0.0016)	0.016	1.0
		L	0.072	(0.0072)	0.37	0.19
		M	0.16	(0.016)	8.8	0.018
		H	0.27	(0.027)	6.1	0.044
	Clams	L	0.40	(0.024)	0.37	1.1
		M	8.1	(0.48)	8.8	0.92
		H	1.3	(0.079)	6.1	0.21
	Medaka	R	0.17	(0.021)	0.016	10.6
		L	0.33	(0.041)	0.37	0.89
		M	0.75	(0.093)	8.8	0.085
		H	0.48	(0.060)	6.1	0.079

* Treatment: Reference, low, medium, high.
** See text p. 16 for explanation of symbols.
† Range based on 95 percent confidence interval for lipid (see Table 4).

Table 5

Calculated Data Using Time-Sequence Sampled Residues and Simple Kinetic Model for Fresh Weight Dichlorobiphenyls in Organisms Exposed to Sheboygan Harbor Sediments

Temperature, °C	Organism	Treatment*	C_{ss}** $\mu g\ g^{-1}$	± (Range†)	C_s $\mu g\ g^{-1}$	Sediment BAF
4	Mussels	R	0.0092	(0.00092)	0.016	0.58
		L	0.024	(0.0024)	0.37	0.065
		M	0.027	(0.0027)	8.8	0.0031
	Trout	M	0.28	(0.043)	8.8	0.032
		H	0.26	(0.040)	6.1	0.042
20	Mussels	R	0.016	(0.0016)	0.016	1.0
		L	0.072	(0.0072)	0.37	0.19
		M	0.16	(0.016)	8.8	0.018
		H	0.27	(0.027)	6.1	0.044
	Clams	L	0.40	(0.024)	0.37	1.1
		M	8.1	(0.48)	8.8	0.92
		H	1.3	(0.079)	6.1	0.21
	Medaka	R	0.17	(0.021)	0.016	10.6
		L	0.33	(0.041)	0.37	0.89
		M	0.75	(0.093)	8.8	0.085
		H	0.48	(0.060)	6.1	0.079

* Treatment: Reference, low, medium, high.
** See text p. 16 for explanation of symbols.
† Range based on 95 percent confidence interval for lipid (see Table 4).

Table 6

Calculated Data Using Time-Sequence Sampled Residues and Simple Kinetic Model for Fresh Weight Trichlorobiphenyls in Organisms Exposed to Sheboygan Harbor Sediments

Temperature, °C	Organism	Treatment*	C_{ss}** $\mu g\ g^{-1}$	± (Range†)	C_s $\mu g\ g^{-1}$	Sediment BAF
4	Mussels	R	0.0024	(0.00024)	0.036	0.067
		L	0.056	(0.0056)	0.79	0.071
		M	0.017	(0.0017)	4.7	0.0036
	Clams	R	0.013	(0.0008)	0.036	0.36
	Fatheads	L	0.032	(0.0037)	0.79	0.041
		H	0.081	(0.0092)	8.2	0.0099
	Trout	L	0.22	(0.034)	0.79	0.28
		M	0.16	(0.025)	4.7	0.034
		H	0.25	(0.038)	8.2	0.030
20	Mussels	R	0.011	(0.0011)	0.036	0.31
		L	0.16	(0.016)	0.79	0.20
		M	0.13	(0.013)	4.7	0.028
		H	0.19	(0.019)	8.2	0.023
	Clams	L	0.31	(0.018)	0.79	0.39
		M	0.75	(0.044)	4.7	0.16
		H	0.77	(0.045)	8.2	0.094
	Medaka	R	0.18	(0.022)	0.036	5.0
		L	0.94	(0.12)	0.79	1.2
		M	3.9	(0.49)	4.7	0.83
		H	1.6	(0.20)	8.2	0.20

* Treatment: Reference, low, medium, high.
** See text p. 16 for explanation of symbols.
† Range based on 95 percent confidence interval for lipid (see Table 4).

Table 7

Calculated Data Using Time-Sequence Sampled Residues and Simple Kinetic Model for Fresh Weight Tetrachlorobiphenyls in Organisms Exposed to Seboygan Harbor PCB-Contaminated Sediments

Temperature, °C	Organism	Treatment*	C_{ss}** µg g^{-1}	± (Range†)	C_s µg g^{-1}	Sediment BAF
4	Mussels	R	0.0071	(0.00071)	0.28	0.025
		M	0.018	(0.0018)	12.0	0.0015
		H	0.57	(0.057)	18.0	0.032
	Clams	R	0.053	(0.0031)	0.28	0.19
	Fatheads	L	0.044	(0.0051)	1.7	0.026
		H	0.11	(0.013)	18.0	0.0061
	Trout	L	0.10	(0.016)	1.7	0.059
		M	0.12	(0.019)	12.0	0.010
		H	0.26	(0.040)	18.0	0.014
20	Mussels	R	0.014	(0.0014)	0.28	0.050
		L	0.30	(0.030)	1.7	0.18
		M	0.28	(0.028)	12.0	0.023
		H	0.33	(0.033)	18.0	0.018
	Clams	L	0.33	(0.019)	1.7	0.19
		H	0.81	(0.047)	18.0	0.045
	Medaka	R	0.15	(0.019)	0.28	0.54
		H	6.3	(0.79)	18.0	0.35

* Treatment: Reference, low, medium, high.
** See text p. 16 for explantion of symbols.
† Range based on 95 percent confidence interval for lipid (see Table 4).

Table 8

Calculated Data Using Time-Sequence Sampled Residues and Simple Kinetic Model for Fresh Weight Pentachlorobiphenyls in Organisms Exposed to Sheboygan Harbor PCB-Contaminated Sediments

Temperature, °C	Organism	Treatment*	C_{ss}** $\mu g\ g^{-1}$	± (Range†)	C_s $\mu g\ g^{-1}$	Sediment BAF
4	Mussels	R	0.0027	(0.00027)	0.016	0.17
		L	0.0091	(0.00091)	0.37	0.024
		M	0.0045	(0.00045)	2.5	0.0018
	Fatheads	L	0.048	(0.0055)	0.37	0.13
		H	0.043	(0.0049)	3.8	0.011
	Trout	R	0.029	(0.0046)	0.016	1.81
		L	0.036	(0.0057)	0.37	0.097
		H	0.058	(0.0090)	3.8	0.015
20	Mussels	R	0.0057	0.00057)	0.016	0.36
		L	0.11	(0.011)	0.37	0.30
		M	0.28	(0.028)	2.5	0.11
		H	0.14	(0.014)	3.8	0.037
	Clams	L	0.093	(0.0055)	0.37	0.25
		M	2.4	(0.14)	2.5	0.96
		H	0.28	(0.017)	3.8	0.074
	Medaka	R	0.11	(0.014)	0.016	6.88
		L	0.66	(0.082)	0.37	1.78
		H	0.76	(0.094)	3.8	0.20

* Treatment: Reference, low, medium, high.
** See text p. 16 for explanation of symbols.
† Range based on 95 percent confidence interval for lipid (see Table 4).

Table 9

Calculated Data Using Time-Sequence Sampled Residues and Simple Kinetic Model for Fresh Weight Hexachlorobiphenyls in Organisms Exposed to Sheboygan Harbor PCB-Contaminated Sediments

Temperature, °C	Organism	Treatment*	C_{ss}** $\mu g\ g^{-1}$	± (Range†)	C_s $\mu g\ g^{-1}$	Sediment BAF
4	Mussels	R	0.084	(0.0084)	0.062	1.35
		L	0.0093	(0.00093)	0.68	0.014
		M	0.0061	(0.00061)	4.7	0.0013
	Fatheads	L	0.090	(0.010)	0.68	0.13
		H	0.062	(0.0070)	7.4	0.0084
	Trout	R	0.061	(0.0096)	0.062	0.98
		L	0.048	(0.0048)	0.68	0.071
		M	0.069	(0.011)	4.7	0.015
		H	0.078	(0.012)	7.4	0.011
20	Mussels	R	0.0090	(0.00090)	0.062	0.15
		L	0.20	(0.020)	0.68	0.29
		M	0.50	(0.050)	4.7	0.11
		H	0.32	(0.032)	7.4	0.043
	Clams	R	0.99	(0.058)	0.062	16.0
		L	0.22	(0.013)	0.68	0.32
		M	0.28	(0.016)	4.7	0.060
		H	0.39	(0.023)	7.4	0.053
	Medaka	R	0.18	(0.022)	0.062	2.9
		L	0.91	(0.11)	0.68	1.34
		H	2.7	(0.33)	7.4	0.36

* Treatment: Reference, low, medium, high.
** See text p. 16 for explanation of symbols.
† Range based on 95 percent confidence interval for lipid (see Table 4).

Table 10

Calculated Data Using Time-Sequence Sampled Residues and Simple Kinetic Model for Fresh Weight Total PCB in Organisms Exposed to Sheboygan Harbor PCB-Contaminated Sediments

Temperature, °C	Organism	Treatment*	C_{ss}** $\mu g\ g^{-1}$	± (Range†)	C_s $\mu g\ g^{-1}$	Sediment BAF
4	Mussels	R	0.028	(0.0028)	0.45	0.062
		L	0.20	(0.020	4.0	0.050
		M	0.072	(0.072)	33.0	0.0022
	Fatheads	L	0.25	(0.029)	4.0	0.063
		H	0.37	(0.042)	44.0	0.0084
	Trout	L	1.0	(0.16)	4.0	0.25
		M	0.64	(0.10)	33.0	0.019
		H	0.85	(0.13)	44.0	0.019
20	Mussels	R	0.054	(0.0054)	0.45	0.12
		L	0.83	(0.083)	4.0	0.21
		M	0.87	(0.087)	33.0	0.026
		H	1.1	(0.11)	44.0	0.025
	Clams	L	1.2	(0.069)	4.0	0.30
		M	5.3	(0.31)	33.0	0.16
		H	3.3	(0.19)	44.0	0.075
	Medaka	R	0.81	(0.10)	0.45	1.80
		L	4.3	(0.58)	4.0	1.1
		H	8.9	(1.1)	44.0	0.20

* Treatment: Reference, low, medium, high.
** See text p. 16 for explanation of symbols.
† Range based on 95 percent confidence interval for lipid (see Table 4).

Table 11

Calculated Data Using Time-Sequence Sampled Residues and Simple Kinetic Model for Fresh Weight Aroclor 1242 in Organisms Exposed to Sheboygan Harbor PCB-Contaminated Sediments

Temperature, °C	Organism	Treatment*	C_{ss}** µg g^{-1}	± (Range†)	C_s µg g^{-1}	Sediment BAF
4	Mussels	R	0.0028	(0.00028)	0.10	0.028
		M	0.059	(0.0059)	23.0	0.0026
	Fatheads	H	0.37	(0.043)	35.0	0.011
	Trout	M	1.2	(0.19)	23.0	0.052
		H	0.88	(0.14)	35.0	0.025
20	Mussels	R	0.047	(0.0047)	0.10	0.47
		L	0.88	(0.088)	4.6	0.19
		M	0.64	(0.064)	23.0	0.028
		H	0.89	(0.089)	35.0	0.025
	Medaka	L	4.7	(0.58)	4.6	1.02
		M	19.0	(2.3)	23.0	0.83
		H	9.5	(1.2)	35.0	0.27

* Treatment: Reference, low, medium, high.
** See text p. 16 for explanation of symbols.
† Range based on 95 percent of confidence interval for lipid (see Table 4).

Table 12

Calculated Data Using Time-Sequence Sampled Residues and Simple Kinetic Model for Lipid-Normalized Dichlorobiphenyls in Organisms Exposed to Sheboygan Harbor Sediments

Temperature, °C	Organism	Treatment*	C_{ss}** $\mu g\ g^{-1}$	TBP $\mu g\ g^{-1}$	p	C_w $\mu g\ \ell^{-1}$	Whole Water log BAF
4	Mussels	R	3.6	2.0	1.8	0.011	5.51
		L	9.3	43.0	0.22	0.02	5.67
		M	10.0	1000.0	0.01	0.022	5.66
	Trout	M	6.5	1000.0	0.0065	0.045	5.16
		H	6.0	730.0	0.0082	0.029	5.32
20	Mussels	R	6.0	2.0	3.0	0.054	5.05
		L	28.0	43.0	0.65	0.33	4.93
		M	60.0	1000.0	0.060	0.89	4.83
		H	100.0	730.0	0.14	0.14	5.85
	Clams	L	20.0	43.0	0.47	0.54	4.57
		M	400.0	1000.0	0.40	0.66	5.78
		H	66.0	730.0	0.090	0.46	5.16
	Medaka	R	2.5	2.0	1.3	0.058	4.63
		L	4.9	43.0	0.11	0.74	3.82
		M	11.0	1000.0	0.011	0.42	4.42
		H	7.1	730.0	0.0097	0.43	4.22

* Treatment: Reference, low, medium, high.
** See text p. 16 for explanation of symbols.

