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SECTION V. A.

PCB BIOTRANSFORMATIONS: GLOSSARY

TERMS

1. "Additive Effect": To heighten or increase the intensity of a peak in a chromatogram (enhancement).

2. Aerobe: A microorganism that lives only in air or free oxygen.

3. Aerobic microbial (bio)degradation: The reduction of a chemical component from a higher to a lower type by the action of aerobic microbes.

4. Anaerobe: A microorganism that flourishes without free air.

5. Anaerobic microbial (bio)degradation: The reduction of a chemical component from a higher to a lower type by the action of anaerobic microbes.

6. Anaerobic dechlorination: A specific PCB microbial degradation process whereby chlorine is selectively removed from a congener as the result of anaerobic microbial actions.

7. Aroclor: Trade name (Monsanto) for a series of commercial PCB and polychlorinated terphenyl mixtures marketed in the United States.

8. Aroclor degradation: A reductive modification with respect to the proportions of the individual PCB congeners present in the specific Aroclor.

9. Aroclor transformation: Any change (either reduction or enhancement) in the unique characteristics of the composition of a specific Aroclor.

10. Chromatogram: A tracing of the detector output from a chromatograph which consists of a series of peaks with time.

11. Chromatographic pattern alteration: Any change or modification in chromatographic peak pattern relative to the chromatogram produced by a known reference material (e.g., a specific Aroclor).

12. Congener: One of the 209 PCBs or other group of compounds, not necessarily the same homolog.

13. Degrade: To reduce from a higher to a lower type.

14. Enhance: To heighten or increase in intensity.

15. Environmental aging (weathering): The process whereby the Aroclor(s) present in an environmental sample undergoes modification with respect to the proportions of individual PCB congeners present as the result of partial vaporization, adsorption onto surfaces, and/or extraction into water. True molecular solution in water is shown (on chromatograms) as the non-selective loss of the more volatile and more water-soluble congeners from the Aroclors in the sediments.

16. "High-end drop-off": The pattern alteration observed when higher chlorinated PCB congeners (usually penta- and hexa-) undergo anaerobic dechlorination.

17. High resolution gas-liquid chromatography: Gas chromatography with a capillary column.

18. Homolog: One of the 10 degrees of chlorination of PCBs ($C_{12}H_9Cl$ through $C_{12}Cl_{10}$) or other group of compounds varying by systematic addition of a substituent.

19. Isomer: Any PCB or other compound which has the same molecular formula, different positional substitutions. 2,2'-Dichlorobiphenyl and 2,3-dichlorobiphenyl are isomeric; 4-chlorobiphenyl and 2,3,4-trichlorobiphenyl are not.

20. "Low-end drop-off": The pattern alteration observed when lower chlorinated PCB congeners are removed from samples by weathering.

21. Pattern alterations: Changes in a characteristic chromatographic pattern. The effect of the changes will be reflected by peak enhancements, reductions, or both. (See chromatographic pattern alterations.)

22. Polychlorinated biphenyl (PCB): One of 209 individual compounds having the molecular formula ($C_{12}H_aCl_{-10-n}$, where n = 0-9. This definition includes monochlorobiphenyls, but not biphenyl.

23. PCB degradation: A conversion whereby a PCB congener of a higher chlorine content is reduced (converted) to one of a lower chlorine content.

24. PCB "enrichment": A term used to describe compositional distribution differences between vapor phase and solid or liquid phase Aroclors. The vapor phase is enriched with lower chlorinated congeners relative to a specific Aroclor standard.

25. PCB transformation: Any change whereby a PCB congener is converted into another compound.

26. Qualitative: Having to do with establishing the presence or identity of a compound.

27. Quantitative: Having to do with measuring the amount or concentration of a compound in a sample.

28. Retention time: Time between injection and detection of a compound on a chromatographic system under specified conditions, expressed in seconds or minutes.

29. Transformation: Any change which gives a different appearance.

30. Weathering: A process which gives a compositional change in an Aroclor residue (see environmental aging).

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SECTION V. B.

PCB BIODEGRADATION: GENERAL

1. Polychlorinated biphenyls (PCBs) can be reductively dechlorinated by a biologically mediated process under anaerobic conditions at normal environmental temperatures. Chlorines are preferentially removed from meta and/or para positions. Ortho substituted chlorobiphenyls are usually the predominant products.

2. A pronounced concentration effect has been observed in laboratory experiments. Dechlorination appears to proceed more readily at elevated PCB concentrations. Dechlorination has been observed at the highest concentrations tested (5,000 ppm of Aroclor 1254).

3. Dechlorination of Aroclors 1242, 1248, 1254, and 1260 has been observed in laboratory experiments. Dechlorination of Aroclor 1260 tends to be slower than the other Aroclors.

4. Different dechlorination patterns have been obtained by using microorganisms from different sediments, and from the same sediment under different conditions. Different patterns have also been described for environmental samples. These patterns may be the result of dechlorination by different species or strains of microorganisms.

5. Dechlorination is most rapid about 25°C. It proceeds more slowly at 12°C, and has not been observed at 4°C, or at 37°C and above.

6. Dechlorination of PCBs is inhibited by oxygen. Inocula are still active after intermittent exposure to air.

7. Addition of carbon sources/electron donors may stimulate PCB dechlorination. Substrates shown to support dechlorination are acetone, glucose, and a mixture of acetate, propionate, butyrate, and hexanoic acid. Results of feeding experiments suggest that dechlorination activity may be more easily lost if such carbon sources are constantly available.

8. Greater PCB dechlorinating activity is generally associated with inocula prepared from PCB contaminated sediments. It appears that the dechlorinating microorganisms conserve energy from dechlorination of PCBs.

9. Dechlorination of aromatic compounds is a biological electron acceptor for some anaerobic microorganisms and thus relieves the condition most limiting for growth in anaerobic sediments. In addition dechlorination has been

shown to provide energy for microbiol growth. Thus dechlorination offers a selective advantage (benefit) to microorganisms. This is the rationale for why dechlorinators may be expected to develop in sediments contaminated with PCBs.

10. PCB dechlorinating activity has been retained after eight successive transfers with pyruvate as the electron donor and PCBs as the electron acceptor.

11. Dechlorination reduces the toxicity of a PCB mixture such as Aroclor 1242.

12. Dechlorination yields lesser chlorinated PCB congeners that can be more rapidly and extensively degraded aerobically than the initial mixture.

13. The following references support and further detail the above propositions concerning biodegradation of PCBs:

Alder, A.C., M. Haggblom, and L.Y. Young. 1990. Dechlorination of PCBs in sediments under sulfate reducing and methanogenic conditions. Abstract Q-47. 90th Annual Meeting of the American Society for Microbiology. Anaheim, CA.

Bedard, D.L., M.L. Haberl, R.J. May, and M.J. Brennan. 1987. Evidence for novel mechanisms of polychlorinated biphenyl metabolism in Alcaligenes eutrophus H850. Appl. Environ. Microbiol. 53:1103-1112.

Bedard, D.L., R.E. Wagner, M.J. Brennan, M.L. Haberl, and J.F. Brown, Jr. 1987. Extensive degradation of Aroclors and environmentally transformed polychlorinated biphenyls by Alcaligenes eutrophus H850. Appl. Environ. Microbiol. 53:1094-1102.

Brown, J.F., Jr. and R.E. Wagner. 1990. PCB movement, dechlorination and detoxication in the Acushnet estuary. Environ. Toxicol. Chem. In press.

Brown, J.F., D.L. Bedard, M.J. Brennan, J.C. Carnahan, H. Feng, and R.E. Wagner. 1987. Polychlorinated biphenyl dechlorination in aquatic sediments. Science 236:709-712.

Brown, J.F., R.E. Wagner, D.L. Bedard, M.J. Brennan, J.C. Carnahan, R.J. May, and T.J. Tofflemire. 1984. PCB transformations in upper Hudson sediments. Northeast. Environ. Sci. 3:167-179.

Brown, J.F., R.E. Wagner, H. Feng, D.L. Bedard, M.J. Brennan, J.C. Carnahan, and R.J. May. 1987. Environmental dechlorination of PCBs. Environ. Toxicol. and Chem. 6:579-593.

Chen, M., C.S. Hong, B. Bush, and G.-Y. Rhee. 1988. Anaerobic biodegradation of polychlorinated biphenyls by bacteria from Hudson River sediments. Ecotoxicology and Environmental Safety 16:95-105.

Dolfing, J., and J.M. Tiedje. 1987. Growth yield increase linked to reductive dechlorination in a defined 3-chlorobenzoate degrading methanogenic coculture. Arch. Microbiol. 149:102-105.

Kohler, H.P.E., D. Kohler-Staub, and D.D. Focht. 1988. Cometabolism of polychlorinated biphenyls: enhanced transformation of Aroclor 1254 by growing bacterial cells. Appl. Environ. Microbiol. 54:1940-1945.

Mohn, W.W. and J.M. Tiedje. 1990. Strain DCB-1 conserves energy for growth from reductive dechlorination coupled to formate oxidation. Arch. Microbiol. 153:267-271.

Nies, L. and T.M. Vogel. 1990. Effects of substrate on dechlorination of Aroclor 1242 in anaerobic sediments. Appl. Environ. Microbiol. In press.

Quensen, J.F., III, S.A. Boyd, and J.M. Tiedje, 1990. Dechlorination of four commercial polychlorinated biphenyl mixtures (Aroclors) by anaerobic microorganisms from sediments. Appl. Environ. Microbiol. In press.

Quensen, J.F., III, J.M. Tiedje, and S.A. Boyd. 1988. Reductive dechlorination of polychlorinated biphenyls by anaerobic microorganisms from sediments. Science 242:752-754.

Research and Development Program for the Destruction of PCBs. Eighth Progress Report. 1989. General Electric Company Corporate Research and Development. Schnectady, NY.

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SECTION V. F.

SPECIAL RESEARCH INVESTIGATION - PHASE II

EVALUATION OF PCB TRANSFORMATIONS IN NEW BEDFORD HARBOR SEDIMENTS

1. Authorization to conduct Phase II of the Special Research Investigation was received by Yoakum and Associates, Inc. (hereinafter referred to as "YAI") on May 22, 1989.

2. Phase II of the investigation was designed by Anna M. Yoakum to determine the identity of the individual PCB congeners undergoing reductive dechlorination and to ascertain, if possible, the most probable transformation pathways.

3. The analytical support for Phase II consisted of two tasks, Task 15 and Task 18.

   3.a. Task 15. Analysis of selected NBH sediment samples by levels of chlorination using gas chromatography/mass spectrometry (hereinafter referred to as "GC/MS") as described in EPA Method 680 (1985).

   3.b. Task 18. Congener-specific PCB analysis of selected NBH sediment samples using GC/MS and a custom approach adapted from Alford-Stevens et al. (1986) and EPA Method 680 (1985).

   3.c. Analytical support for the Phase II Investigation was provided by International Technology Corporation, Analytical Services (hereinafter referred to as "ITAS"), Knoxville, Tennessee, as their project YOK 43544.

   3.d. Data evaluations for the Phase II Investigation were performed by YAI.

4. Seven (7) samples from the Task 7 Investigation representing five (5) sampling sites were selected for the Phase II study.

   4.a. Archived sample extracts from Task 7 were used in the Phase II Study.

   4.b. On June 15, 1989, the storage vials and their seals were inspected by personnel from YAI and ITAS to verify the integrity of the sample extracts.

4.c. The Task 7 samples selected for further characterization covered the entire range of dechlorination observed from the least (NBH-112-02) to the most advanced (NBH 105/106 and NBH-110-02).

4.d. The reported PCB concentrations (as Aroclors) based on the Task 7 study ranged from an average concentration of 100 ppm for the composite sample NBH-113-01/02 to 44,000 ppm for sample NBH-112-02.

4.e. The Task 7 samples chosen by YAI for the Phase II Investigation were:

4.e.1. NBH-110-02,
4.e.2. NBH-111-01,
4.e.3. NBH-112-02,
4.e.4. Composite of NBH-105 and NBH-106, field duplicates from the same sampling site, and
4.e.5. Composite of NBH-113-01 and NBH-113-02, the 0-3" and 3"-6" samples from site NBH-113, respectively.

4.f. The instructions for the preparation of the Phase II samples from the Task 7 extracts were confirmed by memo from Anna M. Yoakum to Nancy Seabolt on June 16, 1989. A duplicate of this memo is attached as Document No. 001070.

5. The Phase II sample extracts were analyzed for PCB concentration by three approaches: (1) as commercial mixtures (e.g. Aroclors) using packed-column GC/EC data, (2) by level of chlorination (homologs) by GC/MS, and (3) quantitation of individual PCB congeners or isomer groups using a DB-5 capillary column and full-scan GC/MS.

6. To assure the integrity of the data and to verify that no changes had occurred during storage, the extracts were analyzed by packed-column GC/EC prior to their submittal for analysis by GC/MS.

6.a. Duplicate copies of the original chromatograms from projects BME 40786 and BME 40805 and the YOK 43544 chromatograms are attached as Document Nos. 001071-001086.

6.b. Aroclor concentrations were calculated for the Phase II (YOK 43544) samples using the packed column GC/EC data.

7. A comparison of the Task 7 data and the YOK 43544 data as percent Aroclors 1016 and/or 1242 and Aroclor 1254 as well as total Aroclors as mg/kg are accurately reported in Table 1 hereof.

8. Based on the favorable comparison of packed column GC/EC chromatograms and Aroclor data, the five (5) Phase II sample extracts were submitted for analysis by capillary column (DB-5) GC/MS.

9. The levels of chlorination in the Phase II extracts were determined by GC/MS using two different instruments and two different calibration approaches.

   9.a. The calibration approaches are described in the YOK 43544 project narratives, duplicates of which are attached as Document Nos. 002742 and 003069.

   9.b. The quantitation routine used for homolog series determinations by GC/MS automatically quantitates all PCBs present in the samples. It is not necessary that all PCBs quantitated be present in the standard.

   9.c. Duplicate copies of the GC/MS data packages are attached hereto as Document Nos. 002740-003814.

10. Results of homolog distribution analysis (as weight percent) for Phase II (Task 15) are reported in Table 2. Data represent the average of two GC/MS determinations.

   10.a. Table 2 hereof accurately depicts the homolog distribution of the Phase II samples.

11. Using current, state-of-the-art, analytical methodology, not all PCB congeners that occur in a commercial mixture (Aroclor) or in an environmental sample can be separated into single peaks with the use of only one GC capillary column.

   11.a. As a consequence, the unambiguous identification and subsequent accurate quantitation of the 209 polychlorinated biphenyl congeners which are theoretically possible cannot be accomplished using this approach.

   11.b When coelution of PCB congeners occurs, peaks are quantified as aggregates of congeners. Despite these limitations, much valuable information can be derived from the analysis of environmental samples using DB-5 (SE54) capillary columns and high resolution gas chromatography/electron capture detection (HRGC/ECD).

12. A National Bureau of Standards (NBS) standard reference material (SRM) which certifies both the identity and concentration of individual PCB congeners in a commercial Aroclor mixture is not available. In order to perform congener-specific PCB analysis, therefore, it is necessary to rely upon both literature references and individual PCB congeners as standards and retention time markers.

13. This experimental approach permitted the determination of 143 chromatographically distinguishable PCB congeners or congener groups in the Phase II investigation.

13.a This approach provides a valid means of quantitating the changes in the relative abundance of PCB congeners found in the sediments when compared to the composition of the commercial products used by manufacturing facilities in the proximity of NBH.

13.b In addition, the use of GC/MS provides tentative identification of non-PCB compounds found in the samples as well as PCB congeners formed during dechlorination which are either absent from or present only as very minor constituents in Aroclor 1016, Aroclor 1242, and Aroclor 1254.

14. A cross-reference of PCB congener elution order for SE-54, DB-1, and DB-5 capillary columns prepared for use in Phase II data evaluations is contained in Table 3 hereof.

14.a The relative retention times (RRT) in column 2 and the structure in column 3 of Table 3 for biphenyl and all 209 PCB congeners are listed in the order of elution for an SE-54 column as reported by Mullin et al. (1984). Retention times were determined relative to a reference standard, octachloronaphthalene. All 209 theoretically possible congeners were available as reference compounds for the RRT determinations.