Table 13

Calculated Data Using Time-Sequence Sampled Residues and Simple Kinetic Model for Lipid-Normalized Trichlorobiphenyls in Organisms Exposed to Sheboygan Harbor Sediments

Temperature, °C	Organism	Treatment*	C_{ss}** μg g^{-1}	TBP μg g^{-1}	p	C_w μg ℓ^{-1}	Whole Water log BAF
4	Mussels	R	0.91	22.0	0.041	0.0050	5.26
		L	21.0	95.0	0.22	0.0064	6.52
		M	6.4	560.0	0.011	0.0075	5.93
	Clams	R	0.64	22.0	0.029	0.0040	5.20
	Fatheads	L	3.1	95.0	0.033	0.010	5.49
		H	7.7	980.0	0.0079	0.045	5.23
	Trout	L	5.0	95.0	0.053	0.012	5.62
		M	3.7	560.0	0.0066	0.012	5.49
		H	5.7	980.0	0.0058	0.012	5.68
20	Mussels	R	4.2	22.0	0.19	0.0070	5.78
		L	62.0	95.0	0.65	0.035	6.25
		M	50.0	560.0	0.089	0.10	5.70
		H	72.0	980.0	0.073	0.045	6.20
	Clams	L	15.0	95.0	0.16	0.056	5.43
		M	37.0	560.0	0.066	0.072	5.71
		H	38.0	980.0	0.039	0.039	5.99
	Medaka	R	2.7	22.0	0.12	0.0070	5.59
		L	14.0	95.0	0.15	0.076	5.27
		M	58.0	560.0	0.10	0.044	6.12
		H	23.0	980.0	0.023	0.033	5.84

* Treatment: Reference, low, medium, high.
** See text p. 16 for explanation of symbols.

Table 14

Calculated Data Using Time-Sequence Sampled Residues and Simple Kinetic Model for Lipid-Normalized Tetrachlorobiphenyls in Organisms Exposed to Sheboygan Harbor Sediments

Temperature, °C	Organism	Treatment*	C_{ss}** $\mu g\ g^{-1}$	TBP $\mu g\ g^{-1}$	p	C_w $\mu g\ \ell^{-1}$	Whole Water log BAF
4	Mussels	R	2.7	36.0	0.075	0.0046	5.77
		M	6.9	1400.0	0.0049	0.0072	5.98
		H	220.0	2200.0	0.10	0.023	6.98
	Clams	R	2.6	36.0	0.072	0.0033	5.90
	Fatheads	L	4.2	210.0	0.020	0.012	5.54
		H	11.0	2200.0	0.0050	0.052	5.33
	Trout	L	2.3	210.0	0.011	0.0087	5.42
		M	2.8	1400.0	0.0020	0.015	5.27
		H	6.0	2200.0	0.0027	0.012	5.70
20	Mussels	R	5.2	36.0	0.14	0.0031	6.22
		L	120.0	210.0	0.57	0.044	6.44
		M	110.0	1400.0	0.079	0.013	6.93
		H	130.0	2200.0	0.059	0.049	6.42
	Clams	L	16.0	210.0	0.076	0.059	5.43
		H	40.0	2200.0	0.018	0.049	5.91
	Medaka	R	2.2	36.0	0.061	0.037	4.77
		H	94.0	2200.0	0.043	0.048	6.29

* Treatment: Reference, low, medium, high.
** See text p. 16 for explanation of symbols.

Table 15

Calculated Data Using Time-Sequence Sampled Residues and Simple Kinetic Model for Lipid-Normalized Pentachlorobiphenyls in Organisms Exposed to Sheboygan Harbor Sediments

Temperature, °C	Organism	Treatment*	C_{ss}** $\mu g\ g^{-1}$	TBP $\mu g\ g^{-1}$	p	C_w $\mu g\ \ell^{-1}$	Whole Water log BAF
4	Mussels	R	1.0	2.0	0.50	0.00053	6.28
		L	3.5	45.0	0.078	0.00072	6.69
		M	1.7	290.0	0.0059	0.0014	6.08
	Fatheads	L	4.6	45.0	0.10	0.0019	6.38
		H	4.1	460.0	0.0089	0.013	5.50
	Trout	R	0.68	2.0	0.34	0.00026	6.42
		L	0.85	45.0	0.019	0.0022	5.59
		H	1.3	460.0	0.0028	0.0024	5.73
20	Mussels	R	2.2	2.0	1.1	0.00069	6.50
		L	43.0	45.0	0.96	0.0097	6.65
		M	110.0	290.0	0.38	0.038	6.46
		H	55.0	460.0	0.12	0.0091	6.78
	Clams	L	4.6	45.0	0.10	0.012	5.58
		M	120.0	290.0	0.41	0.028	6.63
		H	14.0	460.0	0.030	0.011	6.10
	Medaka	R	1.6	2.0	0.80	0.00057	6.45
		L	9.8	45.0	0.22	0.015	5.82
		H	11.0	460.0	0.024	0.013	5.93

* Treatment: Reference, low, medium, high.
** See text p. 16 for explanation of symbols.

Table 16

Calculated Data Using Time-Sequence Sampled Residues and Simple Kinetic Model for Lipid-Normalized Hexachlorobiphenyls in Organisms Exposed to Sheboygan Harbor Sediments

Temperature, °C	Organism	Treatment*	C_{ss}** $\mu g\ g^{-1}$	TBP $\mu g\ g^{-1}$	p	C_w $\mu g\ \ell^{-1}$	Whole Water log BAF
4	Mussels	R	32.0	7.7	4.2	0.00042	7.88
		L	3.6	81.0	0.044	0.0010	6.56
		M	1.7	290.0	0.0059	0.0014	6.08
	Fatheads	L	8.6	81.0	0.11	0.0018	6.68
		H	5.9	890.0	0.0066	0.022	5.43
	Trout	R	1.4	7.7	0.18	0.00062	6.35
		L	1.1	81.0	0.014	0.0016	5.84
		M	1.6	560.0	0.0029	0.0031	5.71
		H	1.8	890.0	0.0020	0.0045	5.60
20	Mussels	R	3.5	7.7	0.45	0.00035	7.00
		L	75.0	81.0	0.93	0.016	6.67
		M	190.0	560.0	0.34	0.080	6.38
		H	120.0	890.0	0.13	0.017	6.85
	Clams	R	48.0	7.7	6.2	0.00046	8.02
		L	11.0	81.0	0.14	0.024	5.66
		M	14.0	560.0	0.025	0.059	5.38
		H	19.0	890.0	0.021	0.021	5.96
	Medaka	R	2.6	7.7	0.34	0.00057	6.66
		L	14.0	81.0	0.17	0.032	5.64
		H	39.0	890.0	0.044	0.025	6.19

* Treatment: Reference, low, medium, high.
** See text p. 16 for explanation of symbols.

Table 17

Calculated Data Using Time-Sequence Sampled Residues and Simple Kinetic Model for Lipid-Normalized Total PCB Residues in Organisms Exposed to Sheboygan Harbor Sediments

Temperature, °C	Organism	Treatment*	C_{ss}** $\mu g\ g^{-1}$	TBP $\mu g\ g^{-1}$	p	C_w $\mu g\ \ell^{-1}$	Whole Water log BAF
4	Mussels	R	11.0	61.0	0.18	0.023	5.68
		L	76.0	480.0	0.16	0.034	6.35
		M	28.0	3900.0	0.0072	0.040	5.85
	Fatheads	L	24.0	480.0	0.050	0.049	5.69
		H	35.0	5300.0	0.0066	0.18	5.29
	Trout	L	24.0	480.0	0.050	0.053	5.66
		M	15.0	3900.0	0.0038	0.079	5.28
		H	20.0	5300.0	0.0038	0.061	5.52
20	Mussels	R	21.0	61.0	0.34	0.065	5.51
		L	320.0	480.0	0.67	0.43	5.87
		M	330.0	3900.0	0.085	1.1	5.48
		H	430.0	5300.0	0.081	0.60	5.86
	Clams	L	58.0	480.0	0.12	0.69	4.92
		M	260.0	3900.0	0.067	0.84	5.49
		H	160.0	5300.0	0.030	0.58	5.44
	Medaka	R	12.0	61.0	0.20	0.10	5.08
		L	64.0	480.0	0.13	0.94	4.83
		H	130.0	5300.0	0.025	0.55	5.37

* Treatment: Reference, low, medium, high.
** See text p. 16 for explanation of symbols.

Table 18

Calculated Data Using Time-Sequence Sampled Residues and Simple Kinetic Model for Lipid-Normalized Aroclor 1242 Residues in Organisms Exposed to Sheboygan Harbor Sediments

Temperature, °C	Organism	Treatment*	C_{ss}** $\mu g\ g^{-1}$	TBP $\mu g\ g^{-1}$	p	C_w $\mu g\ \ell^{-1}$	Whole Water log BAF
4	Mussels	R	1.1	13.0	0.085	0.02	4.74
		M	23.0	2700.0	0.0085	0.03	5.88
	Fatheads	H	36.0	4200.0	0.0086	0.19	5.28
	Trout	M	28.0	2700.0	0.010	0.05	5.75
		H	21.0	4200.0	0.0050	0.05	5.62
20	Mussels	R	18.0	13.0	1.4	0.02	5.95
		L	340.0	560.0	0.61	0.17	6.30
		M	250.0	2700.0	0.093	0.70	5.55
		H	340.0	4200.0	0.081	0.21	6.21
	Medaka	L	69.0	560.0	0.12	0.38	5.26
		M	280.0	2700.0	0.10	0.25	6.05
		H	140.0	4200.0	0.033	0.16	5.94

* Treatment: Reference, low, medium, high.
** See text p. 16 for explanation of symbols.

Table 19

Significant Results of Analysis of Variance Comparing Mean Values of Treatments and PCB Isomer Groups for Proportion (p) of Steady State Reached, Sediment BAF, and Lipid-Normalized Whole Water Log BAF

Variable	Effect	Mean	<	Mean	P
p log-transformed*	Treatment**	M, H	<	L, R	0.0001
		L	<	R	
Sediment BAF log-transformed*	Treatment	M, H	<	L, R	0.0001
Lipid-nomalized whole water log BAF	PCB isomer group	di	<	tetra, penta, hexa	0.0001
		tri	<	penta, hexa	

* Log tranformation was used to correct heterogeneity of variance.
** Treatment: Reference (R), low (L), medium (M), high (H) PCB content in sediment.

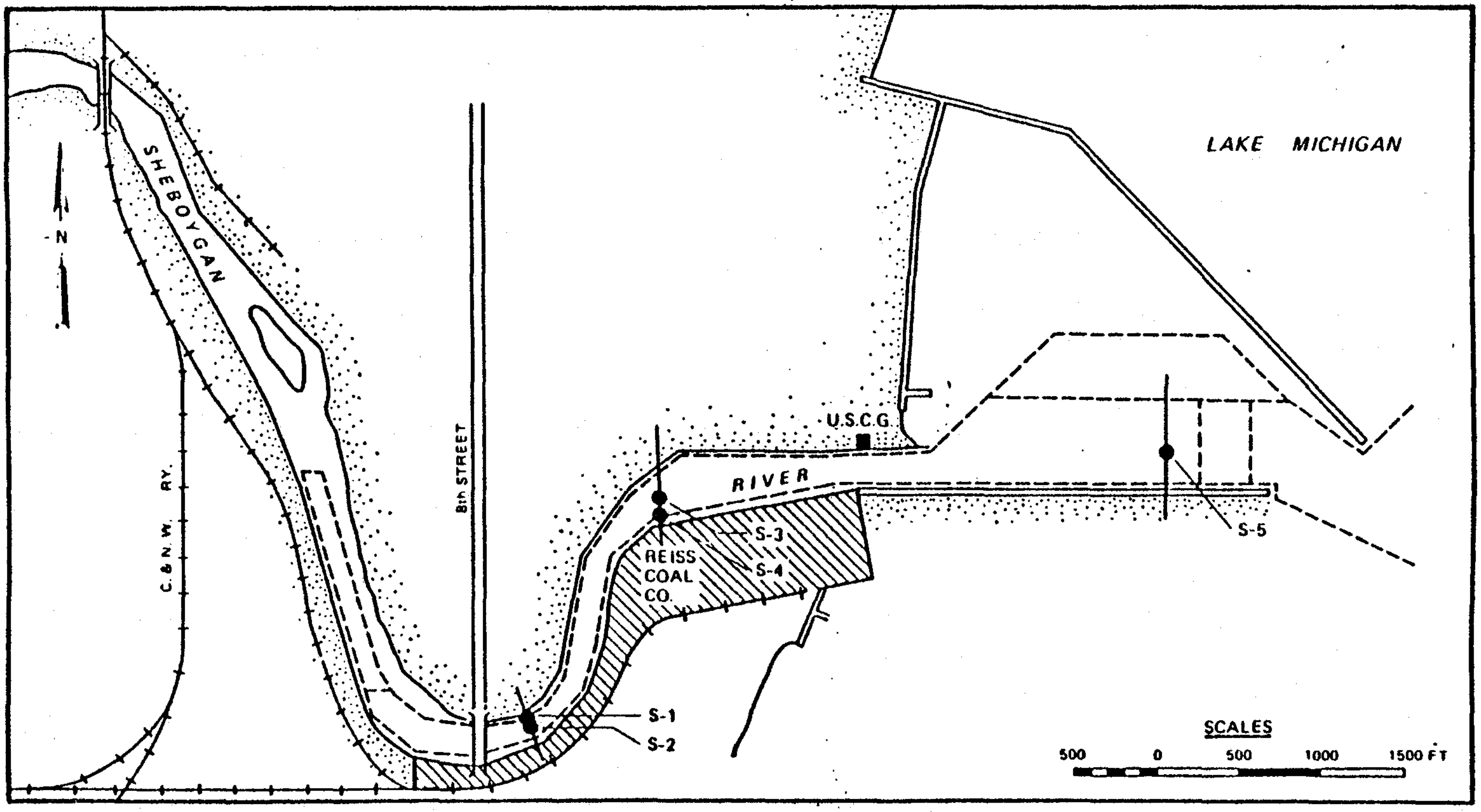

Figure 1. Location of Sediment Sample Sites in Sheboygan Harbor, WI. Collection made 3 April 1984.

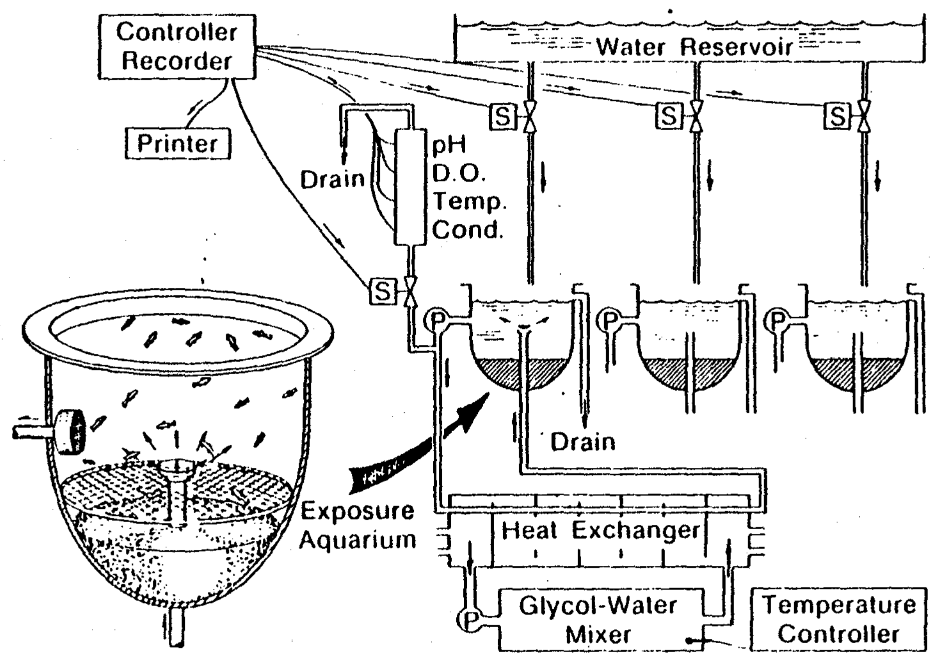

Figure 2. Flow-through Exposure System

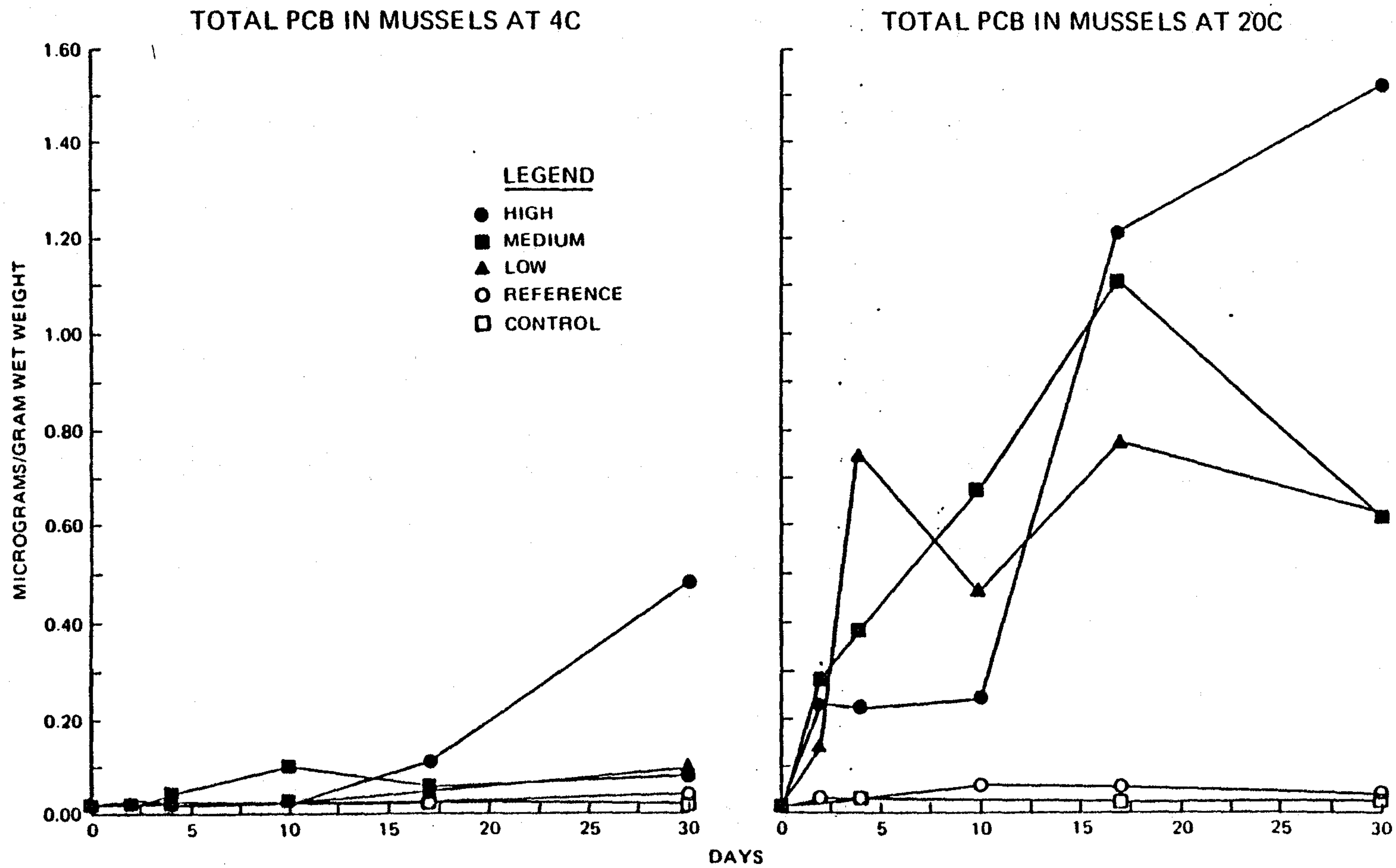

Figure 3. Total PCB in Mussels, Lampsilis silicoidea ventriculata, exposed to Sheboygan Harbor Sediments (R, L, M, and H) or to Washed Gravel (C) at 4°C or 20°C for Periods up to 30 Days.

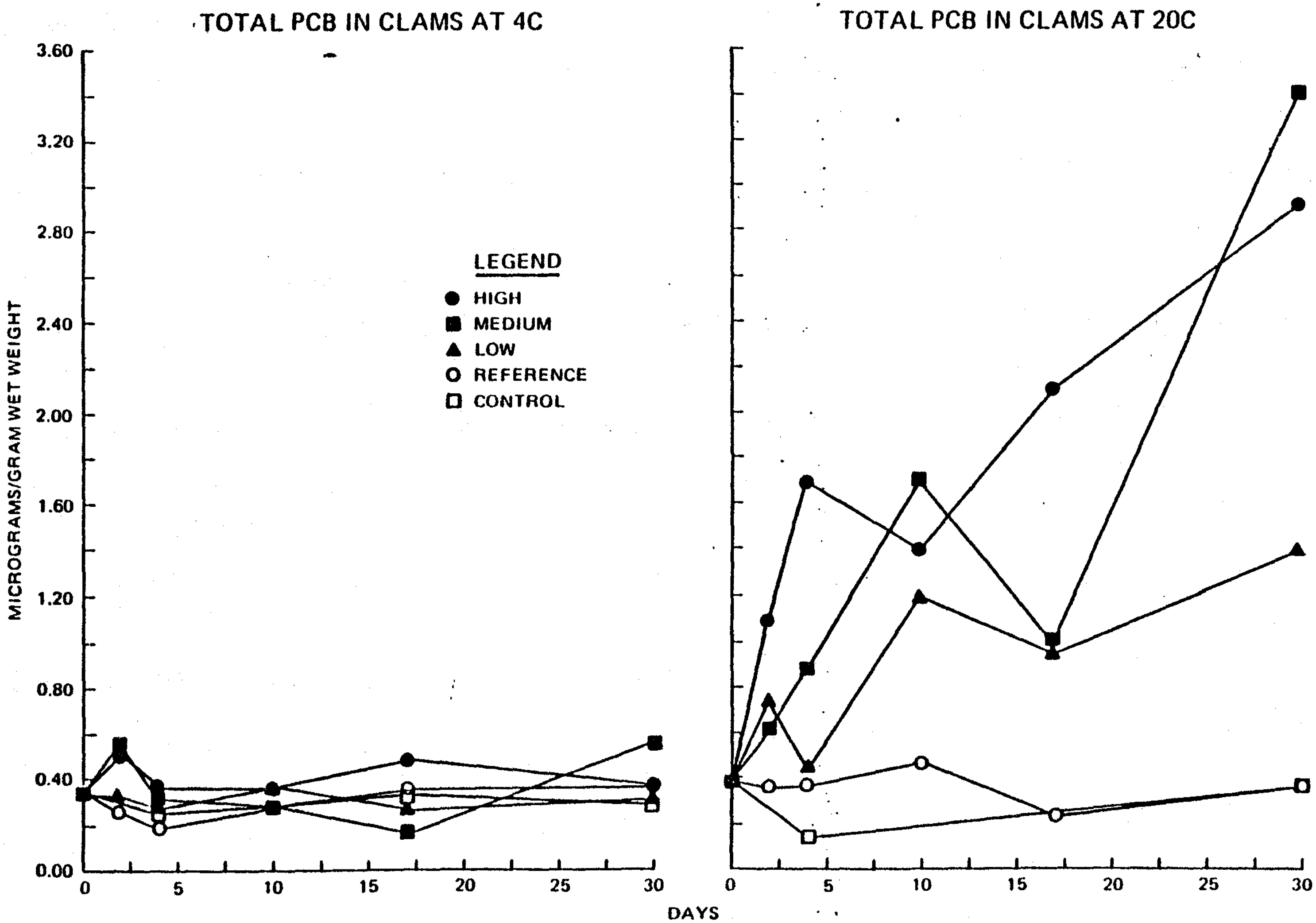

Figure 4. Total PCB in Clams, Corbicula fluminea, exposed to Sheboygan Harbor Sediments (R, L, M and H) or to Washed Gravel (C) at 4°C or 20°C for Periods up to 30 Days.

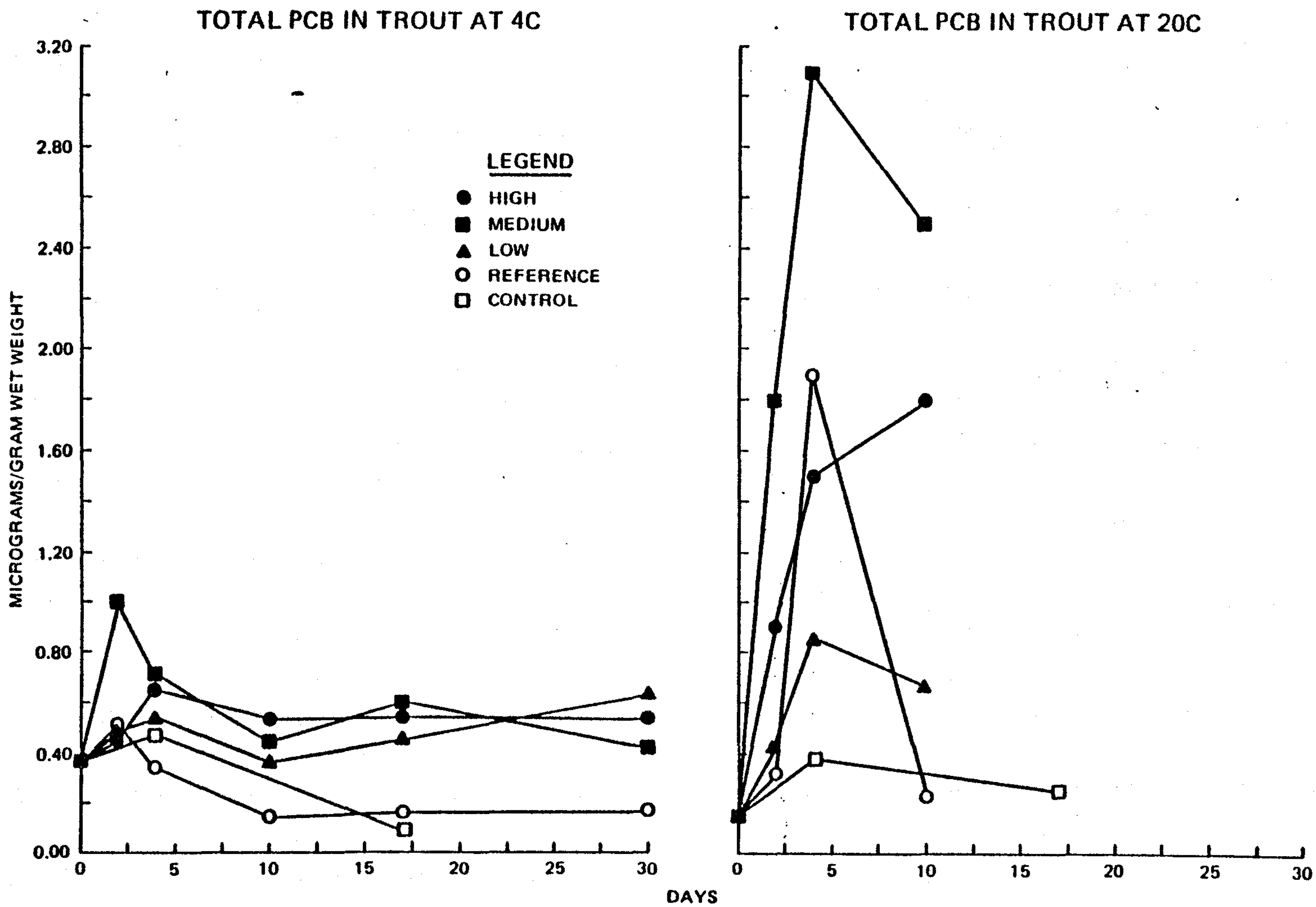

Figure 5. Total PCB in Trout, Salmo gairdneri, Exposed to Sheboygan Harbor Sediments (R, L, M and H) or to Washed Gravel (C) at 4°C or 20°C for Periods up to 30 Days.