14.b The number for each PCB congener in column 4 is according to the system of Ballschmiter and Zell (1980), which was followed by Mullin et al. (1984). The numbering system adopted by the International Union of Pure and Applied Chemists (IUPAC) is the same as the BZ number, with three exceptions. Congeners BZ# 199, 200, and 201 have the IUPAC numbers 200, 201, and 199 respectively.

14.c The eighty-seven (87) chromatographic domains listed in column 5 were identified by Schulz et

al. (1989) as being essentially base-line separated on SE-54 chromatograms. Each domain contains either one well resolved peak or a cluster of unresolved peaks.

14.d Based on the data generated by Schulz et al. (1989), 132 PCB congeners were identified in one or more of eight commercial PCB mixtures. In column 6, the congeners identified by the symbol * were not detected in any of the commercial mixtures (i.e., concentrations were less than 0.05%). Congeners identified by the symbol - were not detected in Aroclor 1016, 1242, or 1254 (i.e., concentrations were less than 0.05%) but were identified in other commercial mixtures.

14.e Brown and Wagner (1986) have identified 140 individual PCB congeners or isomer groups detectable by capillary GC or GC/MS on a DB-1 column. The numbers in column 7 were assigned for 118 distinguishable peaks based on the order of elution for the DB-1 column. (Plaintiff Attachment Doc. No. XII E.R. 0388)

14.f The numbers listed in column 8 represent distinguishable chromatographic peaks for the DB-5 capillary column used in GC/EC (Task 7) and GC/MS (Task 18). The assigned peak numbers coincide where applicable, to those employed by Brown and Wagner (1986). Differences relating to column elution separations and/or GC/MS differentiation of coeluting congeners having different chlorine numbers were assigned the notation peak number prime(1) when appropriate. The DB-5 column has been reported by Alford-Stevens et al. (1985) to provide the same retention order and essentially the same separation capabilities as an SE-54 column.

14.g Column 9 lists the GC/MS scan numbers representing peak elution order for a DB-5 column.

14.h The accurate references for data in Table 3 are:

Alford-Stevens, A., T.A. Bellar, J.W. Eichelberger, and W.L. Budde, 1985. EPA Method 680. Determination of Pesticides and PCBs in Water and Soil/Sediment by Gas Chromatography/ Mass Spectrometry. EMSL Office of Research and Development, U.S. EPA, Cincinnati, Ohio 45268.

Ballschmiter, K. and M. Zell. 1980. Analysis of Polychlorinated Biphenyls (PCB) by Glass Capillary Gas Chromatography: Composition of

Technical Aroclor-and Clophen-PCB Mixtures. Fresenius Zeitschrift fur Analystische Chemie, Vol. 302:210-31.

Brown, J.F., Jr., and R.E. Wagner. 1986. Polychlorinated Biphenyl (PCB) Movement and Transformation in Acushnet Estuary Sediments. Draft of September 26, 1986.

(Plaintiff Attachment Doc. No. XII E.R. 0388 and 0388-A)

Mullin, M.D., C.M. Pochini, S. McCrindle, M. Romkos, S.H. Safe, and L.M. Safe. 1984. High-Resolution PCB Analysis: Synthesis and Chromatographic Properties of All 209 PCB Congeners. Environ. Sci. Technol., Vol 18:468-476.

Schulz, D.E., G. Patrick and J.C. Duinker. 1989. Complete characterization of Polychlorinated Biphenyl Congeners in Commercial Aroclor and Clophen Mixtures by Multidimensional Gas Chromatography-Electron Capture Detection. Environ. Sci. Technol., Vol 23:852-859.

14.i Table 3, attached hereto, contains an accurate cross-reference of PCB congener elution order for SE-54, DB-1, and DB-5 capillary columns.

15. Congener-specific analyses (Task 18) of the Phase II samples were performed on a Finnigan 4023 GC/MS using a DB-5 capillary column and full-scan data collection.

16. GC/MS identifications were made using retention times and full-scan mass spectra. PCBs were confirmed from full mass spectra of all peaks found in the total ion chromatograms for each sample.

17. The GC/MS study (Phase II) provided collaborative data for the Phase I (Task 7) study. Good agreement between the elution patterns and relative peak heights of the HRGC/ECD and total ion current mass chromatograms (RICs) from GC/MS allowed a straightforward correlation between the results of the two detection techniques. GC/MS was further used for congener-specific evaluations to resolve non-isomeric co-eluting compounds.

17a. Duplicates of the reconstructed ion chromatograms (RICs) for Aroclor 1242 and Aroclor 1254 are included as Figures 1 and 2 hereof, respectively.

17b. Duplicates of the RICs for the Phase II samples JJ1004/5, JJ1006, JJ1007, JJ1008, and JJ1009/10 are included as Figures 3-7 hereof, respectively.

17c. GC/MS scan numbers and DB-5 peak identification have been added to selected peaks in Figures 1-7.

18. Concentrations (expressed as mg/kg, dry weight basis) of individual PCB congeners in Task 18 sediment samples from NBH are accurately reported in Table 4 hereof.

19. Quantitative data are presented only for those peaks where the presence of PCB congeners could be verified.

20. Table 4 accurately represents the presence and concentration of PCB congeners in the samples of the Phase II Investigation.

21. A comparison of the analytical results for the total PCB content of the Phase II samples as determined from packed column GC/EC data (Table 1) as Aroclors and from individual congener quantitations (Table 4) are found in Table 5 hereof. The lower values for PCB concentrations as Aroclor mixtures result primarily from Method 8080 quantitation restrictions which fail to take into account the transformation peak enhancements.

22. Two of the Task 7 sample locations, NBH-110 and NBH-113, showed the presence of new, full-scale peaks in both the packed column and DB-5 capillary column chromatograms. These peaks were tentatively identified as mono-, di-, and trichlorobiphenyls, based on their early elution times.

23. Examination of the mass spectra for these peaks in the corresponding Task 18 samples, JJ1006 and JJ1009/10, revealed that the peaks were not PCB congeners. The compounds were tentatively identified as being mono-, di, and trichloronaphthalenes.

23a. Mass spectra for four peaks, present in sample JJ1006, and tentatively identified as chloronaphthalenes by computer library searches, are illustrated in Figure 8 hereof.

24. A subsequent request was made to ITAS by YAI that standards be obtained and that the identity of the compounds be confirmed.

25. On July 19, 1989, the compounds were confirmed as being mono-, di-, and trichloronaphthalenes. Duplicates of the GC/MS confirmation data package are attached herewith as Document Nos. 003720-003814.

26. The NBH transformation pattern, described by Brown and Wagner (1986) as Pattern H, was confirmed in these samples by the GC/MS data.

27. The congener-specific data from Table 4 were used to determine the distribution of PCBs in Phase II sediment samples.

28. It is reasonable to expect that those PCB congeners which are relatively abundant in the commercial PCB mixtures (Aroclors 1016, 1242, and 1254) used by industries in the NBH area would also be relatively abundant in NBH sediments. This simple picture is modified, however, by the physical/chemical properties unique to each congener. Congener partitioning, or translocation, between different environmental compartments can occur as the result of vapor pressure, solubility and lipophilicity (as measured by octanol-water partition coefficient).

29. Once commercial mixtures of PCBs are released into the environment their compositions can change due to the differential behaviors of the congeners.

30. Two congeners may be equally abundant in the commercial mixture while differing in physical/chemical properties and also in their susceptibility to in-situ anaerobic reductive dechlorination.

31. Any change resulting in the formation of altered congener distributions destroys the identity of the Aroclor originally present in the samples. There is no doubt that PCBs are present, but the source of a particular congener may have been the original Aroclor release or it may be the product of dechlorination of higher chlorinated congeners from the original Aroclor formulations.

32. Changes observed in the relative abundance of PCB congeners in four (4) of the Phase II (Task 18) samples are presented in Table 6 hereof.

33. Table 6 accurately lists the relative abundance of PCB congeners in selected NBH sediments and Aroclor standards expressed as weight percent of total PCBs present.

34. Selection criteria and data provided by Schulz et al. (1989) were used in determining those congeners for which their absence could be established by retention times on SE-54 (Mullin et al., 1984).

35. Verification of the absence of additional congeners in Aroclor 1242 and Aroclor 1254 as reported by Schulz et al. (1989) was done using GC/EC and GC/MS data for the DB-5 capillary column.

36. The Aroclor 1242 and Aroclor 1254 congener-specific quantitations were in agreement with those of Brown and Wagner (1986) which employed response factors determined by

an independent approach described previously (Brown et al., 1987).

37. Data generated in the Phase I (Task 7) and Phase II (Tasks 15 and 18) investigations have been used by YAI to evaluate anaerobic reductive dechlorination in NBH samples.

38. Data currently available from the site specific studies of Brown and Wagner (1986); Lake, Pruell, and Osterman (1989); and Quensen and Tiedje (1990) indicate that in-situ anaerobic reductive dechlorination of PCB congeners is occurring in New Bedford Harbor sediments.

39. These data indicate that the dechlorination regime is a complex, multifaceted system in which the higher chlorinated congeners (octa, hepta, hexa, and penta-) appear to be preferentially dechlorinated.

40. The cascading nature of the dechlorination process is evident upon examination of chromatograms from different locations within the estuary. This same phenomenon is shown for progressive incubation periods in the Aroclor 1248 dechlorination experiment of Quensen and Tiedje (1990) using NBH microbes.

41. Laboratory studies by Abramowicz et al. (1989) confirm the sequential, primary dechlorination pathway of BZ105 to be 234-34 ---> 24-34 ---> 24-3 ---> 2-3 ---> 2- for Hudson River microbes and 234-34 ---> 24-34 ---> 24-4 ---> 2-4 ---> 2 for Silver Lake microbes. The para- removal orientation from BZ 66 (24-34) to yield BZ 25 (24-3) has been observed in NBH.

42. Numerous transient increases have been observed for congeners which are first produced by the dechlorination of more highly chlorinated congeners and then subsequently dechlorinated.

43. The anaerobic dechlorination of PCBs in NBH is structure dependent.

44. Congeners most sensitive to the dechlorinating agent(s) in New Bedford Harbor carry the following reactive groups:

    2345-, 2346-, 234-, 235-, 245-, and -34.

45. The most prevalent dechlorination pathways occurring in NBH sediments are shown in Figure 9 hereof.

46. The dechlorination regime observed in NBH selectively removes chlorine from the meta- and para- substitution positions.

47. The dechlorination proceeds in a step-wise manner with the removal of the meta chlorine from the 2345-, 2346-, 234-, 235-, and 236- groups. The dechlorination of the 236 group has been observed in samples showing advanced dechlorination. The congeners BZ51 (24-26) and BZ53 (25-26) are formed by the dechlorination of BZ91 (236-24) and BZ95 (236-25), respectively.

48. Chlorine is removed from the para- position for the group 245- and specifically from the -34 group of congeners BZ66 (24-34) and BZ70 (25-34) to yield BZ25 (24-3) and BZ26 (25-3), respectively.

49. Lesser chlorinated, ortho substituted PCB congeners are accumulating in NBH sediments. Ortho chlorines are more resistant to reductive dechlorination than meta and para chlorines.

50. The PCB congener dechlorination pattern observed in NBH sediments is similar to that seen by Brown and Wagner (1989) at numerous sites around the country.

51. The extent of the dechlorination observed is variable and appears to be dependent upon at least the following inter-related factors:

    51.a PCB concentration,

    51.b sediment depth horizon,

    51.c presence and concentration of anaerobic microbes,

    51.d congener structure (chlorine number and substitution pattern).

52. Commercial PCB products (Aroclors) are complex mixtures of individual congeners, each of which behave independently so that a wide range of dechlorination rates would be anticipated to occur simultaneously.

53. The extent and the position of the chlorination of each congener appears to alter the pathway and rate of biotransformation.

54. In laboratory experiments, Quensen and Tiedje (1990) and Quensen, Tiedje, and Boyd (1988), have demonstrated PCB dechlorination by anaerobic bacteria.

    54.a Dechlorination rate was found to be related to PCB concentration; the most rapid dechlorination occurred at the highest (700 ppm) concentration studied.

    54.b Lag times have been observed in laboratory experiments before dechlorination is observed.

55. Site specific investigations indicate the following:

55.a The rate at which dechlorination occurs appears to be concentration dependent.

55.b Dechlorination rates appear to be congener specific.

55.c Dechlorination does not appear to be occurring at a constant rate.

55.d It is easier to estimate the extent of dechlorination which has occurred than to estimate the rate at which it has occurred.

56. Brown and Wagner (1986) and Lake et al. (1989) have used half losses to characterize the dechlorination reaction.

56.a Brown and Wagner (1986) normalized Aroclor 1254 data to peak 61 and Aroclor 1242 data to peak 39 so that relative changes could be compared among samples showing differing degrees of dechlorination.

56.b Lake et al. (1989) used the same peaks to calculate the percentages of Aroclor 1242 and Aroclor 1254 as original composition of the Aroclor mixture in the samples.

56.c In both investigations, peaks 39 and 61 were considered most resistant to dechlorination changes.

56.d Quensen and Tiedje (1990) have demonstrated that both peaks can be dechlorinated with NBH microbes.

56.e There are indications from the Task 18 study that certain congeners in peak 39 are formed from Aroclor 1254 in advanced stages of dechlorination.

56.f In addition to the apparent resistivity to dechlorination of the 236 group, it appears that peaks 61 and 39 are being formed at approximately the same rate as they are being dechlorinated.

57. It is unlikely that the rate of dechlorination in NBH is a first order kinetic reaction. Nevertheless, a measure of the effectiveness of the dechlorination of specific PCB congeners can be expressed in terms of half-losses.

57.a For a first order reaction, the number of half losses, X, corresponding to a reduction of concentration to a fraction, C/C_o, of the original concentration is X or $t_{1/2} = -1.443 \ln C/C_o$.

57.b One half-loss equals 50% removal; six half-losses represent greater than 98% removal.

58. By assuming a time of Aroclor input into the estuary and by assuming a first order kinetic reaction, estimates of average rates of dechlorination on a specific congener basis can be calculated using the formula $t_{1/2} = 0.693/k$ where

    k = dechlorination rate and
    $t_{1/2}$ = half loss, expressed as years.

59. Based on plant records to determine mean weighted usages, environmental exposure periods of 30 years for Aroclor 1254 and 23 years for Aroclor 1242 were estimated.

60. The assumption can be made, based on the homolog composition of Aroclors 1242 and 1254, that more than 95% of the penta and all of the hexa and higher chlorinated biphenyls in NBH sediments are due to Aroclor 1254 releases. In the Phase II data evaluation involving half-loss calculations, the mono- through tetra- congeners were calculated using the Aroclor 1242 environmental exposure period of 23 years. The 30-year exposure period for Aroclor 1254 was used for all remaining congeners (penta and higher).

61. Congener dechlorination transformations based on half-loss (or doublings) are plotted in Figures 10-13 for four (4) selected NBH sediments.

62. Figures 10-13 hereof are comparative abundance plots showing the measured abundance of each congener relative to the predicted starting mixture of Aroclor 1242 and Aroclor 1254 in the samples derived from packed column GC/EC data.

    62.a Figures 10 and 11 illustrate advanced dechlorination in sample numbers NBH 110-02 and NBH 105/106, respectively.

    62.b Moderate dechlorination has occurred in sample number NBH 111-01 (Figure 12).

    62.c Slight dechlorination is shown by sample number NBH 112-02 (Figure 13).

63. Plots illustrating the extent of congener dechlorination transformations in Aroclor 1248 which occurred using Site 19 and Site 17 microbes (data from Quensen and Tiedje, 1990) are shown in Figures 14 and 15 hereof, respectively.

    63.a The extensive dechlorination illustrated in Figure 14 for the Site 19 microbes is very similar to that shown in Figures 10 and 11.

    63.b While the dechlorination with the Site 17 microbes is not as extensive as that occurring with the Site 19

microbes, greater than 75% of the hexa and penta congeners shown in Figure 15 have been dechlorinated to penta and tetra congeners. This demonstrates the presence of the dechlorinating agent(s) in NBH sediments containing less than 50 ppm total PCBs.