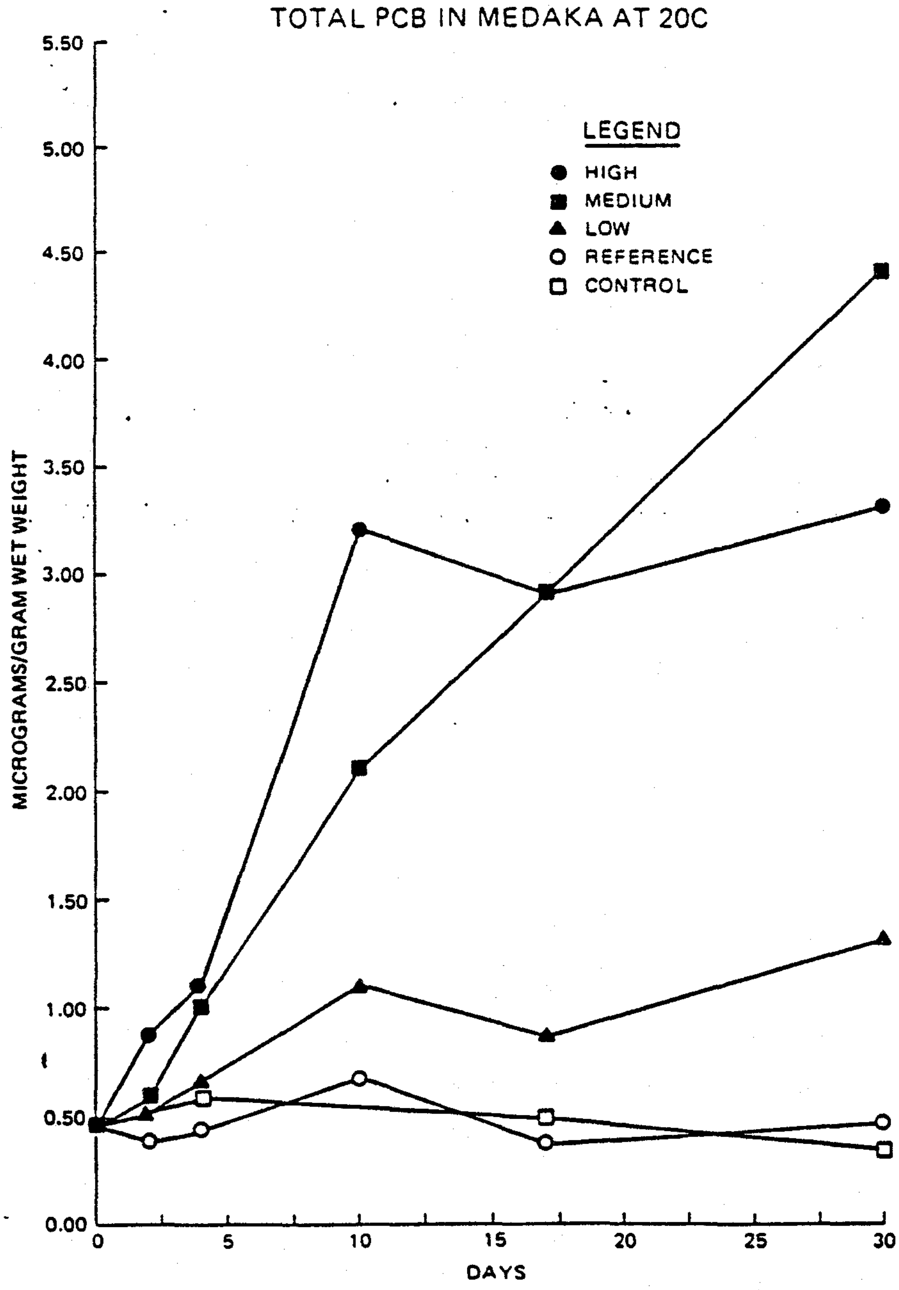

Figure 6. Total PCB in Medaka (killifish), Oryzias latipes, Exposed to Sheboygan Harbor Sediments (R, L, M, and H) or to Washed Gravel (C) at 20°C for periods up to 30 days.

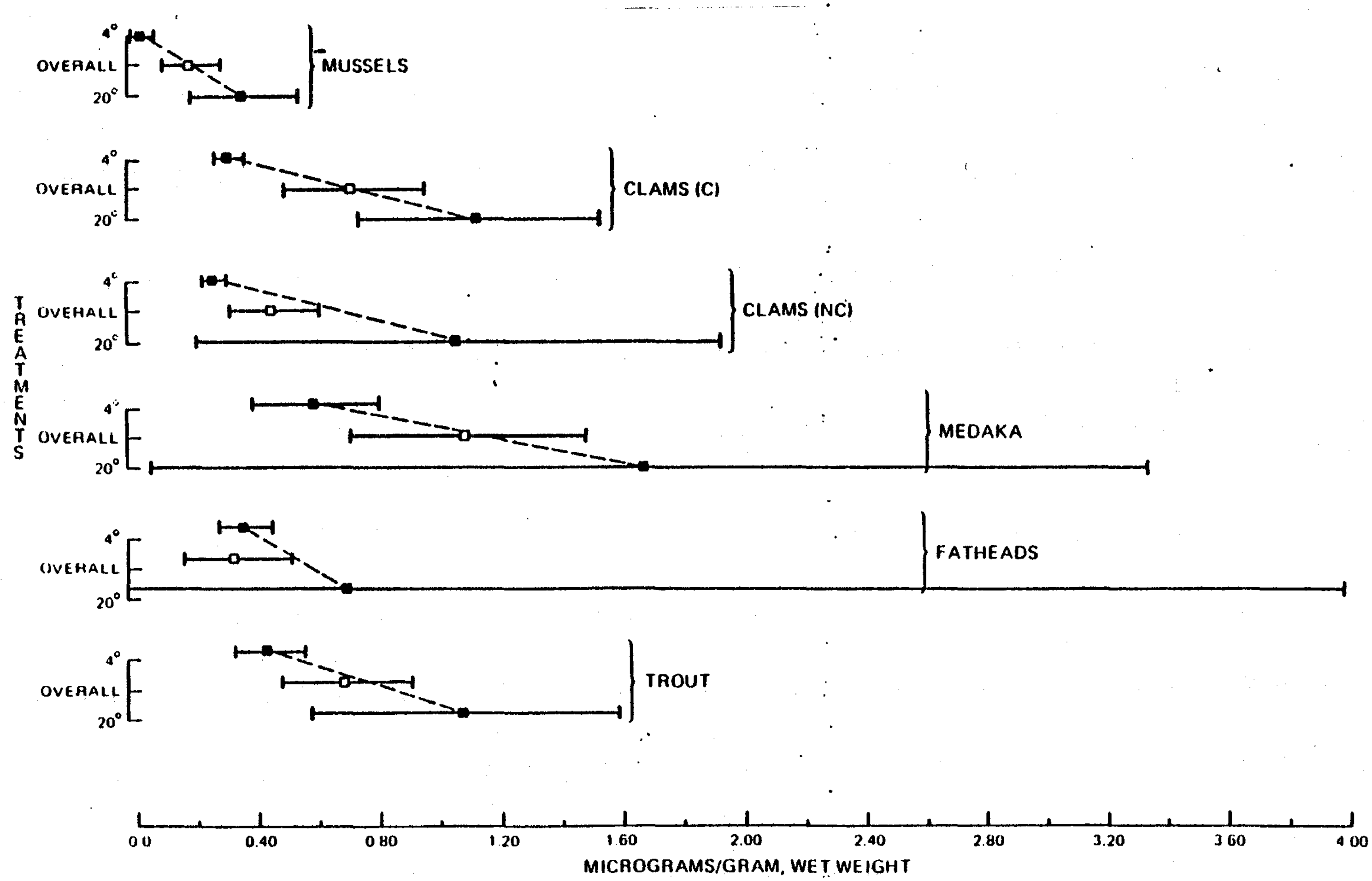

Figure 7. Fresh Weight Total PBC Means and 95% Confidence Intervals for all Organisms at 4°C, 20°C, and Overall (4°C and 20°C). Temperature Pairs Matched for Sediment Homogenate (R, L, M, and H) and Day. Clams (C) in Direct Contact with Sediment; Clams (NC), no Contact with Sediment.

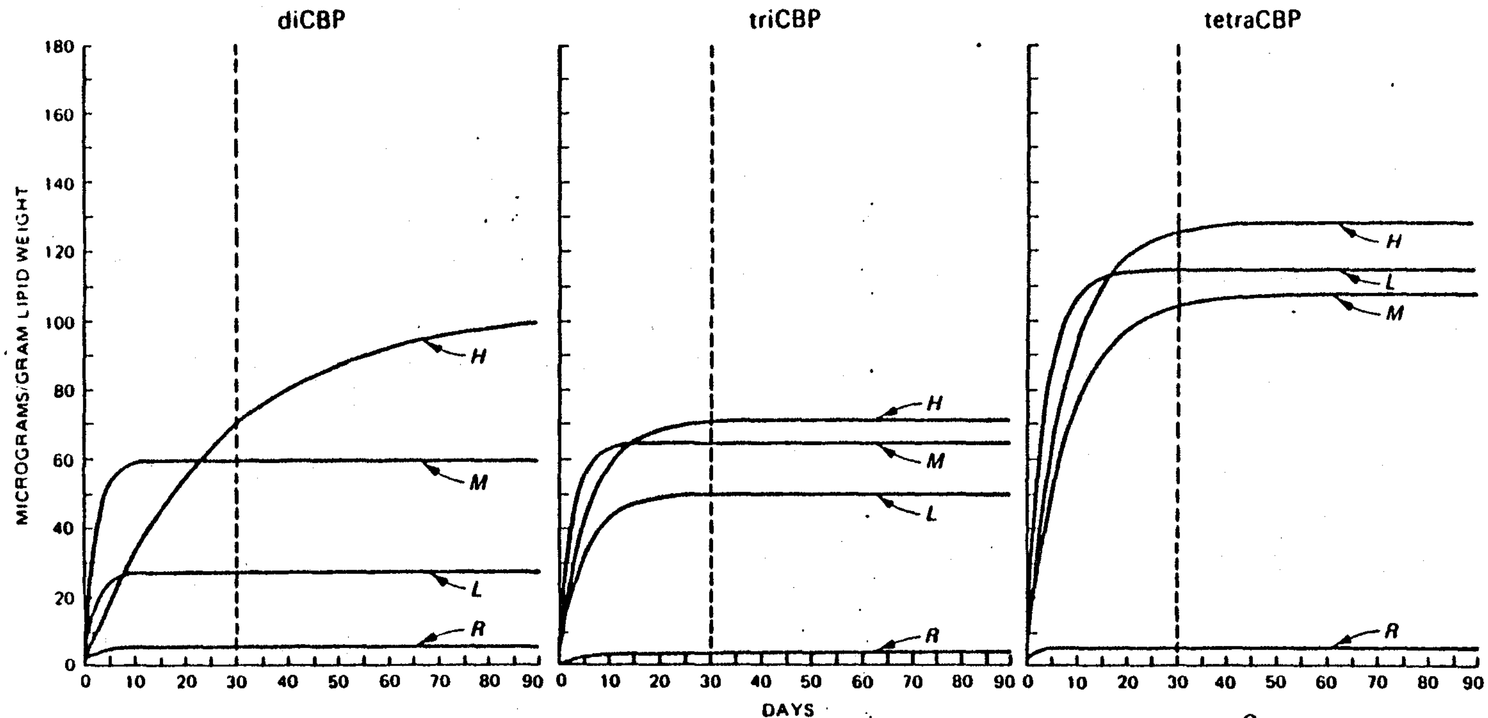

Figure 8a. Regression Estimates Fitted by Equation (1) for Mussels at 20°C Exposed to Sediment Homogenates R, L, M, and H. Lipid-normalized Concentration by Isomer Group. Portions of Curves Beyond 30 Days are Projections Calculated by the Model.