63.c The total PCB content of the Site 17 and Site 19 sediments was 38 and 585 ppm, respectively.

64. This experiment illustrates the onset of dechlorination at Site 17, but at a slower rate than at Site 19, presumably due to a less well established microbe population at Site 17.

65. The dechlorination regime for PCBs in NBH is characterized by a step-wise removal of chlorine atoms from the biphenyl structure; therefore, the relative reactivity for the individual PCB congeners to the dechlorinating agent(s) can be expressed as the number of half-losses observed.

66. Relative reactivity data (as half-losses or doublings) and dechlorination rate constants for two NBH samples (NBH 110-02 and NBH 105/106) exhibiting advanced dechlorination are contained in Table 7 hereof.

67. Table 8 hereof contains half-loss/doubling data and dechlorination rate constants for samples NBH 111-01 and NBH 112-02.

68. Both half-loss values and dechlorination rate constants vary widely. Both are highly congener dependent and sample dependent.

69. Sample number NBH 112-02 exhibits the least dechlorination and has the highest PCB concentration (58,000 ppm).

69a. Based on the PCB concentration distribution observed and the extensive dechlorination occurring in the northern reaches of the NBH estuary (YAI Task 10 Report), it is inappropriate to consider this sample as a typical NBH sediment.

69b. It is significant to note that evidence of reductive dechlorination was observed in this sample as illustrated by Figure 13.

70. Congener selectivity patterns for the dechlorination process and the prominent dechlorination pathways (Figure 9) were derived from the data given in Tables 7 and 8.

71. Experimental findings of the YAI investigations are in agreement with the studies of Brown and Wagner (1986) and Lake et al. (1989) in the following areas:

71.a The spatial distribution of PCBs in New Bedford Harbor sediments is spotty and extremely variable.

71.b The concentrations of PCBs in NBH sediments vary considerably.

71.c In-situ reductive dechlorination of PCB congeners has occurred in NBH sediments.

71.d The dechlorination process preferentially removes meta and para chlorines from the more highly chlorinated congeners, thereby lowering the chlorine content of the PCB residues in the NBH sediments.

72. A comparison of the chlorine content of a dechlorinated Task 15 sample, NBH 105/106, and Aroclor 1254 is shown in Figure 16.

72.a The total chlorine content of sample number NBH 105/106 is 44.8%.

72.b The total chlorine content of Aroclor 1254 is 54%.

73. The properties of PCB congeners differ depending on the chlorine substitution, thus, environmental alterations may influence the toxicological significance of PCB mixtures.

74. Both Brown and Wagner (1986) and Lake et al. (1989) have reported a decrease in concentration of congeners which are associated with toxic effects as a result of anaerobic dechlorination of NBH sediments.

75. Brown and Wagner (1986) have estimated the removal of congener (BZ 105) 234-34 as being greater than 90%, based on a mean half-time of removal of 8 $\pm$2 years. They consider BZ 105 to be the primary biochemically active congener in NBH sediments.

76. Lake et al. (1989) projected a half-life for BZ 105 of 7.5 years and 4.4 years for two of their samples showing fairly extensive dechlorination. They also reported preferential attack on the potentially toxic coplanar and mono-ortho substituted congeners.

77. A decrease in concentration, as the result of anaerobic dechlorination, of some congeners known for their bioaccumulation potential (e.g. 245-245, 245-25, 245-24) was also reported by Lake et al. (1989).

78. Brown and Wagner (1986) have reported that the dechlorination of NBH sediments has resulted in a net loss of pharmacologically active congeners. Included in this group are congeners having chlorine substitution at both para positions (4,4') and at least <u>two</u> of the four meta

positions (3,3',5,5') as well as having the possibility of a coplanar configuration when no more than one ortho position is substituted with chlorine. According to Duinker, Schulz, and Petrick (1988), 13 congeners satisfy these conditions. The fate of these 13 congeners in selected NBH sediments is shown in Table 9 hereof.

78.a The two Phase II samples included in Table 9 show early (NBH 112-02) and advanced (NBH 105/106) stages of dechlorination.

78.b All thirteen congeners listed in Table 9 have been reported to be AHH inducers and as such, have been treated as having toxicological significance.

78.c Eight (8) of the 13 congeners were not found in either of the samples at an analysis limit of 0.01% (based on Total PCB content of samples).

78.d All thirteen congeners contain one or more of the following substitution groups: 34-, 345-, or 2345. All three of these groups are extensively dechlorinated by NBH dechlorination agent(s).

78.e Greater than 90% removal has occurred for 4 of the 5 congeners of interest present in the advanced dechlorination sample. The structure, half-loss, and percent removal for these four congeners in Sample NBH 105/106 are as follow:

1. BZ 37, 34-4, $t_{1/2}$ = 6.7 yrs, % Removal = 90.6
2. BZ 77, 34-34, $t_{1/2}$ = 6.2 yrs, % Removal = 92.4
3. BZ 105, 234-34, $t_{1/2}$ = 4.4 yrs, % Removal = 99.1
4. BZ 156, 2345-34, $t_{1/2}$ = 6.2 yrs, % Removal = 96.6

78.f The congener showing the least removal (BZ 118) has a half-loss of 16.5 years and is 71.8% removed. This congener is undergoing formation as well as dechlorination which accounts for the lower percent removal.

78.g There is every indication that the remaining eight congeners, listed in Table 9 but not detected in the samples, would undergo extensive dechlorination if they were present at concentration levels less than the reported analysis limits.

79. A plot showing the progressive removal of the five congeners listed in Table 9 from the Phase II samples as

the result of anaerobic dechlorination is shown in Figure 17.

80. Both Table 9 and Figure 17 clearly demonstrate the effectiveness of the anaerobic reductive dechlorination in the detoxification of the PCBs in NBH sediments.

81. A treatment similar to that of Table 9 is presented in Table 10 hereof for the same NBH samples showing dechlorination losses for the non-ortho (coplanar) congeners.

81.a Nineteen congeners are considered coplanar.

81.b Eleven of the 19 coplanar congeners were not detected (<0.01%) in either sample.

81.c Significant dechlorination losses are occurring for congeners (BZ) 37, 77, and 80.

81.d The remaining five (5) congeners are mono- and dichlorobiphenyls and are not considered toxic.

82 According to McFarland and Clarke (1989), using potential toxicity, environmental prevalence, and relative abundance in animal tissues as criteria, thirty-six (36) of the 209 possible PCB congeners are of environmental concern.

82.a The fate of thirteen (13) of these 36 congeners in selected NBH sediments is shown in Table 9.

82.b Two additional congeners (BZ 70 and 74) are included in Table 11 hereof, which presents dechlorination losses for the 48 PCB congeners having mono-ortho chlorine substitution.

82.c The remaining 21 congeners contain either di or triortho chlorine substitution and are included because of their reported prevalence and/or bioaccumulation.

83. An evaluation of dechlorination of mono-ortho congeners (Table 11) revealed that those congeners in this classification which are of toxicological concern are undergoing dechlorination and subsequent detoxication.

84. The dechlorination/detoxication process appears to have started in the northern reaches of the estuary and has moved southward into the middle harbor and beyond.

85. Evidence of dechlorination of Aroclor 1254 in samples containing less than 10 ppm total PCBs was observed in chromatograms generated by American Analytical Laboratories, Inc. (AAL) from samples collected by Balsam

Environmental Consultants, Inc. (Balsam) as part of its March 1990 supplemental thin-layer sampling program.

86. Based on the observed reduction in concentration of the AHH inducing congeners listed in Table 9, a PCB concentration of 50 ppm in a dechlorinated sample of NBH sediment (similar to NBH 105/106) is equivalent to a PCB concentration of 8.7 ppm in a sample which has not undergone reductive dechlorination.

86.a. Data from the NUS/GZA Grid Sampling Program, analyzed by ITAS (Plaintiff's RFA Nos. XII.E. 36, 37 and 44; Documents 491170 to 491674, 505001 to 506749, 50100 to 503505, and 581001 to 582671), have been examined to evaluate the dechlorination/detoxication process in the middle harbor.

86.b. Data from the Balsam/AAL March 1990 supplemental thin layer study have been examined to evaluate the dechlorination/detoxication process in sediments containing total PCB concentrations less than 50 ppm.

87. The accurate references cited in the RFAs for SPECIAL RESEARCH INVESTIGATION - PHASE II, Evaluation of PCB Transformations in New Bedford Harbor Sediments are:

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Ballschmiter, K. and M. Zell. 1980. Analysis of Polychlorinated Biphenyls (PCB) by Glass Capillary Gas Chromatography: Composition of Technical Aroclor-and Clophen-PCB Mixtures. Fresenius Zeitschrift fur Analystische Chemie, Vol. 302:210-31.

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(Plaintiff Attachment Doc. No. XII E.R. 0388 and 0388-A)

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Lake, J.L., R.J. Pruell, and F.A. Osterman. 1989. Dechlorination of PCBs in Sediments of New Bedford Harbor. EPA Report: Narragansett, Rhode Island.

McFarland, V.A., and J.V. Clark. 1989. Environmental occurrence, abundance, and potential toxicity of polychlorinated biphenyl congeners: considerations for a congener-specific analysis. Environmental Health Perspective. 81: 225-239.

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Quensen, J.F., III, J.M. Tiedje and S.A. Boyd. 1988. Reductive dechlorination of polychlorinated biphenyls by anaerobic microorganisms from sediments. Science 242:752-754.

Quensen, J.F., III, and J.M. Tiedje. 1990. Dechlorination of Aroclor 1248 by microorganisms from

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Schulz, D.E., G. Patrick and J.C. Duinker. 1989. Complete characterization of Polychlorinated Biphenyl Congeners in Commercial Aroclor and Clophen Mixtures by Multidimensional Gas Chromatography-Electron Capture Detection. Environ. Sci. Technol., Vol 23:852-859.

1452L

RIC
07/14/89 17:35:00
SAMPLE: AROCLOR 1242 250 PPM
CONDS.: INST:4023,RESTEK RTX-5,.32MM/30M/1UM 40-325@10C/M 1UL INJ
RANGE: G 1,2200 LABEL: N 2, 3.0 QUAN: A 0, 1.0 J 0 BASE: U 20, 3

DATA: AR420714
CALI: CAL0929 #3

SCANS 800 TO 1650

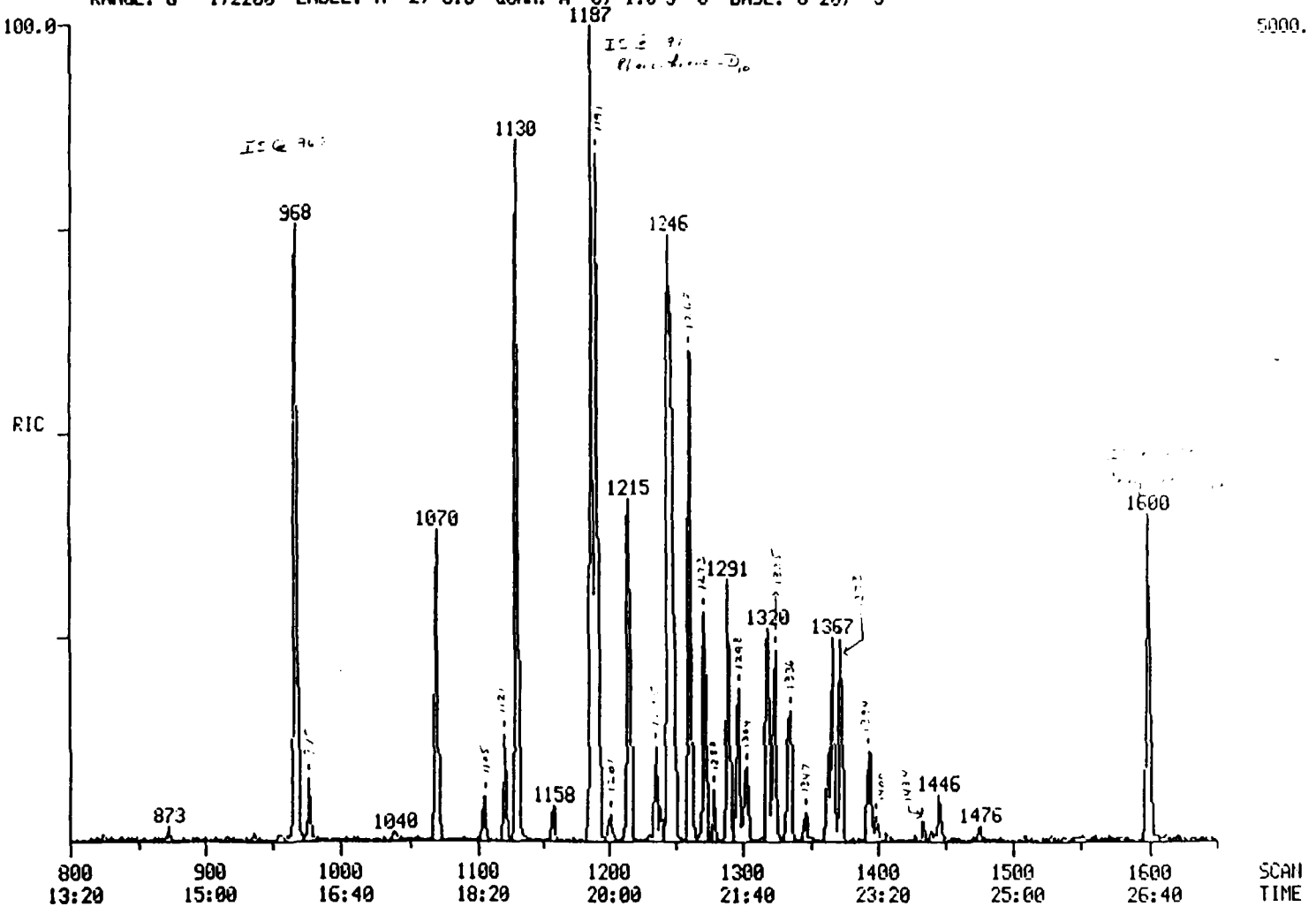


FIGURE 1. RIC for Aroclor 1242

RIC
07/14/89 18:22:00
SAMPLE: AR540714
CONDS.: INST:4023,RESTEK RTX-5,.32MM/30M/1UM 40-325@10C/M 1UL INJ
RANGE: G 1,2200 LABEL: N 2, 3.0 QUAN: A 0, 1.0 J 0 BASE: U 20, 3