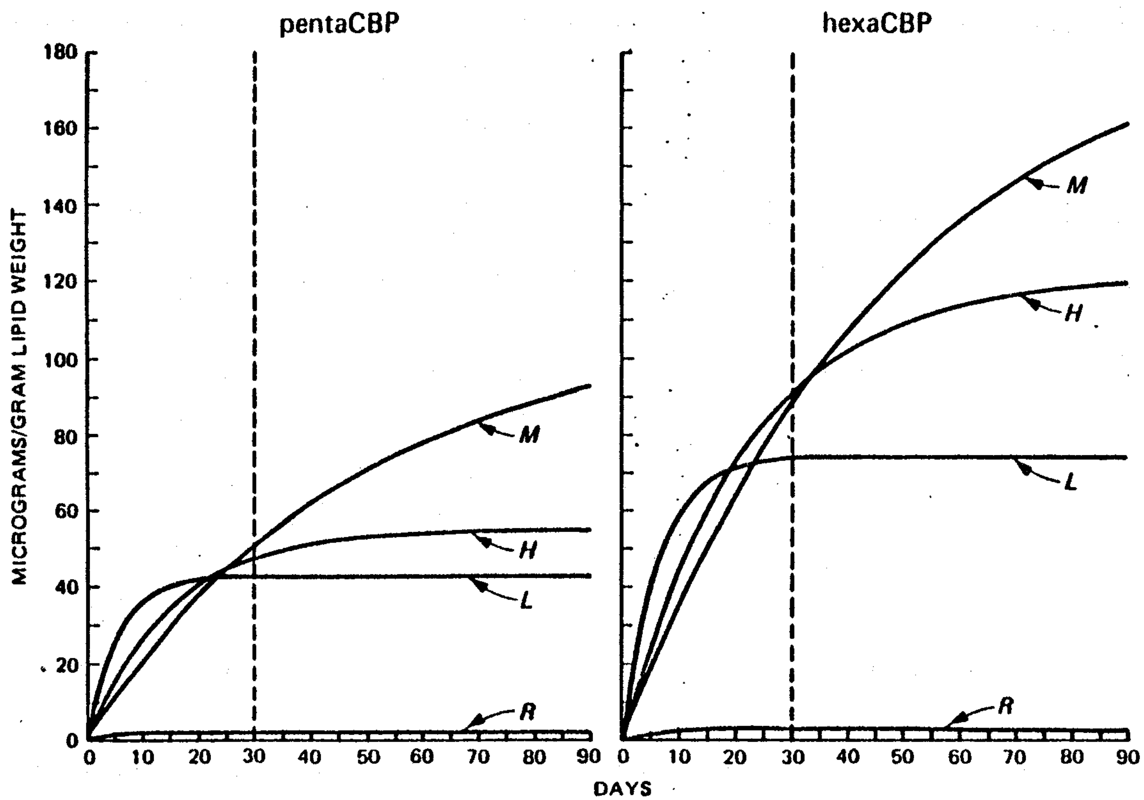

Figure 8b. Regression estimates as in Figure 8a.

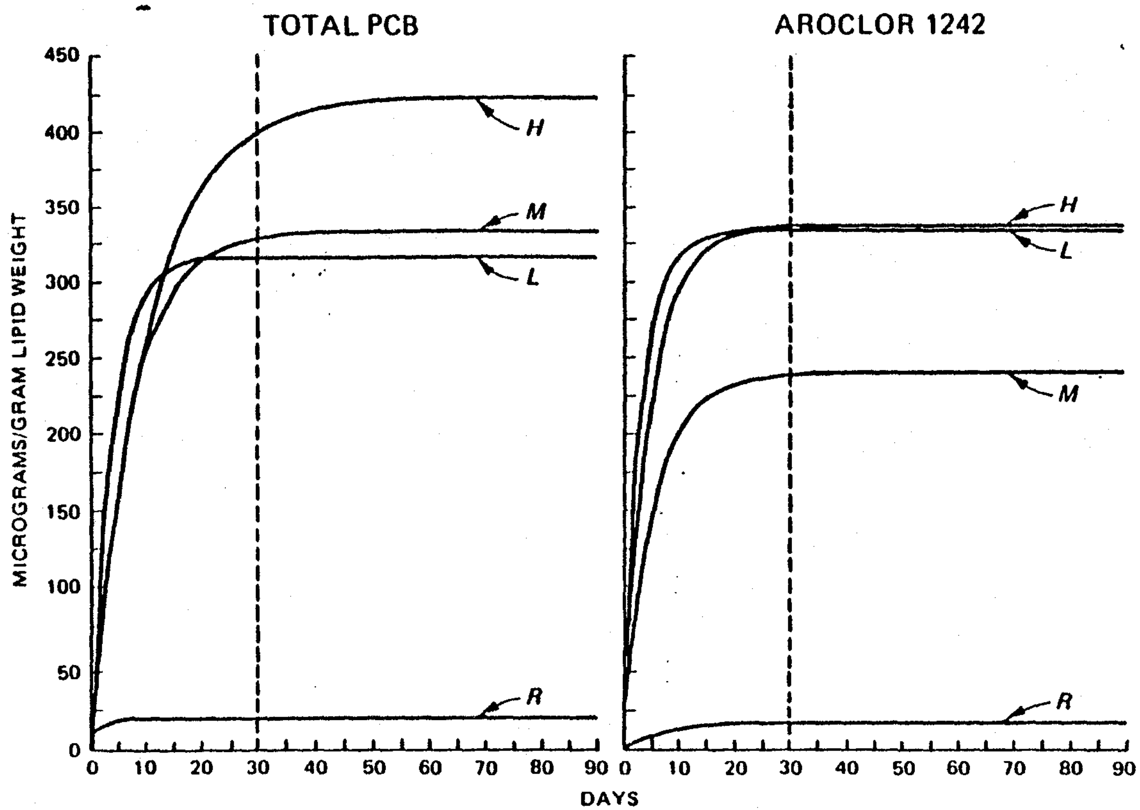

Figure 8c. Regression Estimates for Total PCB and Aroclor 1242 in Mussels at 20°C. Y-axis on Smaller Scale than Used in Figures 8a and 8b; Other Characteristics of Graphs are similar.

Appendix A: Analytical Data

Analytical data for PCB in Sheboygan Harbor sediment homogenates, aquarium water, and organisms are presented in Tables A1-A14. Polychlorinated biphenyls (PCB) were quantitated by GC/ECD as totals in isomer groups dichlorobiphenyl through decachlorobiphenyl (two chlorines per molecule through ten chlorines per molecule) as the total of all PCB and, whenever possible, as Aroclor 1242, 1254, or 1260.

Lower limit values are the smallest amount of PCB that could be reliably detected in a sample. A "less-than" symbol (<) means that the compounds were not detectable at or above the lower limit value.

A period (.) in a column headed A1242, A1254, or A1260 means that a chromatogram could not be matched with an Aroclor standard and does not indicate that PCB was not detected.

Table A1. Characteristics of Sediments; Concentrations: ug/g (ppm), Dry Weight

Sed.[2]	Trt.[3]	Polychlorinated Biphenyls[1]												
		Di	Tri	Tetra	Penta	Hexa	Hepta	Octa	Nona	Deca	Total	A1242	% TOC	% PSD[4]
R	A(1)	0.04	0.07	0.09	0.02	0.08	0.01	<0.01	<0.01	<0.01	0.31	<0.10	1.5	63:18:19
	A(2)	<0.01	0.02	0.16	0.02	0.03	0.01	0.01	<0.01	<0.01	0.25	<0.10	1.3	61:20:19
	B	<0.01	<0.01	0.29	<0.01	0.03	0.01	0.02	<0.01	<0.01	0.35	<0.10	1.4	
	C	<0.01	0.02	0.31	0.01	0.06	0.01	0.02	<0.01	<0.01	0.43	<0.10	1.3	
	D	<0.01	0.06	0.57	0.02	0.11	0.01	0.07	0.03	0.03	0.90	.	1.8	
L	A(1)	0.52	0.94	2.0	0.43	0.71	0.05	<0.01	<0.01	<0.01	4.7	6.4	1.5	62:18:20
	B	0.16	0.56	1.3	0.24	0.51	<0.01	0.04	<0.01	<0.01	2.8	2.8	1.7	
	C	0.23	0.73	1.6	0.31	0.58	<0.01	<0.01	<0.01	<0.01	3.5	4.0	1.4	
	D	0.55	0.91	1.9	0.51	0.91	0.05	0.08	0.04	0.01	5.0	5.2	1.8	
M	A(1)	12.	7.3	10.	3.4	6.9	0.07	0.19	<0.01	<0.01	40.	31.	1.8	44:20:36
	B	7.2	3.5	12.	2.0	3.7	0.04	0.12	<0.01	<0.01	29.	18.	1.4	
	C	7.0	3.9	13.	2.0	3.8	0.04	0.12	<0.01	<0.01	30.	19.	1.7	
	D	8.8	4.1	12.	2.4	4.4	0.04	0.12	<0.01	<0.01	32.	22.	1.5	
H	A(1)	4.1	9.8	14.	4.2	8.3	0.07	0.21	<0.01	<0.01	41.	40.	1.6	37:28:35
	B	3.1	6.6	24.	3.5	6.6	0.06	0.22	<0.01	<0.01	44.	30.	1.4	
	C	3.2	7.5	11.	3.2	5.9	0.05	0.18	<0.01	<0.01	31.	34.	1.9	
	D	14.	9.0	22.	4.4	8.9	0.09	0.10	0.03	0.03	59.	37.	1.6	

1. Total in isomer groups or by Aroclor standards.
2. Sediment: Reference, Low, Medium and High PCB.
3. See text, p. 8.
4. Percent Particle Size Distribution as sand:silt:clay.

Table A2. PCB Concentrations in Unfiltered Aquarium Water, ng/l (ppt)

Sed.[1]	Temp.[2]	Aq.[3]	Di	Tri	Tetra	Penta	Hexa	Hepta	Octa	Nona	Deca	Total	A1242
R	4	15	7.1	3.0	1.9	0.26	0.62	0.088	1.5	0.088	<0.088	15.	.
		18	11.	5.0	4.6	0.53	0.42	<0.10	1.3	<0.10	<0.10	23.	20.
	20	3	58.	7.0	37.	0.57	0.57	<0.095	0.095	<0.095	<0.095	100.	36.
		6	54.	7.0	3.1	0.69	0.35	<0.12	0.12	<0.12	<0.12	66.	20.
L	4	13	28.	12.	8.7	2.2	1.6	<0.043	0.69	0.043	0.043	53.	40.
		19	23.	10.	12.	1.9	1.8	<0.048	0.48	<0.048	<0.048	49.	50.
		21	20.	6.4	5.2	0.72	1.0	0.036	0.22	0.072	<0.036	34.	30.
	20	4	740.	76.	73.	15.	32.	<1.2	1.2	<1.2	<1.2	940.	380.
		7	170.	21.	27.	6.5	13.	<0.25	0.25	<0.25	<0.25	240.	110.
		9	330.	35.	44.	9.7	16.	<0.28	0.28	<0.28	<0.28	440.	170.
M	4	14	45.	12.	15.	3.6	3.1	0.13	0.043	0.043	0.043	79.	50.
		17	32.	10.	7.8	1.3	1.4	<0.029	0.12	0.029	<0.029	53.	40.
		24	22.	7.5	7.2	1.4	1.4	0.036	0.54	0.072	0.036	40.	30.
	20	2	420.	44.	60.	18.	38.	<0.76	1.5	<0.76	<0.76	580.	250.
		5	320.	30.	29.	6.1	11.	<0.18	0.18	<0.18	<0.18	400.	150.
		12	890.	100.	13.	38.	80.	<1.5	4.5	<1.5	<1.5	1100.	700.
H	4	20	29.	12.	12.	2.4	4.5	0.15	0.31	0.15	0.15	61.	50.
		22	47.	45.	52.	13.	22.	0.48	0.64	0.16	<0.16	180.	190.
		23	23.	20.	24.	5.4	8.1	0.16	0.39	<0.079	<0.079	81.	80.
	20	8	430.	33.	48.	13.	25.	0.45	0.67	<0.11	<0.11	550.	160.
		10	280.	35.	48.	14.	27.	<0.47	0.94	<0.47	<0.47	410.	180.
		11	480.	45.	49.	9.1	17.	0.12	0.48	<0.12	<0.12	600.	210.