DATA: AR540714 #1
CALI: CAL0929 #3

SCANS 800 TO 1650

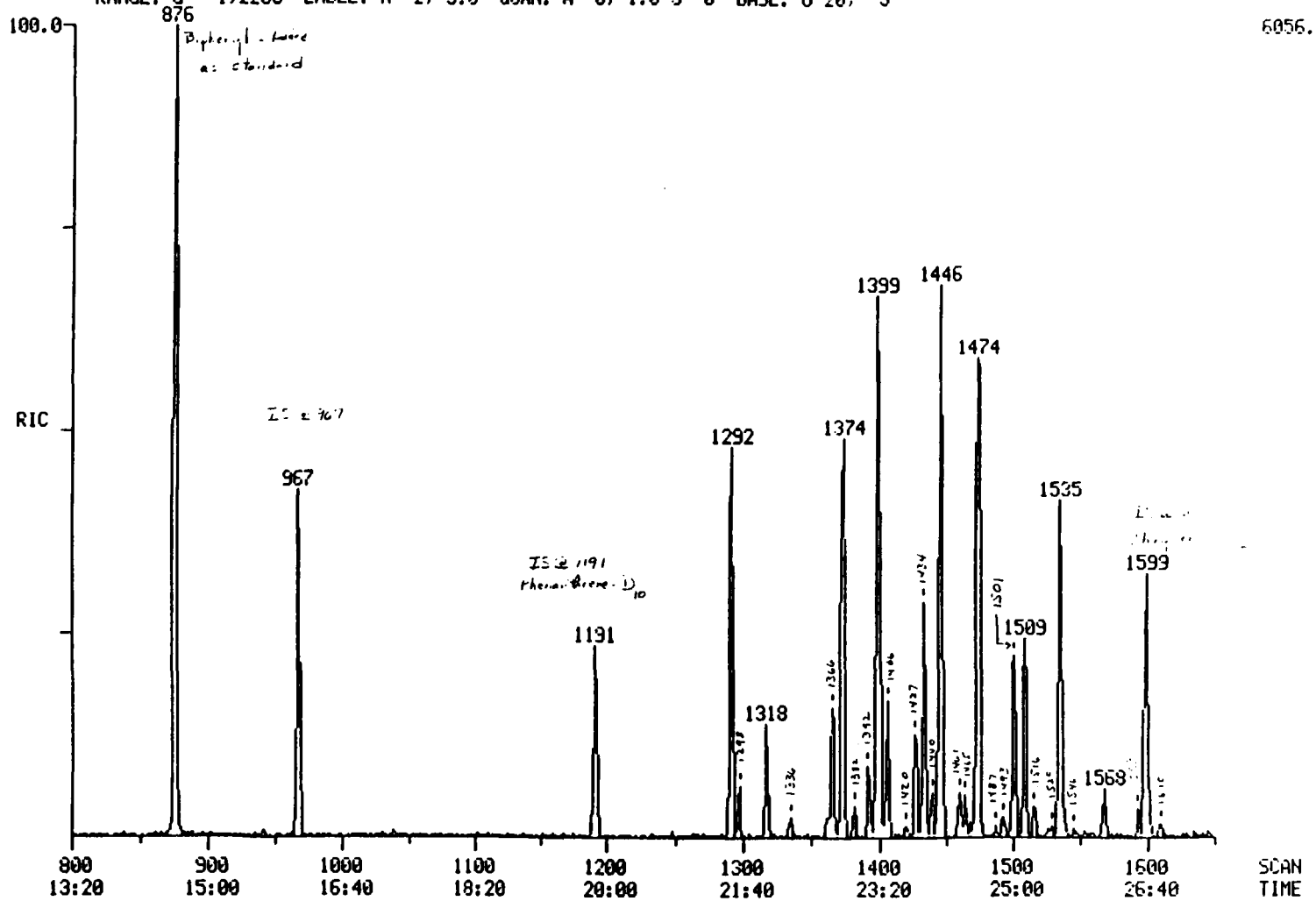


FIGURE 2. RIC for Aroclor 1254

RIC
07/17/83 19:43:00
SAMPLE: JJ1004/5
CONDS.: INST:4023,RESTEK RTX-5,.32MM/30M/1UM 40-325@10C/M 1UL INJ
RANGE: G 1,2200 LABEL: N 2, 3.0 QUAN: A 0, 1.0 J 0 BASE: U 20, 3

DATA: JJ10045R #1
CALI: CAL0929 #3

SCANS 800 TO 1650

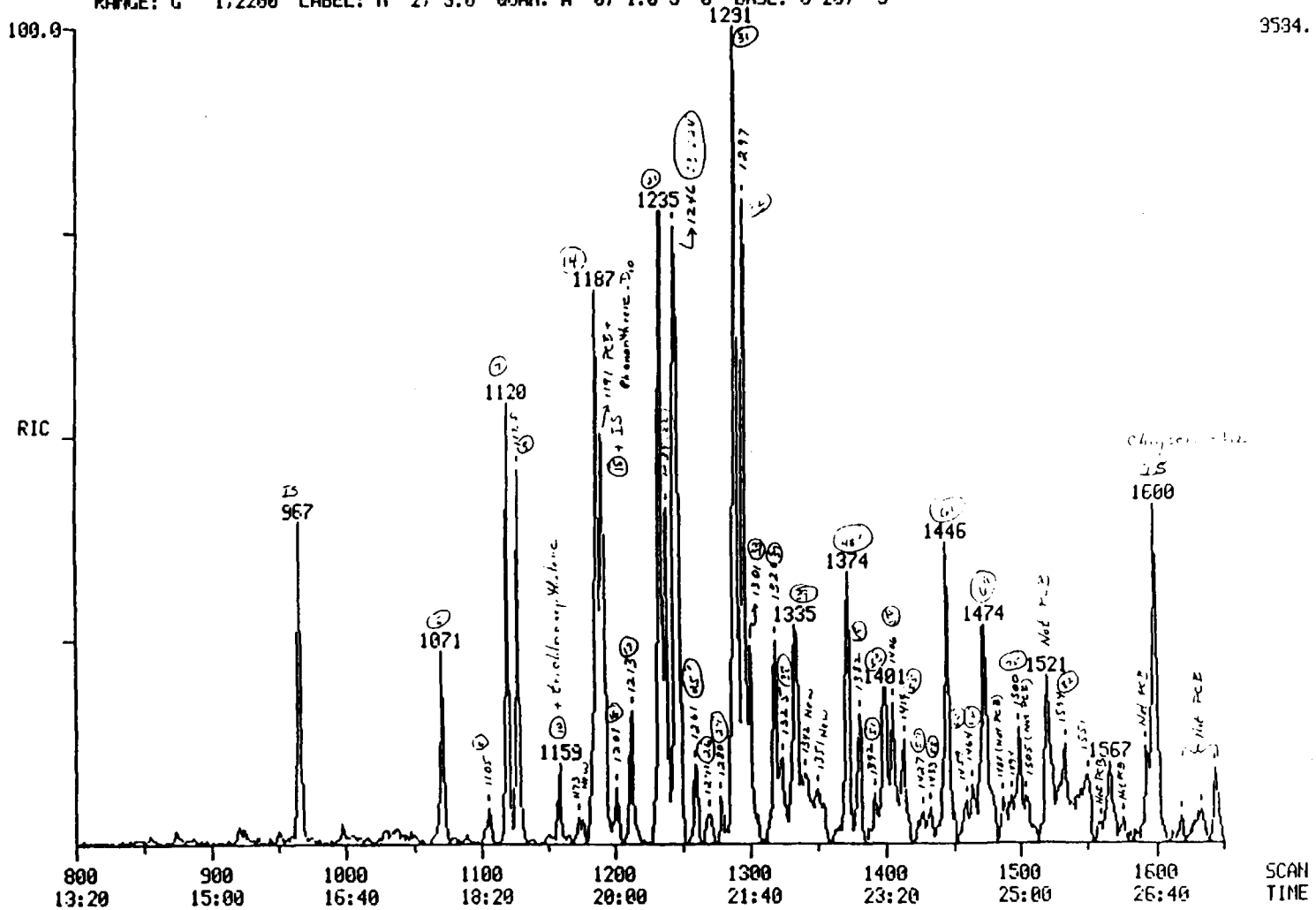


FIGURE 3. RIC for NBH Sample JJ1004/5

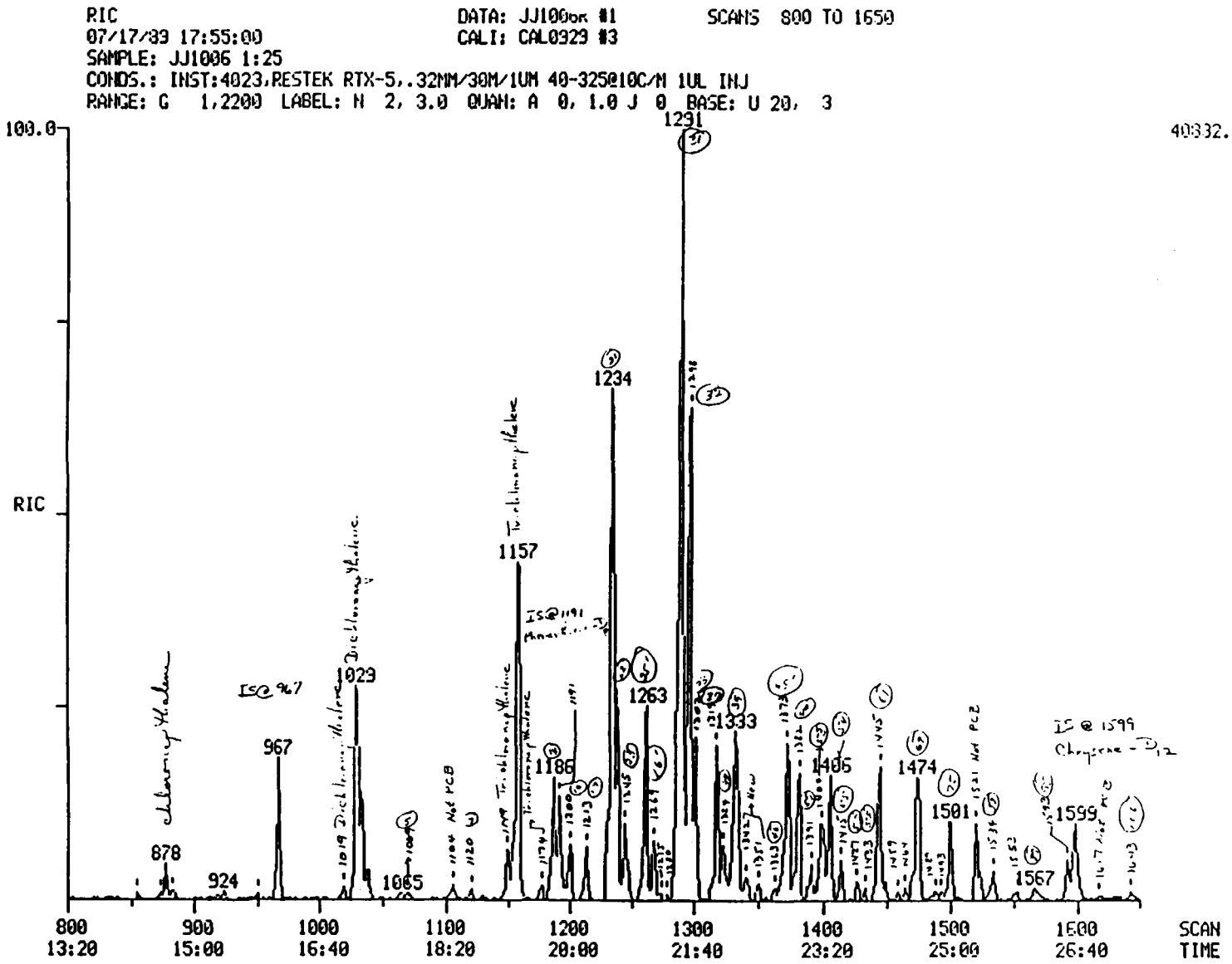


FIGURE 4. RIC for NBH Sample JJ1006

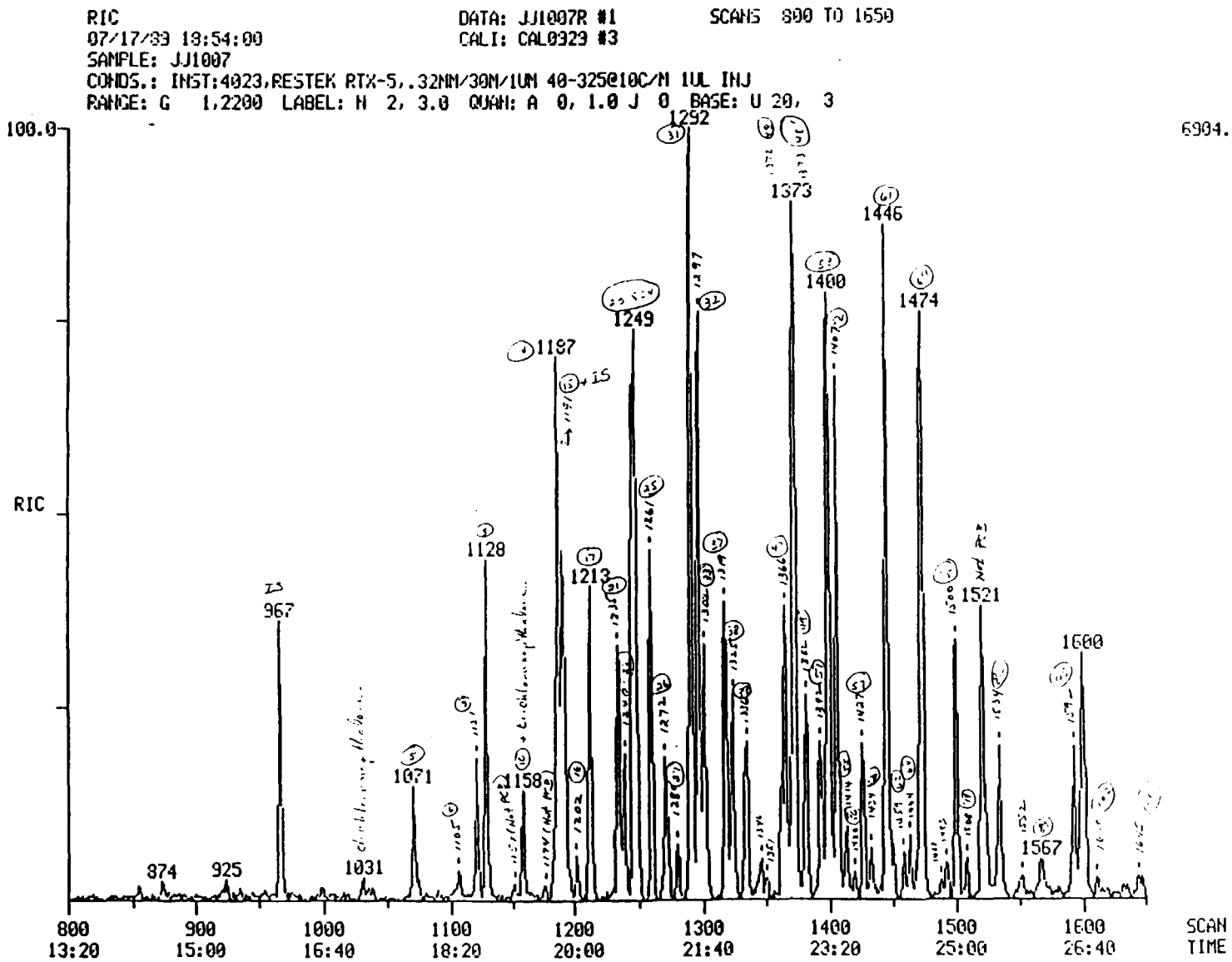


FIGURE 5. RIC for NBH Sample JJ1007

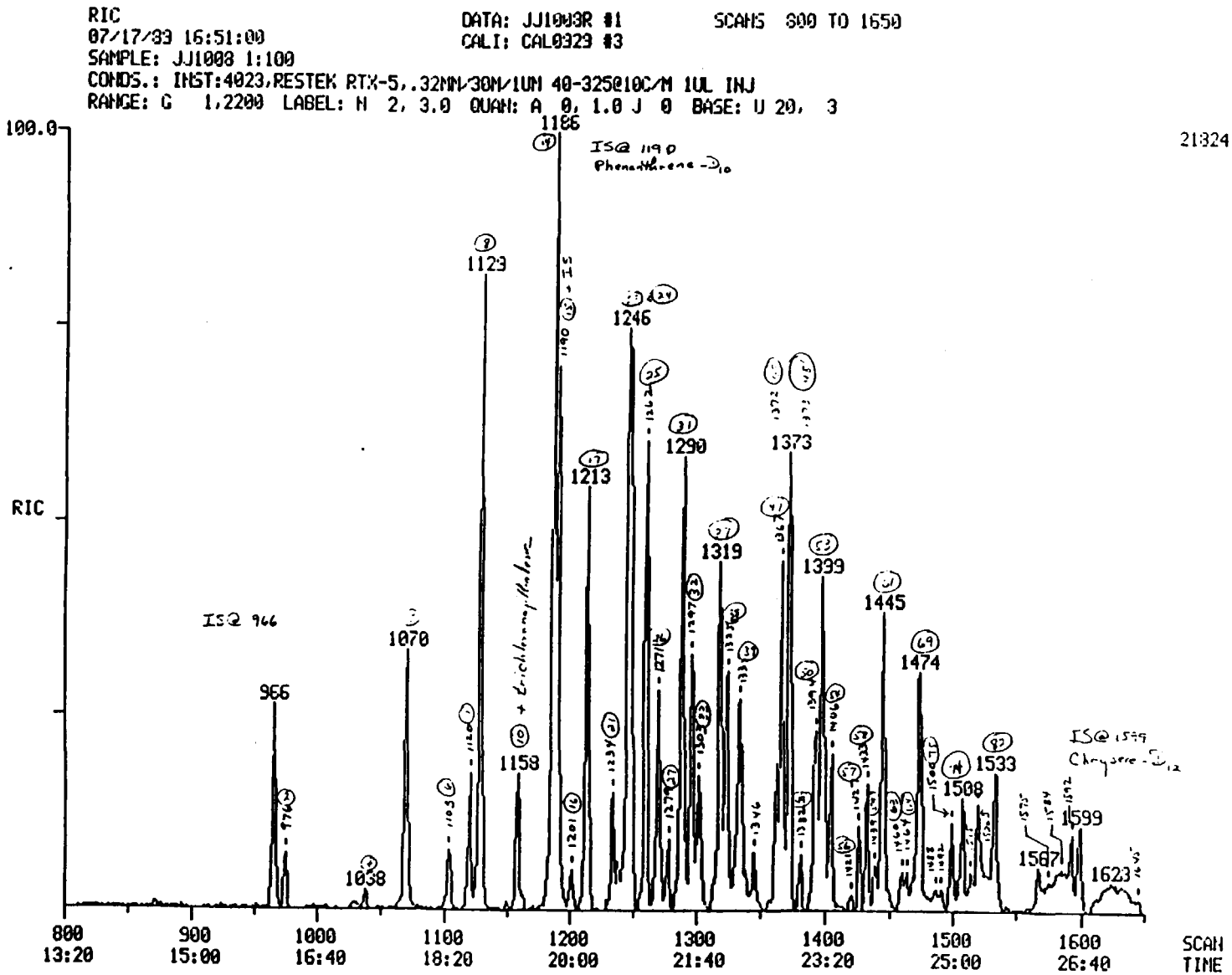


FIGURE 6. RIC for NBH Sample JJ1008

RIC
07/17/89 20:41:00
SAMPLE: JJ1009/10
CONDS.: INST:4023,RESTEK RTX-5,.32MM/30M/1UM 40-325010C/M 1UL INJ
RANGE: G 1,2200 LABEL: N 2, 3.0 QUAN: A 0, 1.0 J 0 BASE: U 20, 3

DATA: JJ100910R2 #1 SCANS 800 TO 1650
CALI: CAL0929 #3

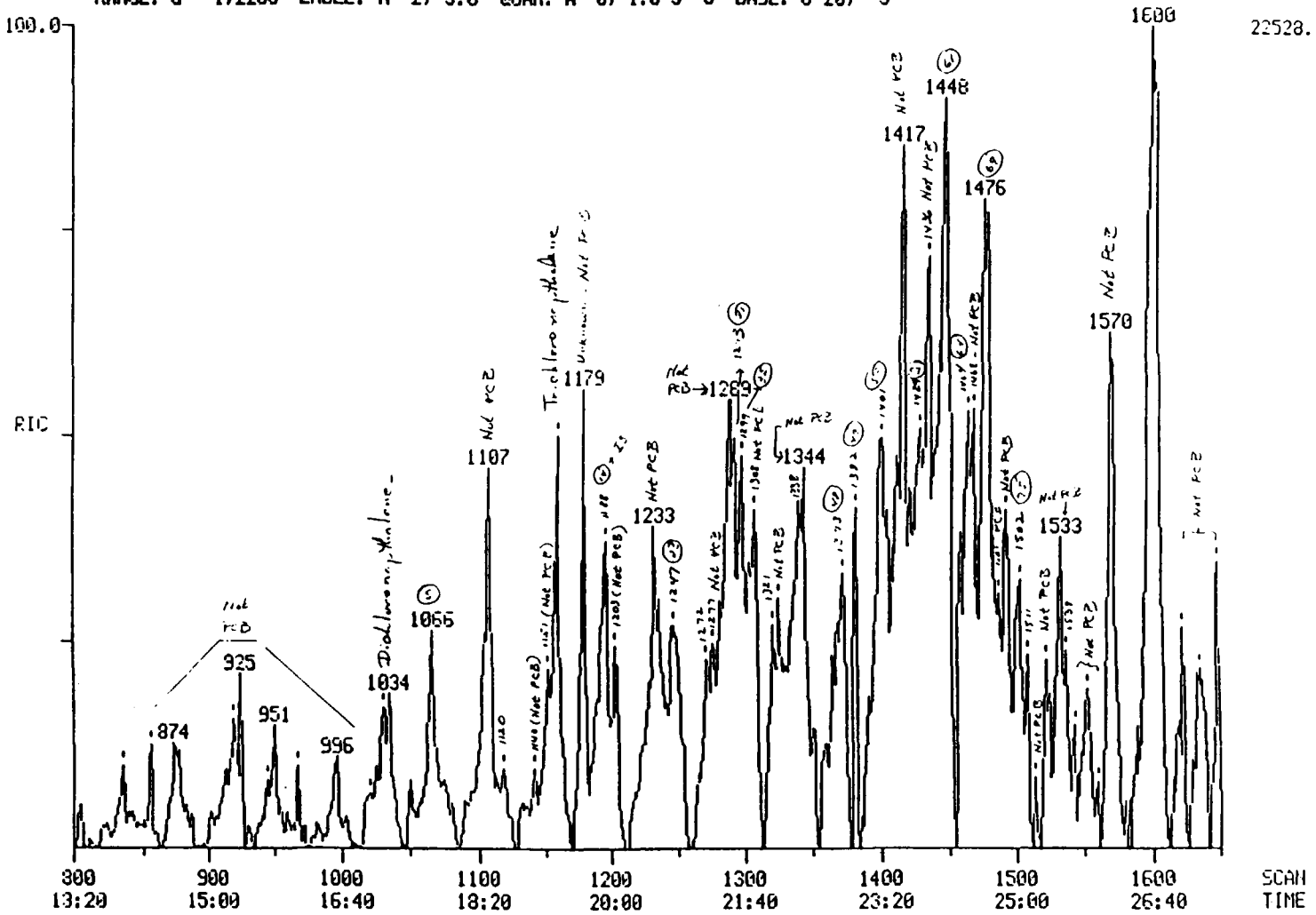


FIGURE 7. RIC for NBH Sample JJ1009/10

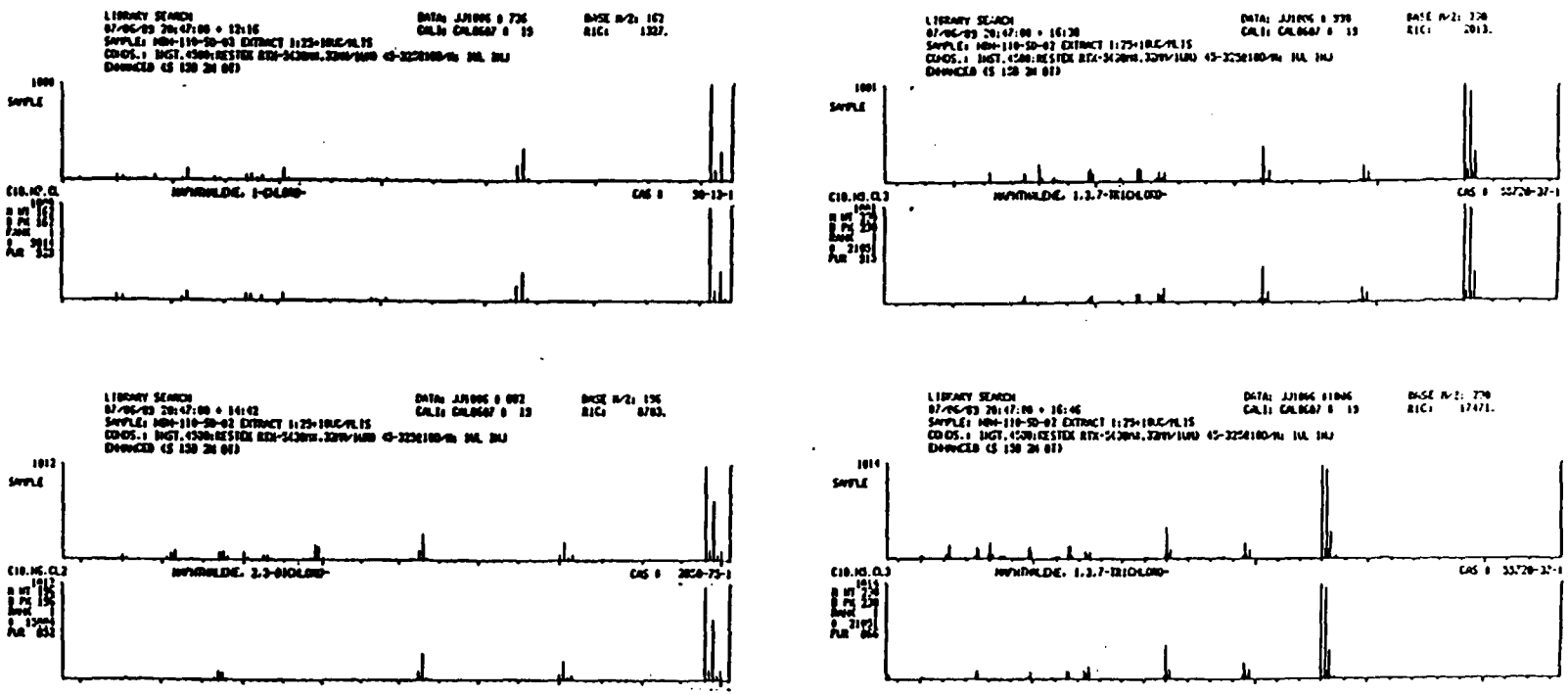


FIGURE 8. Mass Spectra for Tentatively Identified Chloronapthylenes in NBH Sample JJ1006

Figure 9. NBH DECHLORINATION PATHWAYS

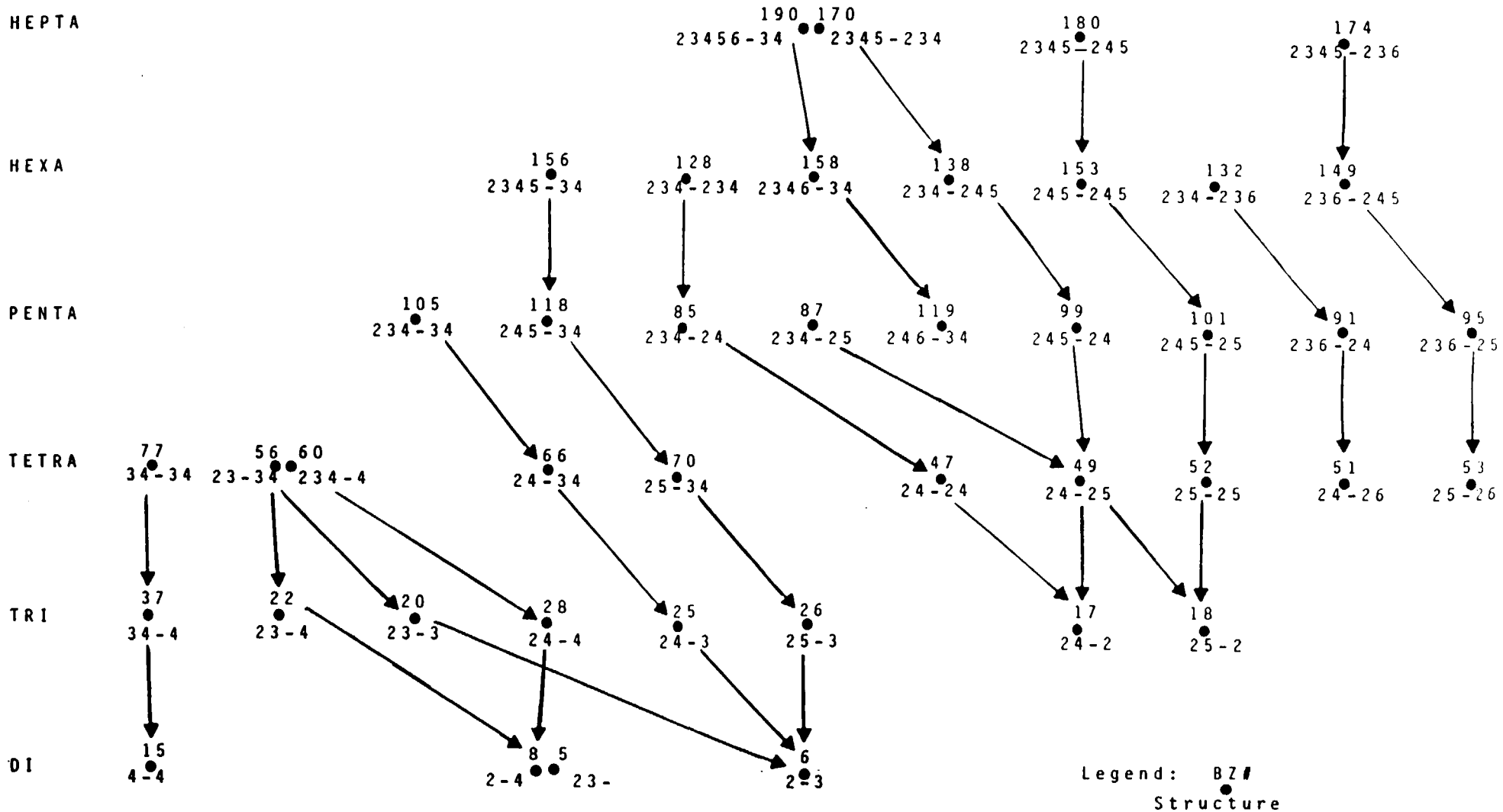


FIGURE 10.

CONGENER DECHLORINATION TRANSFORMATIONS

SAMPLE NBH 110-02 (JJ 1006)

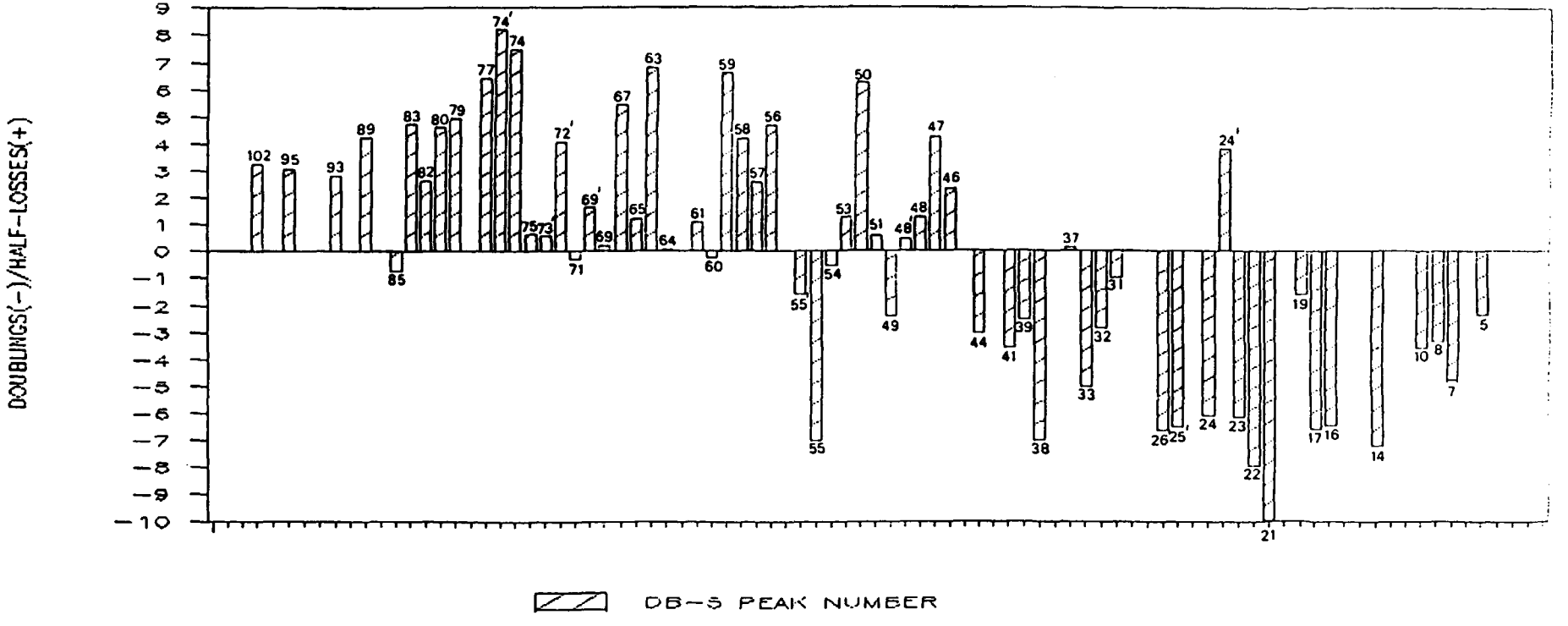


FIGURE 11.