1. Sediment: Reference, Low, Medium and High PCB.
2. Temperature, degrees C.
3. Aquarium no.

Table A3. PCB Concentrations as Isomer Groups and Lipid Content at 4 Degrees[1] C in Clams, ng/g (ppb), Wet Weight

					Polychlorinated Biphenyls									
Exp.[2]	Trt.[3]	Aq.[4]	Time[5]	% Lipid	Di	Tri	Tetra	Penta	Hexa	Hepta	Octa	Nona	Deca	Total
	B	.	-17	1.8	36.	9.4	33.	40.	99.	20.	16.	2.3	<0.58	260.
	I	.	0	3.0	77.	11.	24.	40.	170.	15.	1.1	2.1	<1.1	340.
C	R	18	2	1.5	33.	8.7	27.	13.	140.	16.	10.	<0.87	<0.87	250.
		18	4	2.1	25.	11.	17.	<1.1	120.	9.5	1.1	<1.1	<1.1	180.
		18	10	1.9	97.	10.	27.	<0.87	120.	10.	10.	<0.87	<0.87	270.
		18	17	2.3	77.	29.	54.	49.	130.	8.6	0.95	<0.95	<0.95	350.
		18	30	2.1	66.	8.5	59.	<0.85	200.	18.	12.	<0.85	<0.85	360.
	L	21	2	1.9	73.	35.	29.	40.	130.	12.	3.7	<0.92	<0.92	320.
		21	4	1.7	50.	11.	24.	47.	120.	10.	7.0	0.63	<0.63	270.
		21	10	2.0	48.	74.	21.	41.	150.	25.	4.0	<1.0	<1.0	360.
		21	17	2.5	37.	14.	22.	6.3	150.	16.	14.	1.0	<1.0	260.
		21	30	2.0	57.	40.	42.	32.	130.	5.0	1.7	<1.7	<1.7	310.
	M	24	2	2.3	140.	50.	61.	87.	190.	17.	14.	0.92	<0.92	560.
		24	4	2.1	74.	13.	19.	45.	140.	12.	10.	0.92	<0.92	310.
		24	10	2.1	49.	22.	35.	37.	130.	6.2	3.7	<1.2	<1.2	280.
		24	17	2.4	43.	21.	23.	33.	14.	13.	10.	1.1	<1.1	160.
		24	30	3.1	80.	43.	83.	99.	220.	17.	17.	1.4	<1.4	560.
	H	23	2	1.9	110.	42.	63.	66.	200.	20.	12.	0.83	<0.83	510.
		23	4	2.1	23.	18.	53.	40.	210.	9.3	6.2	<1.0	<1.0	360.
		23	10	1.8	76.	56.	22.	40.	140.	19.	4.0	<1.0	<1.0	360.
		23	17	2.2	140.	32.	50.	42.	190.	17.	11.	0.91	<0.91	480.
		23	30	1.8	100.	49.	48.	34.	120.	5.0	17.	1.0	<1.0	370.

Table A3 (Concluded). PCB Concentrations as Isomer Groups and Lipid Content at 4 Degrees[1] C in Clams, ng/g (ppb), Wet Weight

Exp.[2]	Trt.[3]	Aq.[4]	Time[5]	% Lipid	Polychlorinated Biphenyls Di	Tri	Tetra	Penta	Hexa	Hepta	Octa	Nona	Deca	Total
N	C	16	4	1.6	86.	3.3	13.	19.	110.	9.8	8.9	0.81	<0.81	250.
		16	17	2.1	120.	5.6	12.	42.	120.	13.	12.	0.81	<0.81	330.
		16	30	2.3	53.	7.0	21.	36.	150.	12.	5.1	<1.0	<1.0	280.
	R	15	30	2.2	19.	10.	55.	<1.5	160.	10.	1.5	<1.5	<1.5	260.
	L	13	30	2.2	23.	14.	41.	<0.93	120.	11.	12.	0.93	<0.93	220.
		19	30	2.2	48.	7.7	37.	<0.96	150.	14.	15.	<0.96	<0.96	270.
	M	14	30	1.9	48.	16.	23.	35.	130.	14.	7.2	<1.2	<1.2	270.
	H	22	10	2.4	57.	56.	71.	52.	180.	28.	6.0	<1.0	<1.0	450.
		20	30	2.3	26.	9.5	33.	<1.2	180.	17.	15.	1.2	<1.2	280.
		22	30	1.9	23.	9.1	20.	45.	140.	14.	5.7	<1.1	<1.1	260.

1. Background sample taken at ambient temperature, approximately 20 degrees C.
2. Exposure: C = clams in contact with sediment, N = clams not in contact with sediment.
3. Treatment: Background, Initial, Control; Reference, Low, Medium and High PCB sediments.
4. Aquarium no.
5. In days referenced to start of experiment.

Table A4. PCB Concentrations as Isomer Groups and Lipid Content at 20 Degrees[1] C in Clams, ng/g (ppb), Wet Weight

Exp.[2]	Trt.[3]	Aq.[4]	Time[5]	% Lipid	Polychlorinated Biphenyls Di	Tri	Tetra	Penta	Hexa	Hepta	Octa	Nona	Deca	Total
	B	.	-17	1.8	36.	9.4	33.	40.	99.	20.	16.	2.3	<0.58	260.
	I	.	0	2.9	45.	7.4	41.	72.	190.	22.	14.	<0.93	<0.93	390.
C	R	6	2	2.5	19.	15.	45.	69.	200.	8.1	2.7	<1.4	<1.4	360.
		6	4	2.3	47.	14.	25.	63.	180.	30.	10.	0.80	0.80	370.
		6	10	2.3	66.	92.	49.	54.	180.	26.	6.0	<1.0	<1.0	470.
		6	17	1.7	33.	25.	21.	36.	100.	3.8	5.8	0.97	<0.97	230.
		6	30	1.6	69.	37.	36.	44.	150.	7.6	11.	0.76	<0.76	360.
	L	9	2	2.1	150.	130.	150.	90.	210.	10.	2.1	<1.0	<1.0	740.
		9	4	1.0	120.	86.	97.	39.	90.	3.0	1.8	<0.60	<0.60	440.
		9	10	2.1	260.	280.	270.	120.	290.	18.	5.0	<1.0	<1.0	1200.
		9	17	1.7	230.	200.	230.	92.	180.	5.8	11.	<0.96	<0.96	950.
		9	30	1.6	330.	320.	340.	120.	250.	5.9	4.4	0.74	<0.74	1400.
	M	12	2	1.4	180.	110.	120.	57.	140.	5.2	7.8	0.86	<0.86	620.
		12	4	1.6	260.	160.	190.	85.	190.	7.5	1.9	<0.94	<0.94	890.
		12	10	3.1	630.	350.	320.	110.	290.	8.6	14.	<1.7	<1.7	1700.
		12	17	1.3	320.	190.	200.	91.	200.	13.	8.3	0.63	<0.63	1000.
		12	30	1.9	1100.	770.	810.	250.	490.	11.	3.2	<1.6	<1.6	3400.
	H	11	2	2.9	290.	200.	220.	100.	240.	13.	5.6	<1.4	<1.4	1100.
		11	4	2.9	220.	210.	750.	140.	320.	25.	14.	1.3	<1.3	1700.
		11	10	1.3	410.	330.	300.	97.	230.	11.	4.0	<1.0	<1.0	1400.
		11	17	2.0	640.	500.	490.	150.	300.	7.2	4.1	<1.0	<1.0	2100.
		11	30	1.8	850.	720.	710.	210.	370.	10.	2.3	0.76	<0.76	2900.

Table A4 (Continued). PCB Concentrations as Isomer Groups and Lipid Content at 20 Degrees[1] C in Clams, ng/g (ppb), Wet Weight

Exp.[2]	Trt.[3]	Aq.[4]	Time[5]	% Lipid	Polychlorinated Biphenyls: Di	Tri	Tetra	Penta	Hexa	Hepta	Octa	Nona	Deca	Total
N	C	1	4	1.1	14.	8.5	12.	25.	70.	5.5	2.5	0.50	<0.50	140.
		1	30	2.0	79.	44.	33.	40.	140.	8.0	12.	0.90	<0.90	360.
	R	3	2	2.3	51.	21.	30.	32.	170.	19.	6.3	<1.3	<1.3	330.
		3	4	1.5	27.	14.	50.	43.	140.	24.	2.9	<0.97	<0.97	300.
		3	10	2.3	35.	43.	42.	50.	190.	10.	6.7	<1.7	<1.7	380.
		3	17	2.9	78.	57.	63.	61.	210.	9.3	7.4	<1.9	<1.9	490.
	L	4	2	2.1	45.	36.	34.	46.	160.	17.	5.3	<1.3	<1.3	340.
		4	4	1.7	43.	32.	61.	49.	120.	13.	13.	0.79	<0.79	330.
		4	10	1.6	46.	53.	46.	45.	140.	7.9	2.6	0.88	<0.88	340.
		4	17	2.5	98.	190.	320.	54.	190.	5.0	17.	<1.6	<1.6	870.
		4	30	1.3	180.	130.	130.	54.	130.	4.0	5.6	0.79	<0.79	630.
	M	2	2	2.3	67.	26.	32.	49.	170.	6.5	1.1	<1.1	<1.1	350.
		2	4	1.3	31.	26.	49.	54.	130.	22.	6.1	0.56	<0.56	320.
		2	10	1.9	150.	100.	110.	78.	210.	19.	8.2	0.91	<0.91	680.
		2	17	1.7	270.	190.	260.	120.	280.	10.	14.	1.1	<1.1	1100.

Table A4 (Concluded). PCB Concentrations as Isomer Groups and Lipid Content at 20 Degrees[1] C in Clams, ng/g (ppb), Wet Weight

Exp.[2]	Trt.[3]	Aq.[4]	Time[5]	% Lipid	Polychlorinated Biphenyls: Di	Tri	Tetra	Penta	Hexa	Hepta	Octa	Nona	Deca	Total
N	H	8	2	3.6	140.	180.	210.	57.	150.	<2.4	2.4	<2.4	<2.4	740.
		8	4	2.1	71.	50.	89.	58.	150.	7.1	5.7	<1.4	<1.4	430.
		8	10	0.93	65.	120.	94.	21.	72.	<1.0	<1.0	<1.0	<1.0	370.
		8	17	2.3	320.	310.	390.	140.	330.	22.	18.	1.4	1.4	1500.
		8	30	2.0	620.	440.	630.	210.	420.	8.9	13.	0.99	<0.99	2300.

1. Background sample taken at ambient temperature, approximately 20 degrees C.
2. Exposure: C = clams in contact with sediment, N = clams not in contact with sediment.
3. Treatment: Background, Initial, Control; Reference, Low, Medium and High PCB sediments.
4. Aquarium no.
5. In days referenced to start of experiment.

Table A5. PCB Concentrations at 4 Degrees C, as Aroclor Standards in Clams, ng/g (ppb), Wet Weight

Exp.[2]	Trt.[3]	Aq.[4]	Time[5]	A1242	A1254	A1260
	B	.	-17	.	160.	.
	I	.	0	.	150.	.
C	R	18	2	.	100.	.
		18	4	.	140.	.
		18	10	.	110.	.
		18	17	.	130.	.
		18	30	.	120.	.
	L	21	2	.	120.	.
		21	4	.	110.	.
		21	10	.	.	320.
		21	17	.	140.	.
		21	30	.	120.	.
	M	24	2	.	160.	.
		24	4	.	130.	.
		24	10	.	120.	.
		24	17	.	130.	.
		24	30	.	200.	.
	H	23	2	.	120.	.
		23	4	.	160.	.
		23	10	.	.	260.
		23	17	.	120.	.
		23	30	.	130.	.
N	C	16	4	.	90.	.
		16	17	.	150.	.
		16	30	.	140.	.
	R	15	30	.	110.	.
	L	13	30	.	120.	.
		19	30	.	140.	.
	M	14	30	.	110.	.

Table A5 (Concluded). PCB Concentrations at 4 Degrees C, as Aroclor Standards in Clams, ng/g (ppb), Wet Weight

Exp.[2]	Trt.[3]	Aq.[4]	Time[5]	A1242	A1254	A1260
N	H	22	10	.	.	350.
		20	30	.	170.	.
		22	30	.	130.	.

1. Background sample taken at ambient temperature, approximately 20 degrees C.
2. Exposure: C = clams in contact with sediment, N = clams not in contact with sediment.
3. Treatment: Background, Initial, Control; Reference, Low, Medium and High PCB sediments.
4. Aquarium no.
5. In days referenced to start of experiment.

Table A6. PCB Concentrations at 20 Degrees C, as Aroclor Standards in Clams, ng/g (ppb), Wet Weight

Exp.[2]	Trt.[3]	Aq.[4]	Time[5]	A1242	A1254	A1260
	B	.	-17	.	160.	.
	I	.	0	.	160.	.
C	R	6	2	.	150.	.
		6	4	.	160.	.
		6	10	120.	.	.
		6	17	.	110.	.
		6	30	130.	130.	.
	L	9	2	590.	260.	.
		9	4	450.	100.	.
		9	10	1700.	.	.
		9	17	1000.	290.	.
		9	30	1500.	430.	.
	M	12	2	500.	150.	.
		12	4	680.	240.	.
		12	10	1700.	430.	.
		12	17	890.	230.	.
		12	30	3500.	1300.	.
	H	11	2	930.	250.	.
		11	4	990.	330.	.
		11	10	1700.	.	.
		11	17	2300.	540.	.
		11	30	2900.	600.	.
N	C	1	4	.	60.	.
		1	30	160.	100.	.
	R	3	2	.	150.	.
		3	4	.	100.	.
		3	10	.	130.	.
		3	17	.	170.	.
	L	4	2	.	110.	.
		4	4	.	110.	.
		4	10	180.	130.	.
		4	17	780.	310.	.
		4	30	500.	160.	.