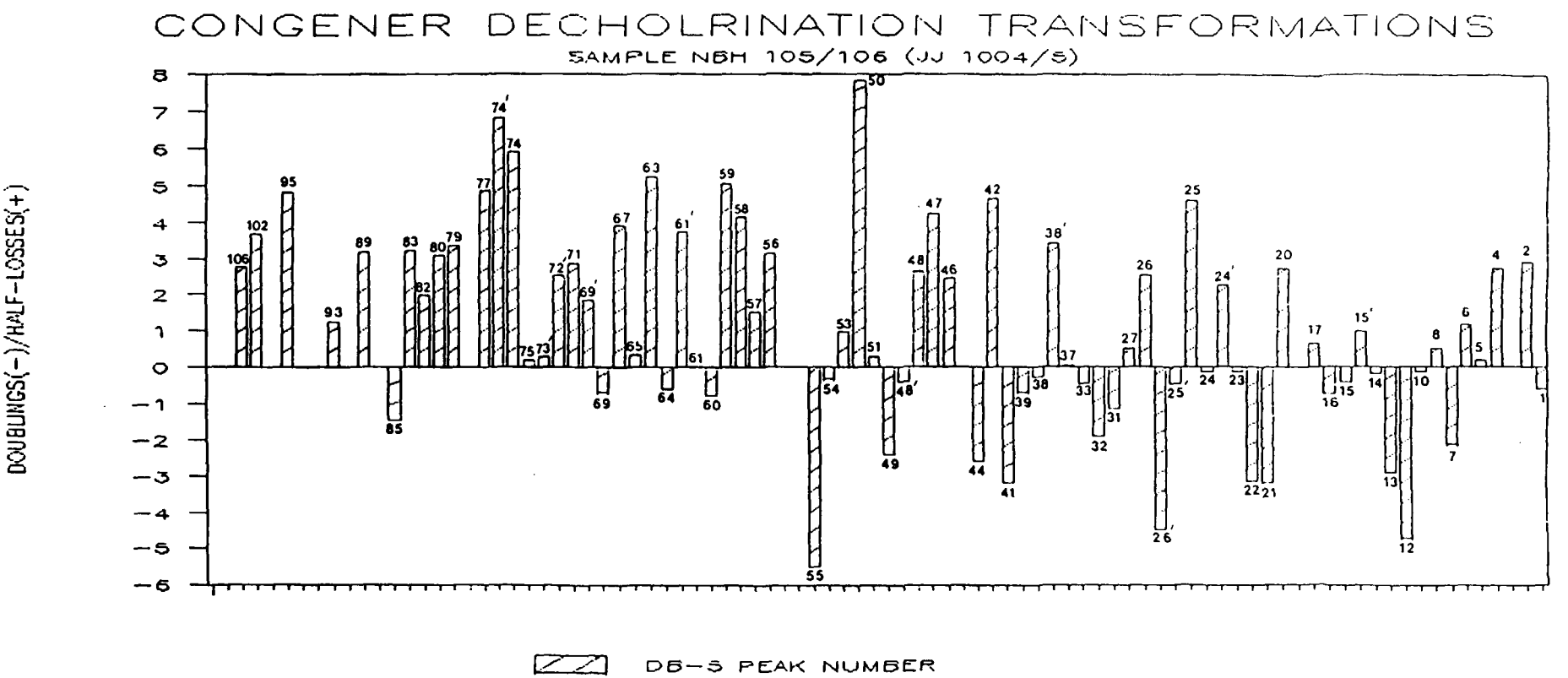

CONGENER DECHOLRINATION TRANSFORMATIONS
SAMPLE NBH 105/106 (JJ 1004/5)
DOUBLINGS(-)/HALF-LOSSES(+)
8
7
6
5
4
3
2
1
0
-1
-2
-3
-4
-5
-6
DB-5 PEAK NUMBER

FIGURE 12.

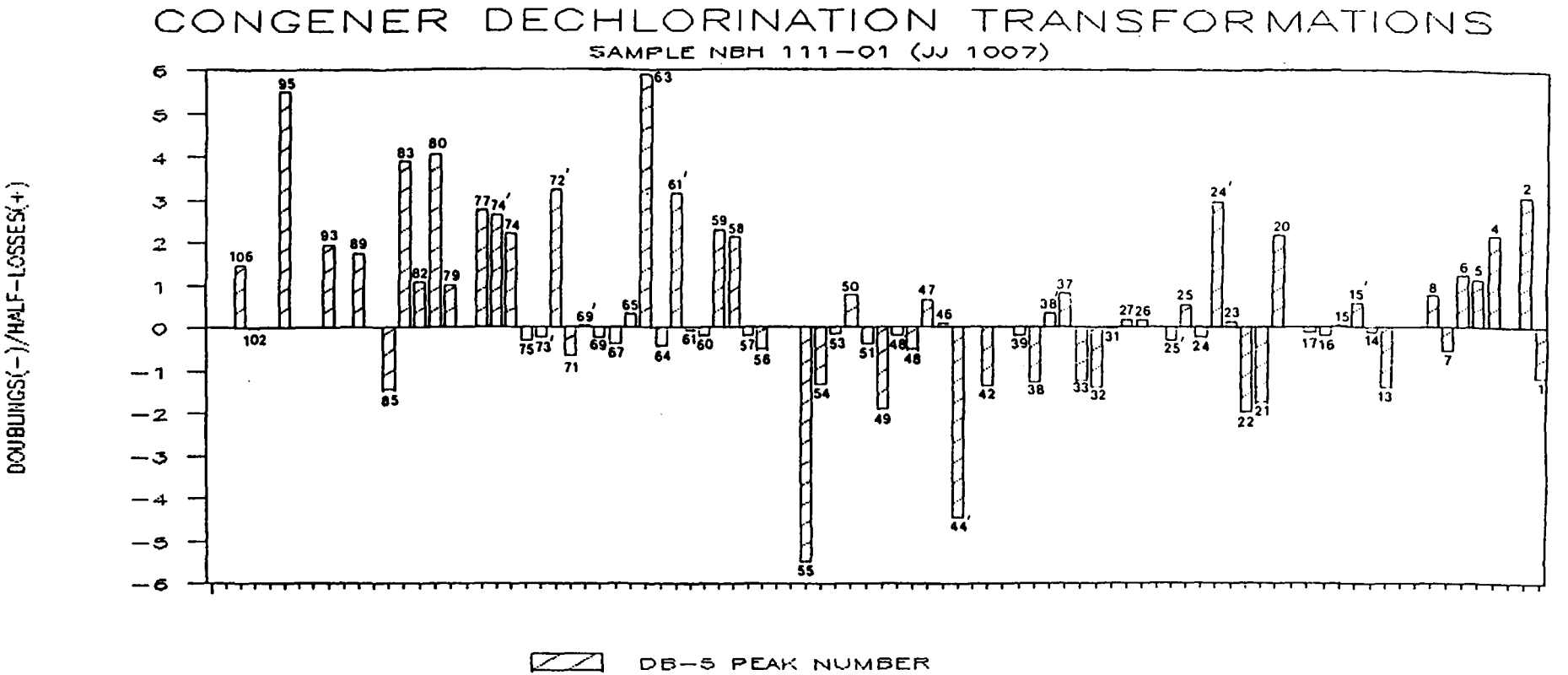

CONGENER DECHLORINATION TRANSFORMATIONS
SAMPLE NBH 111-01 (JJ 1007)
DOUBLINGS(-)/HALF-LOSSES(+)
6
5
4
3
2
1
0
-1
-2
-3
-4
-5
-6
DB-5 PEAK NUMBER

FIGURE 13.

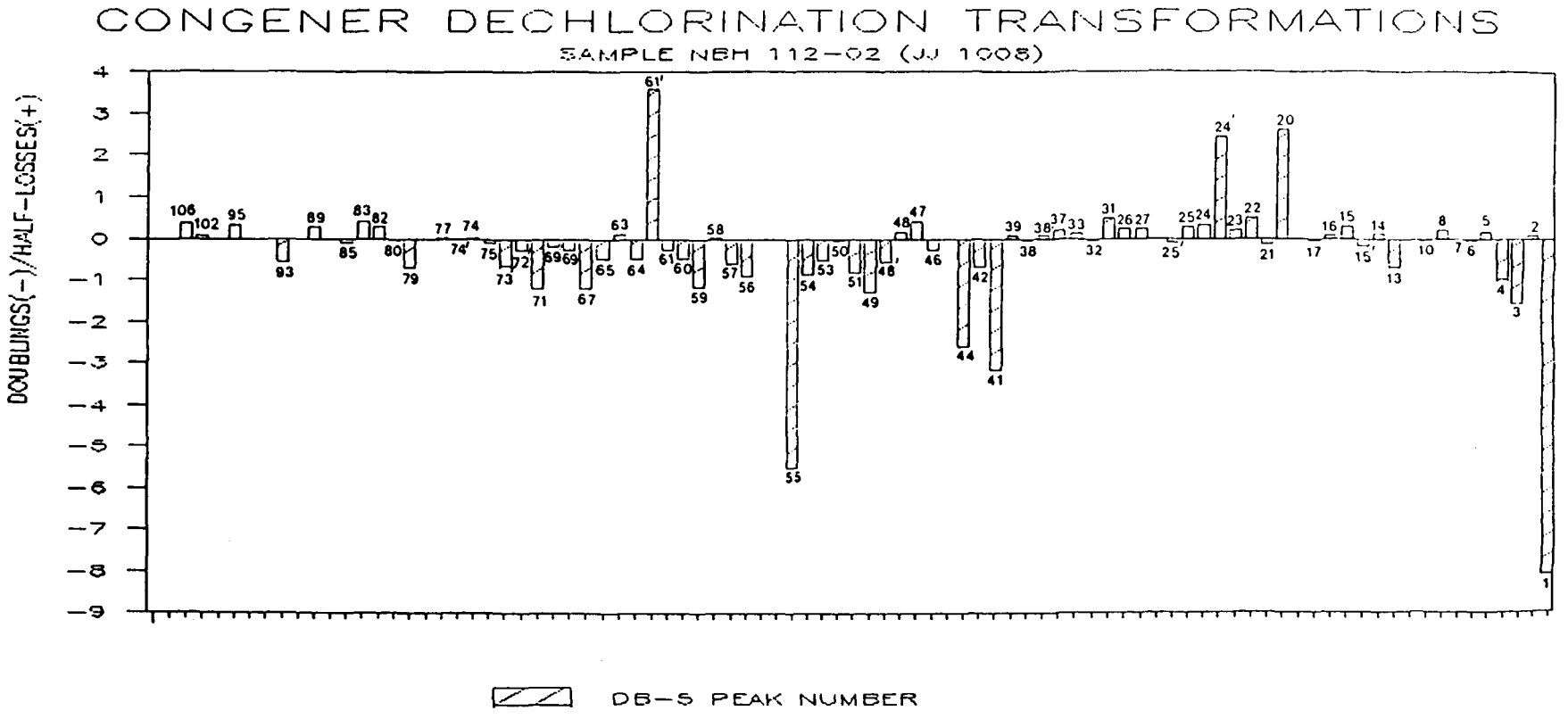

CONGENER DECHLORINATION TRANSFORMATIONS
SAMPLE NBH 112-02 (JJ 1008)
DOUBLINGS(-)/HALF-LOSSES(+)
4
3
2
1
0
-1
-2
-3
-4
-5
-6
-7
-8
-9
DB-5 PEAK NUMBER

FIGURE 14. CONGENER DECHLORINATION TRANSFORMATIONS

QUENSEN EXPERIMENT - SITE # 19 MICROBES

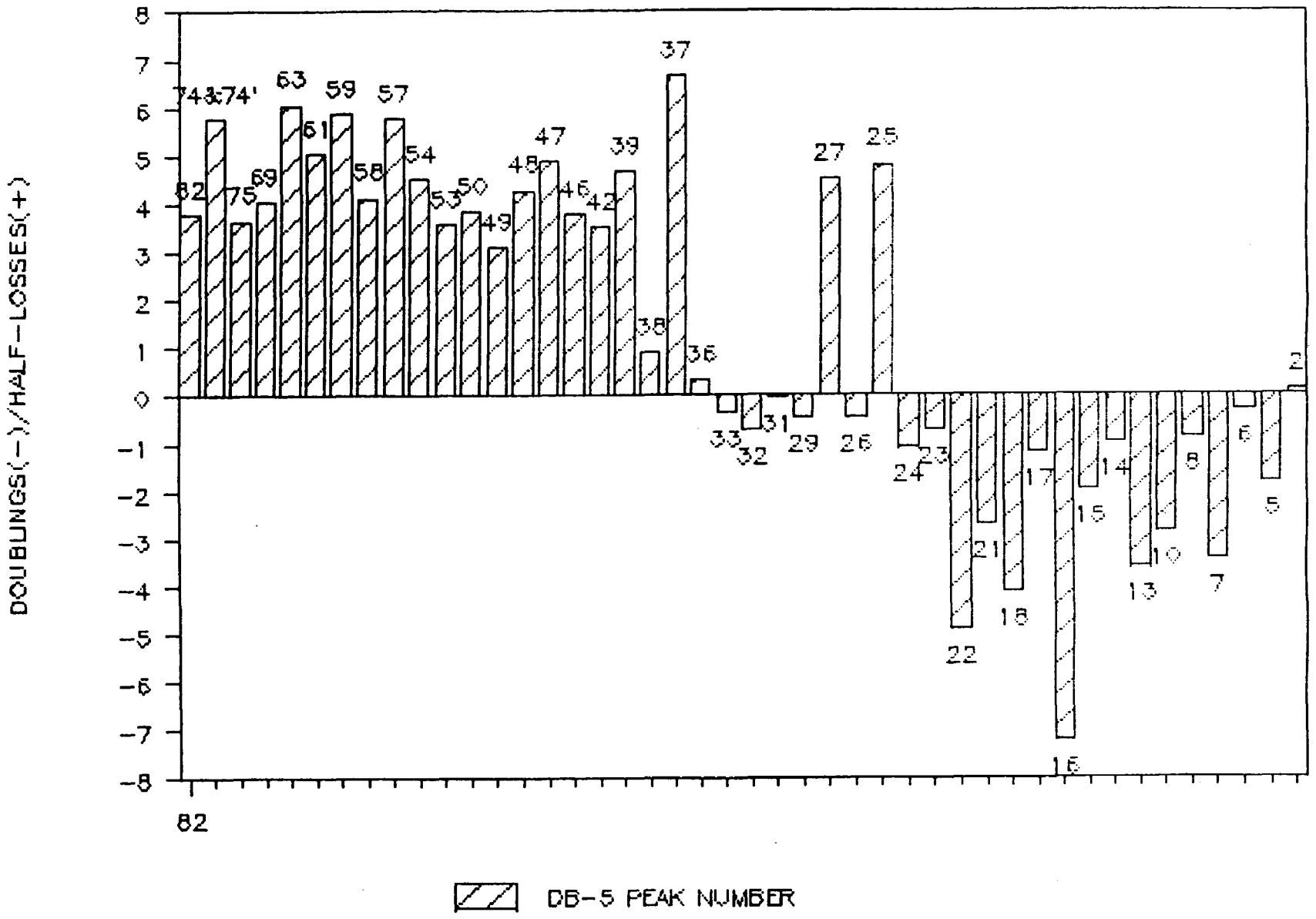


FIGURE 15.

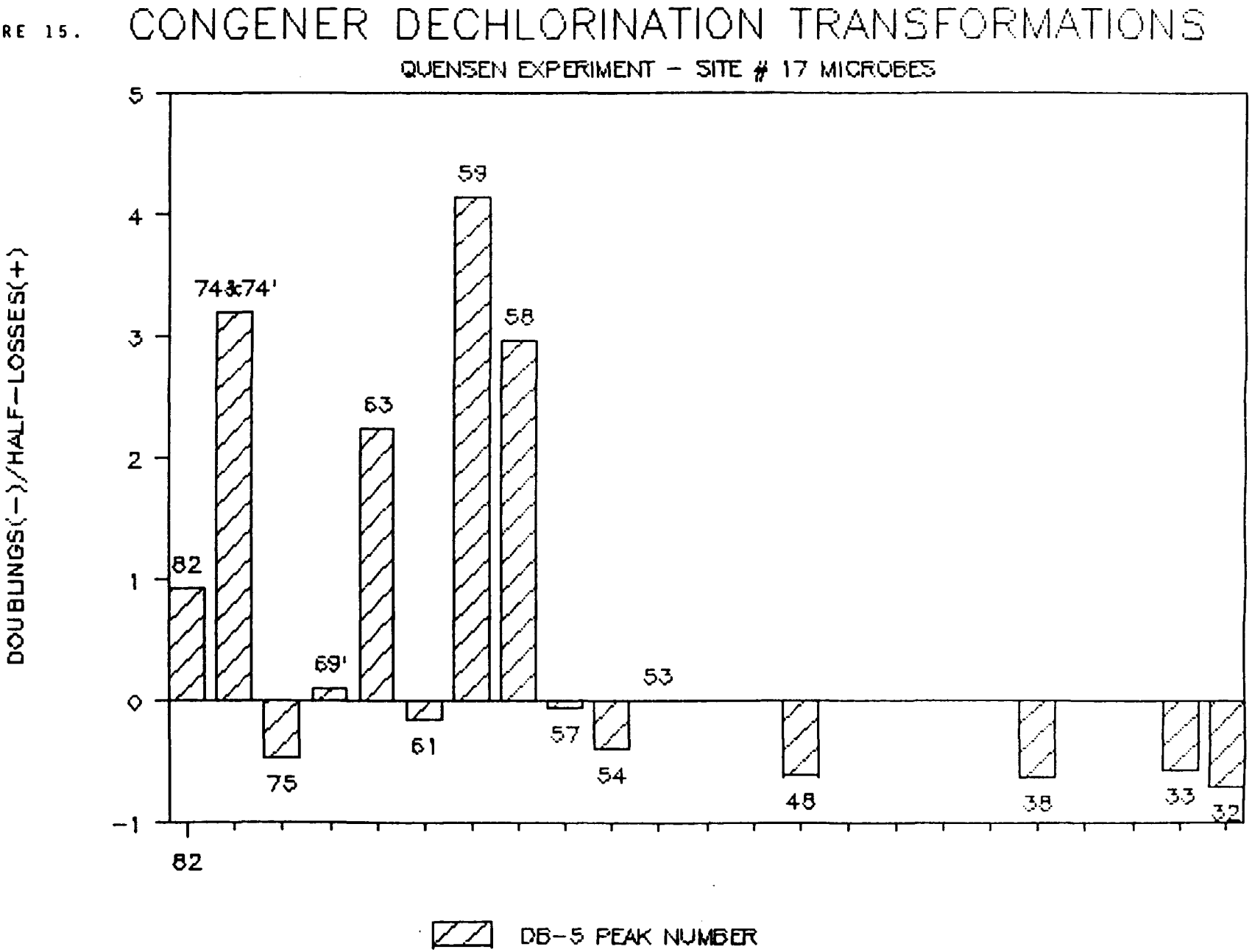
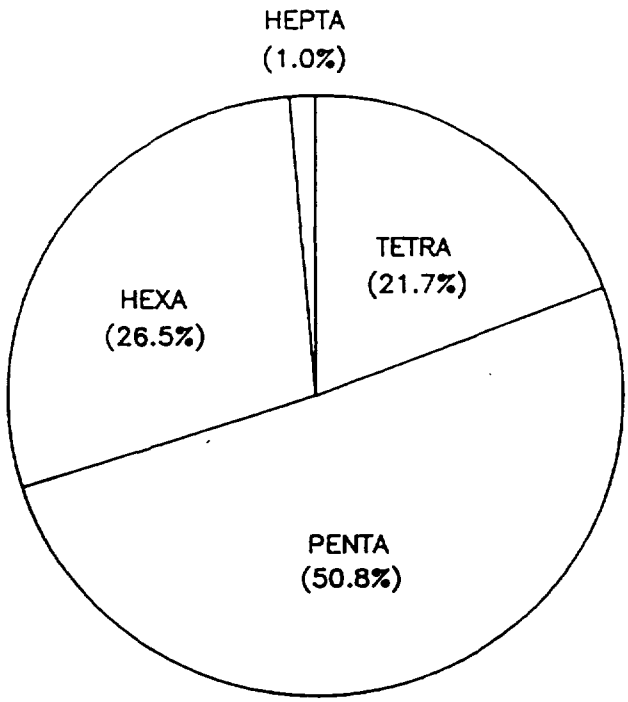
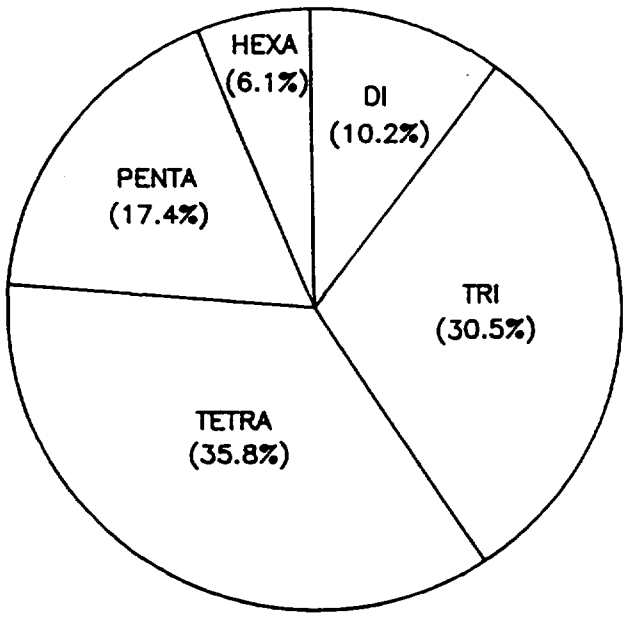

CONGENER DECHLORINATION TRANSFORMATIONS
QUENSEN EXPERIMENT - SITE # 17 MICROBES
DOUBLINGS(-)/HALF-LOSSES(+)
5
4
3
2
1
0
-1
82
74&74'
75
69'
63
61
59
58
57
54
53
48
38
33
32
82
DB-5 PEAK NUMBER

FIGURE **16** HOMOLOG DISTRIBUTION (% OF TOTAL Cl)
AROCLOR 1254 VS. SAMPLE NBH 105/106 (JJ 1004/5)

AROCLOR 1254



NBH 105/106 (JJ 1004/5)



6002/60027

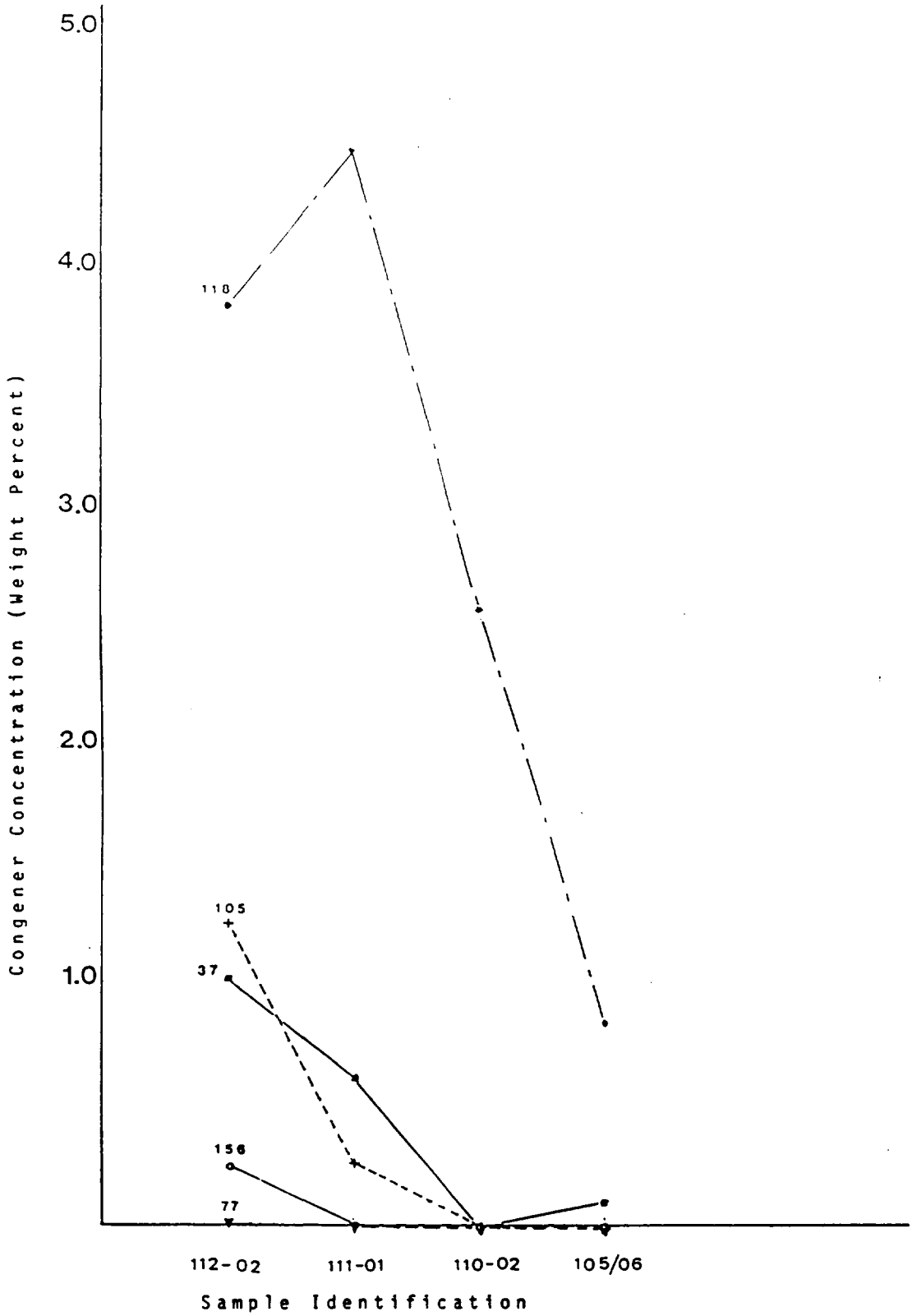


FIGURE 17. Removal of Congeners by Reductive Dechlorination

Table 1. Comparison of PCB Concentrations Measured as Aroclors for Task 7 and Phase II

Sample	% Aroclor 1016/1242	% Aroclor 1254	Total Aroclors (ppm)
Task 7 - NBH 105 & 106	68.5	31.5	445.
Phase II JJ 1004/5	66.1	33.9	620.
Task 7 NBH-110-02	Not Reported	100.	3000.
Phase II JJ 1006	Not Reported	100.	2800.
Task 7 NBH 111-01	46.5	53.5	9900.
Phase II JJ 1007	45.1	54.9	9100.
Task 7 NBH-112-02	63.6	36.4	44,000.
Phase II JJ 1008	61.0	39.0	41,000.
Task 7 NBH-113-01/02	25.0	75.0	100.
Phase II JJ 1009/10	27.3	72.7	150.

TABLE 2.

HOMOLOG DISTRIBUTION FOR TASK 15 SEDIMENT SAMPLES FROM NBH
CONCENTRATIONS EXPRESSED IN WEIGHT PERCENT

SEDIMENT SAMPLE IDENTIFICATION

HOMOLOG LEVEL	NBH 110-02 (JJ 1006)	NBH 105/106 (JJ 1004/5)	NBH 111-01 (JJ 1007)	NBH 112-02 (JJ 1008)	NBH 113-01/02 (JJ 1009/10)
MONO	<0.01	0.1	0.03	0.51	0.01
DI	0.81	14.3	5.8	11.6	2.2
TRI	18.3	33.3	20.4	25.0	9.2
TETRA	48.0	33.4	32.1	28.9	33.5
PENTA	24.3	14.4	31.8	25.4	42.6
HEXA	8.4	4.6	9.7	8.2	12.3
HEPTA	0.14	0.07	0.32	0.1	0.24

Table 3. Cross-reference of Congener Elution Order for SE-54, DB-1 and DB-5 Capillary Columns

Sequence Number	Relative Retention Time (RRT)[1]	Structure (Substitution Pattern)[1]	BZ Congener Number[2]	Domain Number[3]	PCB Congeners Not Found[4]	Brown Peak # (DB-1)[5]	DB-5 Peak Number[6]	GC/MS Scan #[7] (4023)
1	0.0997	Biphenyl	0			1	1	877
2	0.1544	2	1			2	2	977
3	0.1937	3	2			3	3	1032
4	0.1975	4	3			4	4	1038
5	0.2243	2,6	10	1		5	5	1070
6	0.2245	2,2'	4	1		5	5	1070
7	0.2566	2,4	7	2		6	6	1104
8	0.257	2,5	9	2		6	6	1104
9	0.2709	2,3'	6	3		7	7	1120
10	0.2783	2,4'	8	4		8	8	1130
11	0.2785	2,3	5	4		8	8	1130
12	0.2973	3,5	14		*	9	9	
13	0.3045	2,2',6	19	5		10	10	1158
14	0.3165	2,4,6	30		*	11	11	
15	0.3238	3,3'	11		*	12	12	1173
16	0.3298	3,4	12		*	13	13	
17	0.3315	3,4'	13		*	13	13'	1183
18	0.3378	2,2',5	18	6		14	14	1187
19	0.3387	4,4'	15	6		14	15'	1191
20	0.3398	2,2',4	17	6		15	15	1191
21	0.3508	2,3,6	24	7		16	16	1201
22	0.3521	2,3',6	27	7		16	16	1201
23	0.3625	2,2',3	16	8		17	17	1213
24	0.3636	2,4',6	32	8		17	17	1213
25	0.377	2,3,5	23		*	18	18	
26	0.3782	2',3,5	34	9		19	19	1223
27	0.38	2,2',6,6'	54	9	-	19	19'	
28	0.382	2,4,5	29	10		20	20	1230
29	0.3911	2,3',5	26	11		21	21	1235
30	0.3937	2,3',4	25	12		22	22	1239
31	0.4007	2,2',4,6	50	13	-	24	24'	1247
32	0.4024	2,4',5	31	13		23	23	1246
33	0.4031	2,4,4'	28	13		24	24	1249
34	0.4135	2,3,4	21	14	-	25	25	
35	0.4163	2',3,4	33	14		25	25	1262
36	0.417	2,3,3'	20	14		25	25	1262
37	0.4187	2,2',5,6'	53	14		25	25'	1262
38	0.4242	2,2',4,6'	51	15		26	26'	1268
39	0.4267	2,3,4'	22	15		26	26	1273
40	0.4334	2,2',3,6	45	16		27	27	1280
41	0.4375	3,3',5	36		*	28	28	
42	0.445	2,2',3,6'	46	17		29	29	
43	0.4488	3,4',5	39		*	30	30	
44	0.451	2,3',4,6	69	18				
45	0.4554	2,3',5',6	73	19		31	31	1292
46	0.4557	2,2',5,5'	52	19		31	31	1292