Table A6 (Concluded). PCB Concentrations at 20 Degrees C, as Aroclor Standards in Clams, ng/g (ppb), Wet Weight

Exp.[2]	Trt.[3]	Aq.[4]	Time[5]	A1242	A1254	A1260
N	M	2	2	.	150.	.
		2	4	90.	120.	.
		2	10	440.	670.	.
		2	17	840.	300.	.
	H	8	2	630.	270.	.
		8	4	160.	110.	.
		8	10	490.	.	.
		8	17	1400.	460.	.
		8	30	1900.	560.	.

1. Background sample taken at ambient temperature, approximately 20 degrees C.
2. Exposure: C = clams in contact with sediment, N = clams not in contact with sediment.
3. Treatment: Background, Initial, Control; Reference, Low, Medium and High PCB sediments.
4. Aquarium no.
5. In days referenced to start of experiment.

Table A7. PCB Concentrations and Lipid Content at 4 Degrees[1] C in Mussels, ng/g (ppb), Wet Weight

Trt.[3]	Aq.[4]	Time[5]	% Lipid	Di	Tri	Tetra	Penta	Hexa	Hepta	Octa	Nona	Deca	Total	A1242
				Polychlorinated Biphenyls[2]										
B	.	-17	0.27	5.9	2.2	4.4	1.5	2.2	0.74	0.74	1.5	<0.74	19.	<7.4
I	.	0	0.16	8.3	1.3	5.1	1.0	1.0	<0.25	1.3	0.25	<0.25	18.	<2.5
C	16	4	0.19	8.7	0.81	2.8	1.2	2.2	<0.20	0.61	0.20	<0.20	17.	<2.0
	16	17	0.19	6.5	5.6	9.6	0.42	1.0	1.5	0.63	0.21	<0.21	25.	27.
	16	30	0.25	7.1	2.1	1.6	2.1	2.4	<0.26	2.4	1.1	<0.26	19.	<2.6
R	18	2	0.38	13.	1.2	6.1	3.8	2.6	<0.29	0.87	0.58	<0.29	28.	<2.9
	18	4	0.20	8.2	2.3	2.8	1.7	0.85	<0.28	0.85	<0.28	<0.28	17.	<2.8
	18	10	0.28	9.3	1.2	8.8	1.8	1.2	1.8	0.91	0.30	<0.30	25.	<3.0
	18	17	0.31	8.1	3.8	7.2	3.4	6.6	<0.31	1.9	0.31	<0.31	31.	<3.1
	18	30	0.29	12.	2.6	8.2	4.5	8.4	<0.26	1.8	0.53	<0.26	38.	<2.6
L	21	2	0.34	13.	1.6	9.4	2.2	3.6	<0.27	0.81	0.27	<0.27	31.	<2.7
	21	4	0.24	8.5	5.9	5.6	2.0	2.9	<0.24	2.2	0.73	<0.24	28.	29.
	21	10	0.23	11.	8.0	4.0	2.0	3.0	<0.20	<0.20	<0.20	<0.20	28.	20.
	21	17	0.22	12.	12.	14.	4.1	5.2	<0.23	0.25	0.91	<0.23	48.	55.
	21	30	0.25	24.	23.	33.	6.4	8.1	<0.28	0.84	0.28	<0.28	96.	110.
M	24	2	0.31	7.6	1.4	6.6	2.4	1.0	<0.34	0.69	0.34	<0.34	20.	<3.4
	24	4	0.30	20.	3.6	11.	2.8	3.4	<0.26	0.78	0.52	<0.26	42.	26.
	24	10	0.47	45.	13.	26.	4.7	5.7	2.0	2.3	0.68	0.68	100.	68.
	24	17	0.18	22.	12.	14.	3.6	5.0	<0.23	0.68	0.23	<0.23	58.	41.
	24	30	0.34	28.	17.	21.	5.6	6.7	<0.39	1.1	0.35	<0.35	80.	67.

Table A7 (Concluded). PCB Concentrations and Lipid Content at 4 Degrees[1] C in Mussels, ng/g (ppb), Wet Weight

Trt.[3]	Aq.[4]	Time[5]	% Lipid	Polychlorinated Biphenyls[2]										
				Di	Tri	Tetra	Penta	Hexa	Hepta	Octa	Nona	Deca	Total	A1242
H	23	2	0.28	9.5	1.8	16.	1.1	1.1	<0.36	0.73	0.36	<0.36	31.	<3.6
	23	4	0.21	9.3	1.7	5.4	0.98	0.73	<0.24	1.5	0.24	<0.24	20.	<2.5
	23	10	0.08	8.0	6.0	7.0	1.0	2.0	<0.20	<0.20	<0.20	<0.20	24.	30.
	23	17	0.27	30.	27.	32.	6.7	9.6	<0.24	0.96	0.24	<0.24	110.	110.
	23	30	0.47	220.	94.	110.	23.	34.	<0.48	1.4	0.95	1.4	480.	390.

1. Background sample taken at ambient temperature, approximately 12 degrees C.
2. Total in isomer groups or by Aroclor standards.
3. Treatment: Background, Initial, Control; Reference, Low, Medium and High PCB sediments.
4. Aquarium no.
5. In days referenced to start of experiment.

Table A8. PCB Concentrations and Lipid Content at 20 Degrees[1] C in Mussels, ng/g (ppb), Wet Weight

Trt.[3]	Ag.[4]	Time[5]	% Lipid	Polychlorinated Biphenyls[2] Di	Tri	Tetra	Penta	Hexa	Hepta	Octa	Nona	Deca	Total	A1242
B	.	-17	0.27	5.9	2.2	4.4	1.5	2.2	0.74	0.74	1.5	<0.74	19.	<7.4
I	.	0	0.17	2.2	0.44	1.8	0.67	0.44	<0.22	4.2	3.1	<0.22	13.	<2.2
C	1	4	0.22	9.5	6.4	7.8	1.2	2.1	<0.21	1.6	0.41	<0.21	29.	10.
	1	17	0.11	8.4	11.	3.0	<0.25	<0.25	<0.25	1.3	<0.25	<0.25	24.	<2.5
	1	30	0.19	9.3	1.1	6.7	2.7	2.7	<0.27	0.80	0.27	<0.27	24.	<2.7
R	6	2	0.32	11.	6.7	9.1	1.6	<0.39	<0.39	2.0	0.39	<0.39	31.	<3.9
	6	4	0.25	4.8	6.2	19.	1.0	1.7	<0.34	0.68	<0.34	<0.34	33.	<3.4
	6	10	0.26	19.	10.	18.	3.0	9.0	<0.20	<0.20	<0.20	<0.20	59.	60.
	6	17	0.24	16.	12.	9.3	6.7	8.5	<0.37	1.1	0.37	<0.37	54.	37.
	6	30	0.22	9.6	7.5	7.2	3.6	6.2	<0.33	0.98	0.65	<0.33	36.	33.
L	9	2	0.25	23.	37.	48.	10.	16.	<0.27	0.80	0.27	<0.27	140.	170.
	9	4	0.38	83.	200.	280.	71.	110.	<0.31	2.8	<0.31	<0.31	750.	810.
	9	10	0.11	57.	93.	160.	57.	89.	<0.20	0.90	<0.20	<0.20	460.	610.
	9	17	0.28	66.	170.	280.	91.	160.	0.87	4.6	0.58	<0.29	770.	780.
	9	30	0.23	24.	92.	230.	97.	170.	1.9	5.7	0.48	<0.48	620.	520.
M	12	2	0.27	110.	57.	71.	14.	24.	<0.34	0.68	0.34	<0.34	280.	250.
	12	4	0.47	140.	82.	110.	20.	30.	<0.67	0.67	0.67	<0.67	380.	350.
	12	10	0.22	190.	110.	200.	60.	100.	0.75	3.8	0.75	<0.38	670.	530.
	12	17	0.39	310.	190.	320.	110.	200.	1.6	6.4	0.96	<0.32	1100.	990.
	12	30	0.19	40.	89.	200.	98.	169.	4.1	9.3	0.37	<0.37	610.	410.

Table A8 (Concluded). PCB Concentrations and Lipid Content at 20 Degrees C in Mussels[1], ng/g (ppb), Wet Weight

Trt.[3]	Aq.[4]	Time[5]	% Lipid	Di	Tri	Tetra	Penta	Hexa	Hepta	Octa	Nona	Deca	Total	A1242
				Polychlorinated Biphenyls[2]										
H	11	2	0.33	51.	61.	75.	15.	24	<0.38	1.1	0.38	<0.38	230.	290.
	11	4	0.25	24.	54.	95.	20.	29.	<0.34	1.0	<0.34	<0.34	220.	220.
	11	10	0.07	38.	52.	80.	25.	40.	<0.20	<0.20	<0.20	<0.20	240.	340.
	11	17	0.42	100.	260.	420.	130.	250.	1.2	5.9	0.93	0.93	1200.	1150.
	11	30	0.37	280.	250.	470.	180.	340.	6.1	9.6	0.58	0.29	1500.	1100.

1. Background sample taken at ambient temperature, approximately 12 degrees C.
2. Total in isomer groups or by Aroclor standards.
3. Treatment: Background, Initial, Control; Reference, Low, Medium and High PCB sediments.
4. Aquarium no.
5. In days referenced to start of experiment.

Table A9. PCB Concentrations as Isomer Groups and Lipid Content in Medaka, ng/g (ppb), Wet Weight

Temp.[1]	Trt.[2]	Aq.[3]	Time[4]	% Lipid	Di	Tri	Tetra	Penta	Hexa	Hepta	Octa	Nona	Deca	Total
					Polychlorinated Biphenyls									
.	B	.	-17	8.2	160.	43.	70.	68.	110.	<2.7	2.7	<2.7	<2.7	450.
4	I	.	0	4.9	310.	67.	87.	110.	170.	<6.7	20.	<6.7	<6.7	760.
	C	16	30	4.6	60.	19.	42.	89.	120.	1.5	17.	0.75	<0.75	350.
	R	15	30	3.6	55.	19.	310.	72.	110.	3.8	16.	0.94	3.8	590.
	L	13	30	3.4	160.	82.	72.	75.	100.	6.3	7.0	2.1	0.93	510.
	M	14	30	4.1	260.	130.	260.	110.	140.	8.0	9.1	1.4	2.6	920.
	H	20	30	2.2	160.	97.	190.	55.	83.	5.1	6.1	0.21	1.5	600.
20	I	.	0	8.0	130.	38.	63.	63.	130.	<2.5	23.	<2.5	<2.5	450.
	C	1	4	5.4	170.	93.	110.	80	110.	<2.3	14.	<2.3	<2.3	580.
		1	17	4.3	130.	99.	72.	76.	90.	1.4	13.	1.4	<1.4	480.
		1	30	2.4	81.	75.	33.	44.	67.	3.3	16.	<1.1	<1.1	320.
	R	3	2	7.8	39.	39.	100.	76.	110.	<2.2	13.	<2.2	<2.2	380.
		3	4	8.2	54.	54.	94.	84.	130.	<2.0	12.	<2.0	<2.0	430.
		3	10	4.0	200.	190.	72.	74.	130.	<2.0	8.0	<2.0	<2.0	670.
		3	17	3.8	68.	68.	63.	62.	95.	<1.6	7.9	<1.6	<1.6	360.
		3	30	4.3	69.	90.	120.	61.	96.	<2.0	12.	<2.0	<2.0	450.

Table A9 (Concluded). PCB Concentrations as Isomer Groups and Lipid Content in Medaka, ng/g (ppb), Wet Weight

Temp.[1]	Trt.[2]	Aq.[3]	Time[4]	% Lipid	Polychlorinated Biphenyls: Di	Tri	Tetra	Penta	Hexa	Hepta	Octa	Nona	Deca	Total
20	L	4	2	11.	75.	94.	120.	78.	130.	<2.8	8.3	<2.8	<2.8	510.
		4	4	7.9	140.	120.	140.	87.	150.	<1.8	20.	<1.8	<1.8	660.
		4	10	3.7	230.	200.	260.	150.	200.	6.0	8.0	<1.0	<1.0	1100.
		4	17	2.2	120.	89.	130.	320.	180.	16.	2.4	2.4	<0.81	860.
		4	30	2.7	90.	240.	550.	160.	280.	5.4	22.	0.68	<0.68	1300.
	M	2	2	5.4	110.	110.	110.	92.	130.	3.3	20.	<1.7	<1.7	580.
		2	4	5.9	200.	180.	260.	150.	220.	7.7	23.	<1.5	<1.5	1000.
		2	10	6.1	320.	400.	630.	230.	460.	12.	27.	1.4	<1.4	2100.
		2	17	3.4	360.	510.	950.	320.	660.	16.	34.	<2.0	<2.0	2900.
		2	30	3.3	320.	690.	1600.	530.	1200.	27.	48.	1.1	<1.1	4400.
	H	8	2	4.6	110.	58.	120.	380.	180.	6.6	12.	1.3	<1.3	870.
		8	4	8.7	230.	280.	300.	93.	170.	<2.3	9.1	<2.3	<2.3	1100.
		8	10	4.4	390.	780.	1000.	370.	610.	10.	26.	<2.0	<2.0	3200.
		8	17	3.6	270.	660.	1100.	300.	520.	6.7	20.	<1.7	<1.7	2900.
		8	30	3.0	160.	620.	1400.	360.	740.	8.6	31.	0.96	<0.96	3300.

1. Temperature, degrees C; background sample taken at ambient temperature, approximately 20 degrees C.
2. Treatment: Background, Initial; Low, Medium and High PCB sediments.
3. Aquarium no.
4. In days referenced to start of experiment.

Table A10. PCB Concentrations
as Aroclor Standards in Medaka, ng/g (ppb), Wet Weight

Temp.[1]	Trt.[2]	Aq.[3]	Time[4]	A1242	A1254	A1260
.	B	.	-17	<27.	.	.
4	I	.	0	<67.	.	.
	C	16	30	60.	.	.
	R	15	30	120.	170.	.
	L	13	30	360.	250.	.
	M	14	30	690.	210.	.
	H	20	30	420.	110.	.
20	I	.	0	<25.	.	.
	C	1	4	180.	.	.
		1	17	190.	.	.
		1	30	200.	.	.
	R	3	2	.	220.	.
		3	4	.	260.	.
		3	10	260.	.	190.
		3	17	170.	160.	.
		3	30	570.	180.	.
	L	4	2	380.	280.	.
		4	4	510.	270.	.
		4	10	890.	.	.
		4	17	420.	160.	.
		4	30	1100.	490.	.
	M	2	2	370.	.	.
		2	4	720.	400.	.
		2	10	1900.	810.	.
		2	17	2400.	1300.	.
		2	30	3200.	1800.	.

Table A10 (Concluded). PCB Concentrations as Aroclor Standards in Medaka, ng/g (ppb), Wet Weight

Temp.[1]	Trt.[2]	Aq.[3]	Time[4]	A1242	A1254	A1260
20	H	8	2	290.	180.	.
		8	4	1400.	300.	.
		8	10	4800.	.	350.
		8	17	6300.	980.	.
		8	30	2900.	1300.	.

1. Temperature, degrees C; background sample taken at ambient temperature, approximately 20 degrees C.
2. Treatment: Background, Initial; Low, Medium and High PCB sediments.
3. Aquarium no.
4. In days referenced to start of experiment.

Table A11. PCB Concentrations as Isomer Groups and Lipid Content in Fathead Minnows, ng/g (ppb), Wet Weight

Temp.[1]	Trt.[2]	Aq.[3]	Time[4]	% Lipid	Polychlorinated Biphenyls: Di	Tri	Tetra	Penta	Hexa	Hepta	Octa	Nona	Deca	Total
.	B	.	-17	0.97	5.5	<1.8	20.	29.	65.	<1.8	20.	<1.8	<1.8	140.
4	I	.	0	1.7	90.	7.9	35.	63.	98.	<1.6	6.3	4.8	<1.6	310.
	L	19	2	1.1	44.	25.	27.	40.	71.	<1.3	2.7	<1.3	1.3	210.
		19	4	0.98	25.	15.	36.	31.	50.	<1.1	5.7	<1.1	<1.1	160.
		19	10	1.0	45.	37.	39.	83.	180.	<1.0	<1.0	<1.0	<1.0	380.
		19	17	1.0	20.	28.	32.	25.	38.	<1.3	5.0	<1.3	<1.3	150.
		19	30	1.3	32.	38.	71.	45.	71.	<0.61	12.	2.5	<0.61	270.
	H	22	2	0.97	100.	42.	50.	32.	49.	<1.3	3.9	<1.3	1.3	280.
		22	4	0.89	66.	55.	69.	35.	52.	<1.2	5.8	<1.2	<1.2	280.
		22	10	1.1	110.	95.	92.	42.	60.	<1.0	<1.0	<1.0	<1.0	400.
		22	17	0.98	67.	82.	130.	46.	59.	<1.0	8.2	1.0	2.1	400.
		22	30	1.1	43.	67.	110.	40.	65.	0.50	4.0	0.17	<0.17	330.
20	L	7	10	0.89	43.	93.	120.	38.	71.	<2.0	<2.0	<2.0	<2.0	370.
	M	5	10	0.77	46.	160.	300.	34.	77.	<3.0	<3.0	<3.0	<3.0	620.
	H	10	10	1.0	98.	240.	430.	130.	190.	<2.0	<2.0	<2.0	<2.0	1100.

1. Temperature, degrees C; background sample taken at ambient temperature, approximately 20 degrees C.
2. Treatment: Background, Initial; Low, Medium and High PCB sediments.
3. Aquarium no.
4. In days referenced to start of experiment.

Table A12. PCB Concentrations as Aroclor Standards in Fathead Minnows, ng/g (ppb), Wet Weight

Temp.[1]	Trt.[2]	Aq.[3]	Time[4]	A1242	A1254	A1260
.	B	.	-17	<18.	.	.
4	I	.	0	<16.	.	.
	L	19	2	.	120.	.
		19	4	.	90.	.
		19	10	160.	.	230.
		19	17	.	80.	.
		19	30	200.	.	.
	H	22	2	210.	110.	.
		22	4	240.	90.	.
		22	10	460.	.	.
		22	17	360.	120.	.
		22	30	320.	.	.
20	L	7	10	430.	.	.
	M	5	10	510.	.	.
	H	10	10	1400.	.	.

1. Temperature, degrees C; background sample taken at ambient temperature, approximately 20 degrees C.
2. Treatment: Background, Initial; Low, Medium and High PCB sediments.
3. Aquarium no.
4. In days referenced to start of experiment.

Table A13. PCB Concentrations as Isomer Groups and Lipid Content in Trout, ng/g (ppb), Wet Weight

Temp.[1]	Trt.[2]	Aq.[3]	Time[4]	% Lipid	Polychlorinated Biphenyls									
					Di	Tri	Tetra	Penta	Hexa	Hepta	Octa	Nona	Deca	Total
.	B	.	-17	1.2	170.	220.	250.	260.	23.	0.66	4.2	0.66	2.0	930.
4	I	.	0	5.5	170.	74.	19.	26.	49.	<2.3	21.	<2.3	4.7	360.
	C	16	4	4.9	88.	280.	12.	23.	35.	<2.3	26.	2.3	2.3	470.
		16	17	2.5	20.	14.	12.	14.	23.	<1.2	1.2	<1.2	<1.2	84.
	R	15	2	5.1	140.	130.	160.	31.	23.	<3.8	15.	3.8	3.8	510.
		15	4	3.6	88.	200.	2.9	18.	24.	<2.9	5.9	<2.9	<2.9	340.
		15	10	2.7	55.	18.	12.	16.	30.	1.2	3.6	<1.2	<1.2	140.
		15	17	2.9	55.	17.	20.	17.	45.	<1.3	2.6	<1.3	<1.3	160.
		15	30	3.1	35.	22.	18.	30.	40.	6.7	6.1	0.56	0.56	160.
	L	13	2	6.3	190.	69.	96.	31.	46.	<3.8	38.	3.8	3.8	480.
		13	4	4.7	220.	100.	120.	32.	45.	<4.5	14.	4.5	<4.5	540.
		13	10	3.6	190.	66.	46.	20.	35.	<1.0	4.0	<1.0	<1.0	360.
		13	17	2.9	220.	100.	68.	22.	33.	3.4	0.85	<0.85	<0.85	450.
		13	30	2.6	360.	120.	82.	30.	32.	1.1	2.1	<0.53	<0.53	630.
	M	14	2	9.1	410.	100.	190.	150.	130.	6.3	12.	6.3	<3.1	1000.
		14	4	5.3	320.	92.	200.	40.	52.	<4.0	4.0	<4.0	<4.0	710.
		14	10	3.7	240.	82.	47.	21.	35.	3.9	4.9	0.98	2.9	440.
		14	17	3.7	290.	110.	95.	35.	64.	5.1	2.1	<1.0	<1.0	600.
		14	30	2.4	120.	91.	91.	44.	56.	5.3	1.8	0.59	<0.59	410.

Table A13 (Continued). PCB Concentrations as Isomer Groups and Lipid Content in Trout, ng/g (ppb), Wet Weight

Temp.[1]	Trt.[2]	Ag.[3]	Time[4]	% Lipid	Polychlorinated Biphenyls: Di	Tri	Tetra	Penta	Hexa	Hepta	Octa	Nona	Deca	Total
4	H	20	2	7.2	230.	58.	78.	34.	50.	<2.0	2.0	<2.0	<2.0	450.
		20	4	2.5	240.	130.	140.	40.	64.	<4.0	24.	4.0	4.0	650.
		20	10	4.2	160.	130.	130.	38.	53.	2.8	5.8	1.9	3.7	530.
		20	17	2.9	150.	140.	170.	31.	48.	<1.2	3.4	<1.2	1.2	540.
		20	30	2.2	140.	150.	150.	40.	46.	0.89	2.7	0.44	<0.44	530.
20	I	.	0	2.4	59.	11.	24.	21.	20.	1.3	16.	<1.3	1.3	150.
	C	1	4	3.9	140.	89.	48.	32.	41.	<1.8	27.	<1.8	3.6	380.
		1	17	1.3	77.	63.	57.	20.	30.	<3.3	3.3	<3.3	<3.3	250.
	R	3	2	4.0	110.	51.	78.	27.	42.	<1.4	12.	<1.4	1.4	320.
		3	4	6.5	280.	1400.	60.	52.	78.	5.0	22.	2.5	2.5	1900.
		3	10	2.2	84.	42.	49.	19.	26.	1.2	7.0	<1.2	<1.2	230.
	L	4	2	3.8	110.	97.	130.	30.	54.	<1.4	7.1	<1.4	<1.4	430.
		4	4	3.8	190.	240.	270.	44.	97.	<3.1	19.	<3.1	3.1	860.
		4	10	2.3	140.	180.	220.	46.	70.	2.1	8.2	<1.0	1.0	670.
	M	2	2	3.7	740.	310.	420.	130.	160.	1.2	7.1	<1.2	1.2	1800.
		2	4	4.4	1300.	520.	750.	220.	320.	11.	21.	<1.5	1.5	3100.
		2	10	2.4	460.	500.	900.	230.	370.	2.9	9.7	<0.97	0.97	2500.

Table A13 (Concluded). PCB Concentrations as Isomer Groups and Lipid Content in Trout, ng/g (ppb), Wet Weight

Temp.[1]	Trt.[2]	Aq.[3]	Time[4]	% Lipid	Polychlorinated Biphenyls Di	Tri	Tetra	Penta	Hexa	Hepta	Octa	Nona	Deca	Total
20	H	8	2	4.5	190.	210.	320.	58.	100.	1.7	12.	1.7	1.7	900.
		8	4	4.4	290.	350.	640.	67.	160.	<3.3	27.	3.3	<3.3	1500.
		8	10	2.1	330.	420.	690.	140.	220.	2.0	5.0	<1.0	<1.0	1800.

1. Temperature, degrees C; background sample taken at ambient temperature, approximately 12 degrees C.
2. Treatment: Background, Initial; Low, Medium and High PCB sediments.
3. Aquarium no.
4. In days referenced to start of experiment.

Table A14. PCB Concentrations
as Aroclor Standards in Trout, ng/g (ppb), Wet Weight

Temp.[1]	Trt.[2]	Aq.[3]	Time[4]	A1242	A1254	A1260
.	B	.	-17	90.	30.	.
4	I	.	0	.	.	.
	C	16	4	.	.	.
		16	17	.	.	.
	R	15	2	.	.	.
		15	4	.	.	.
		15	10	.	.	.
		15	17	.	.	.
		15	30	73.	22.	.
	L	13	2	.	.	.
		13	4	.	.	.
		13	10	250.	40.	.
		13	17	340.	30.	.
		13	30	440.	53.	.
	M	14	2	250.	.	.
		14	4	280.	.	.
		14	10	270.	40.	.
		14	17	440.	40.	.
		14	30	440.	41.	.
	H	20	2	340.	.	.
		20	4	600.	.	.
		20	10	480.	90.	.
		20	17	580.	70.	.
		20	30	570.	88.	.
20	I	.	0	.	.	.
	C	1	4	110.	.	.
		1	17	.	.	.
	R	3	2	.	110.	.
		3	4	250.	100.	.
		3	10	150.	50.	.

Table A14 (Concluded). PCB Concentrations as Aroclor Standards in Trout, ng/g (ppb), Wet Weight

Temp.[1]	Trt.[2]	Aq.[3]	Time[4]	A1242	A1254	A1260
20	L	4	2	370.	.	.
		4	4	910.	.	.
		4	10	760.	120.	.
	M	2	2	1500.	.	.
		2	4	2800.	520.	.
		2	10	2800.	710.	.
	H	8	2	770.	.	.
		8	4	1700.	200.	.
		8	10	1900.	400.	.

1. Temperature, degrees C; background sample taken at ambient temperature, approximately 12 degrees C.
2. Treatment: Background, Initial; Low, Medium and High PCB sediments.
3. Aquarium no.
4. In days referenced to start of experiment.