Sequence Number	Relative Retention Time (RRT)[1]	Structure (Substitution Pattern)[1]	BZ Congener Number[2]	Domain Number[3]	PCB Congeners Not Found[4]	Brown Peak # (DB-1)[5]	DB-5 Peak Number[6]	GC/MS Scan #[7] (4023)
47	0.4587	2,2',3,5	43	20	-			
48	0.4593	3,4,5	38	20	-			
49	0.461	2,2',4,5'	49	20		32	32	1297
50	0.4639	2,2',4,4'	47	21		33	33	1302
51	0.4643	2,4,4',6	75	21		34	33	1302
52	0.4651	2,2',4,5	48	21		34	33	1302
53	0.4671	2,3,5,6	65		*	35	35	
54	0.4685	2,3,4,6	62		*	35	35	
55	0.4738	3,3',4	35	22		36	36	1315
56	0.4757	2,2',4,6,6'	104		*		36'	1315
57	0.4832	2,2',3,5'	44	23		37	37	1319
58	0.4858	3,4,4'	37	24		38	38'	1325
59	0.486	2,3,3',6	59	24		38	38	1325
60	0.487	2,2',3,4'	42	24		38	38	1325
61	0.4984	2,3',5,5'	72	24	-	39	39	1335
62	0.4989	2,3',4',6	71	24	-	39	39	1335
63	0.499	2,2',3,4	41	25		39	39	1335
64	0.4999	2,3,4',6	64	25		39	39	1335
65	0.504	2,3',4,5'	68		*	40	40	
66	0.5057	2,2',3,6,6'	96	26		41	41	1342
67	0.5102	2,2',3,3'	40	27		42	42	1345
68	0.5142	2,2',4,5',6	103		*	43	43	
69	0.5155	2,3,3',5	57		*	43	43'	
70	0.5212	2,2',4,4',6	100	28		44	44	1351
71	0.5214	2,3',4,5	67	28		44	44'	1351
72	0.5267	2,3,3',5'	58		*	45	45	
73	0.529	2,3,4',5	63	29		45	45	1358
74	0.5331	2,3,4,5	61	30	-		46	1362
75	0.5331	2,2',3,5,6'	94	30	-	46	46'	1362
76	0.5341	2,4,4',5	74	30		46	46	1362
77	0.5407	2,3',4',5	70	31		47	47	1367
78	0.5408	2',3,4,5	76	31	-	47	47	1367
79	0.5415	2,2',3',4,6	98		*			
80	0.5431	2,2',4,5,6'	102		*	48		
81	0.5437	2,2',3,5,6	93	32				
82	0.5447	2,3',4,4'	66	32		48	48	1373
83	0.5464	3,3',5,5'	80	32	-			
84	0.5464	2,2',3,5',6	95	32		48	48'	1374
85	0.5486	2,2',3,4,6	88	33	-			
86	0.5518	2,3',4,5',6	121		*			
87	0.5549	2,2',3,4',6	91	34		49	49	1382
88	0.5562	2,3,3',4	55	34	-			
89	0.5666	2,2',4,4',6,6'	155	35	-			
90	0.5676	2,3,3',4'	56	35		50	50	1394
91	0.5676	2,3,4,4'	60	35		50	50	1394
92	0.5742	2,2',3,5,5'	92	36		51	51	1392

Sequence Number	Relative Retention Time (RRT)[1]	Structure (Substitution Pattern)[1]	BZ Congener Number[2]	Domain Number[3]	PCB Congeners Not Found[4]	Brown Peak # (DB-1)[5]	DB-5 Peak Number[6]	GC/MS Scan #[7] (4023)
93	0.5744	2,2',3,3',6	84	37		51	51	1392
94	0.5779	2,2',3,4,6'	89		*	52	52	
95	0.5814	2,2',3,4',5	90	38		53	53	1399
96	0.5816	2,2',4,5,5'	101	38		53	53	1399
97	0.5862	2,3,3',5',6	113		*	54	54	
98	0.588	2,2',4,4',5	99	39		54	54	1406
99	0.5894	3,3',4,5'	79		*		54'	
100	0.5968	2,3',4,4',6	119	40		55	55	1415
101	0.5969	2,2',3,4',6,6'	150	40	-	55	55'	1417
102	0.5986	2,3,3',5,6	112		*	55		
103	0.6016	2,3,3',4,6	109	41		56	56	1420
104	0.6024	3,3',4,5	78	41			56'	1420
105	0.6029	2,2',3,3',5	83	41		56	56	1420
106	0.6062	2,2',3,5,6,6'	152		*	57	57'	
107	0.61	2,2',3',4,5	97	42		57	57	1427
108	0.6105	2,2',3,4,5	86	42	-	57	57	
109	0.6132	2,3,4,5,6	116		*			
110	0.6142	2',3,4,5,6'	125		*			
111	0.6149	3,4,4',5	81		*			
112	0.6149	2,2',3,4,6,6'	145		*			
113	0.615	2,3,4',5,6	117		*			
114	0.6171	2,3,4,4',6	115	43		58	58	1434
115	0.6175	2,2',3,4,5'	87	43		58	58	1434
116	0.6183	2,3,3',5,5'	111		*			1434
117	0.6224	2,2',3,4,4'	85	44		59	59	1440
118	0.6243	2,2',3,4',5,6'	148		*			
119	0.6256	2,3',4,5,5'	120	45	-			
120	0.6257	2,2',3,3',6,6'	136	45		60	60	1444
121	0.6295	3,3',4,4'	77	46		61	61'	1447
122	0.6314	2,3,3',4',6	110	46		61	61	1446
123	0.6349	2,2',4,4',5,6'	154		*	62	62	
124	0.6453	2,2',3,3',4	82	47		63	63	1461
125	0.6499	2,2',3,5,5',6	151	47		64	64	1459
126	0.6563	2,2',3,3',5,6'	135	48		65	65	1465
127	0.6563	2,2',3,4,5',6	144	48		66	65	
128	0.6584	2',3,4,5,5'	124		*	65	66	
129	0.6608	2,2',3,4',5,6	147		*	67	67'	
130	0.6626	2,3,3',4,5'	108		*	67	67	
131	0.6628	2,3,3',4',5	107	49		67	67	1469
132	0.6658	2',3,4,4',5	123	50		68	68	
133	0.6672	2,2',3,4',5',6	149	50		69	69	1473
134	0.668	2,3,3',4,5	106		*	69	69'	
135	0.6693	2,3',4,4',5	118	50		69	69'	1475

Sequence Number	Relative Retention Time (RRT)[1]	Structure (Substitution Pattern)[1]	BZ Congener Number[2]	Domain Number[3]	PCB Congeners Not Found[4]	Brown Peak # (DB-1)[5]	DB-5 Peak Number[6]	GC/MS Scan #[7] (4023)
136	0.6707	2,2',3,4,4',6	139		*	70	70	
137	0.6707	2,2',3,4,4',6'	140		*	70	70	
138	0.6789	2,2',3,4,5,6'	143		*	71	71	
139	0.6796	2,2',3,3',5,6	134	51		71	71	1487
140	0.6828	2,3,4,4',5	114	52	-	71	71'	
141	0.6848	2,2',3,4,5,6	142		*			
142	0.6853	2,2',3,3',4,6	131	52		72	72	
143	0.6871	2',3,3',4,5	122	52		72	72'	1490
144	0.6871	2,2',3,3',5,5'	133		*	72	72	
145	0.692	2,3,3',5,5',6	165		*		73	
146	0.692	2,2',3,4',5,6,6'	188		*	73	73	1494
147	0.6955	2,2',3,4',5,5'	146	53		73	73'	1493
148	0.6968	2,3,3',4,5',6	161		*			
149	0.7016	2,2',3,4,4',6,6'	184		*			
150	0.7035	2,2',3,3',4,6'	132	54		74	74	1507
151	0.7036	2,2',4,4',5,5'	153	54		75	75	1500
152	0.7049	2,3,3',4,4'	105	54		74	74'	1509
153	0.7068	2,3',4,4',5',6	168		*	76	76	
154	0.7078	3,3',4,5,5'	127		*			
155	0.7203	2,2',3,4,5,5'	141	55		77	77	1516
156	0.7205	2,2',3,3',5,6,6'	179	55		78	78	1521
157	0.7284	2,2',3,3',4,5'	130	56		79	79	1525
158	0.7305	2,2',3,3',4,6,6'	176	57		81	81	
159	0.7329	2,2',3,4,4',5	137	57		80	80	1528
160	0.7396	2,3,3',4,5,6	160	58				
161	0.7396	2,3,3',4',5,6	163		*	82	82	
162	0.7399	2,3,3',4,5',6	164		*			
163	0.7403	2,2',3,4,4',5'	138	58		82	82	1535
164	0.7416	2,2',3,4,5,6,6'	186		*			
165	0.7429	2,3,3',4,4',6	158	58		83	83	1545
166	0.7501	2,2',3,3',4,5	129	59		84	84	
167	0.7512	3,3',4,4',5	126	59			84'	
168	0.7537	2,2',3,3',5,5',6	178	59		85	85	1552
169	0.7572	2,3,4,4',5,6	166		*	86	86	
170	0.7611	2,2',3,3',4,5',6	175	60		87	87	
171	0.7653	2,2',3,4,4',5,6'	182		*	88	88	
172	0.7654	2,2',3,4',5,5',6	187	61		88	88	1557
173	0.7655	2,3,3',4,5,5'	159		*		88'	
174	0.772	2,2',3,4,4',5',6	183	62		90	90	
175	0.7737	2,3,3',4',5,5'	162		*			
176	0.7761	2,2',3,3',4,4'	128	63		89	89	1568
177	0.7814	2,3',4,4',5,5'	167	64		91	91	
178	0.7848	2,2',3,4,5,5',6	185	65		92	92	
179	0.7965	2,2',3,3',4,5,6'	174	66		93	93	1581
180	0.7968	2,2',3,4,4',5,6	181		*	93	93	
181	0.8031	2,2',3,3',4',5,6	177			94	94	1587

Sequence Number	Relative Retention Time (RRT)[1]	Structure (Substitution Pattern)[1]	BZ Congener Number[2]	Domain Number[3]	PCB Congeners Not Found[4]	Brown Peak # (DB-1)[5]	DB-5 Peak Number[6]	GC/MS Scan #[7] (4023)
182	0.8089	2,2',3,3',4,4',6	171	68		95	95'	
183	0.8089	2,2',3,3',5,5',6,6'	202	68	-	96	96	
184	0.8105	2,3,3',4,4',5	156	68		95	95	1593
185	0.8152	2,2',3,3',4,5,6	173	69		98	98	
186	0.8184	2,3,3',4,4',5'	157	69	-	97	97	
187	0.8197	2,2',3,3',4,5',6,6'	200	69		99	99	1719+
188	0.8217	2,2',3,4,4',5,6,6'	204		*	99	99	
189	0.8269	2,3,3',4,5,5',6	192		*	100	100	
190	0.8278	2,2',3,3',4,5,5'	172	70		100	100	
191	0.8293	2,2',3,3',4,4',6,6'	197	71	-	101	101	
192	0.8362	2,2',3,4,4',5,5'	180	72		102	102	1610
193	0.8397	2,3,3',4',5,5',6	193	73	-	103	103	
194	0.8447	2,3,3',4,4',5',6	191	74	-	104	104	
195	0.8494	2,2',3,3',4,5,6,6'	199	75	-	105	105	
196	0.8625	3,3',4,4',5,5'	169	76	-		106'	
197	0.874	2,2',3,3',4,4',5	170	77		106	106	1645
198	0.874	2,3,3',4,4',5,6	190	77		107	106	
199	0.8845	2,2',3,3',4,5,5',6	198	78	-	108	108	
200	0.8875	2,2',3,3',4,5,5',6'	201	79	-		109	
201	0.8938	2,2',3,3',4,4',5,6	196	80	-	110	110	
202	0.8938	2,2',3,4,4',5,5',6	203	80	-	110	110	
203	0.9142	2,3,3',4,4',5,5'	189	81	-	111	111	
204	0.932	2,2',3,3',4,5,5',6,6'	208	82	-	113	113	1697
205	0.9321	2,2',3,3',4,4',5,6	195	82	-	112	112	
206	0.9423	2,2',3,3',4,4',5,6,6'	207	83	-	114	114	
207	0.962	2,2',3,3',4,4',5,5'	194	84	-	115	115	1719+
208	0.9678	2,2',3',4,4',5,5',6	205	85	-		116	
209	1.0103	2,2',3,3',4,4',5,5',6	206	86	-	117	117	
210	1.0496	2,2',3,3',4,4',5,5',6,6'	209	87	-	118	118	1804

+Based on retention time data for the RT marker 208 and congener standard 209, the octachlorobiphenyl congener supplied as 200 appears to be 194.

Table 1. Cross-reference of Congener Elution Order for SE-54, DB-1 and DB-5 Capillary Columns

Note 1. The relative retention times and structure for biphenyl and all 209 PCB congeners are listed in the order of elution for an SE-54 column as reported by Mullin et al. (1984). Retention times were determined relative to a reference standard, octachloronapthalene. All 209 theoretically possible congeners were available as reference compounds for the RRT determinations.

Note 2. The number of each PCB is according to the system of Ballschmitter and Zell (1980), which was followed by Mullin et al. (1984). The numbering system adopted by the International Union of Pure and Applied Chemists (IUPAC) is equivalent to the BZ number, with three exceptions. Congeners BZ# 199, 200, and 201 have the IUPAC numbers 200, 201, and 199 respectively. Both usages are found in the literature. The IUPAC numbering system was used by Schulz et al. (1989).

Note 3. The complete characterization of PCB congeners in commercial Aroclor mixtures has been reported by Schulz et al. (1989). On the basis of the relative retention times of all 209 possible chlorobiphenyls, all congeners present were identified and quantitated. The actual retention times for each congener were determined on an SE-54 column. Identification and quantitation of congeners known to coelute from the SE-54 column were obtained with a multidimensional gas chromatography technique using either OV-210 or C-87 columns. Eighty-seven (87) chromatographic domains were identified which were essentially base-line separated on the SE-54 chromatographs. Each domain contains either one well-resolved peak or a cluster of unresolved peaks.

Note 4. Based on the data generated by Schulz et al. (1989), 132 PCB congeners were identified in one or more of eight commercial PCB mixtures. The congeners identified by the symbol * were not detected in any of the commercial mixtures (i.e., concentrations less than 0.05%). Congeners identified by the symbol - were not detected in Aroclor 1016, 1242, or 1254 (i.e., concentrations less than 0.05%) but were identified in other commercial mixtures.

Note 5. Brown and Wagner (1986) have identified 140 individual PCB congeners or isomer groups detectable by capillary GC or GC/MS on a DB-1 column. Numbers were assigned for 118 distinguishable peaks based on the order of elution for the DB-1 column.

Note 6. Distinguishable chromatographic peaks for the DB-5 capillary column used for GC/EC (Task 7) and GC/MS (Task 18) were assigned peak numbers coinciding, where applicable, to those employed by Brown and Wagner (1986). Differences relating to column elution separations and/or GC/MS differentiation of coeluting congeners having different chlorine numbers were assigned the notation peak number prime (') when appropriate. The DB-5 column has been reported by Alford-Stevens et al. (1985) to provide the same retention order and essentially the same separation capabilities as an SE-54 column.

Note 7. This tabulation lists GC/MS scan numbers representing peak elution order for DB-5 capillary column.

REFERENCES - Table 1

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Table 4. Congener-specific Analysis of Task 18 Sediment Samples from NBH

Results are expressed as mg/kg (ppm) dry weight (105°C) basis

GC/MS Scan # [1]	DB-5 Peak #	BZ# [2]	Congener Structure[3]	Sample Identification: NBH 110-02 (JJ 1006)	NBH 105/106 (JJ 1004/5)	NBH 111-01 (JJ 1007)	NBH 112-02 (JJ 1008)	NBH 113-01/024 (JJ 1009/10)
Tr (GC/EC)	110	203	23456-245	<0.5	<0.1	<0.5	<1.	
	110	196	2345-2346					
Tr (GC/EC)	109	201	2345-2356	<0.5	<0.1	<0.5	<1.	
1645	106	170	2345-234	<0.5	<0.1	5.0	35.	
	106	190	23456-34					
1610	102	180	2345-245	4.1	<0.1	27.	77.	Not PCB
Tr (GC/EC)	99	200	2346-2356	<0.5	<0.1	<0.5	<1.	
1593	95	156	2345-34	<0.5	<0.1	<0.5	150.	
	95'	171	2346-234	<0.5	<0.1	<0.5	<1.	
Tr 1587	94	177	2356-234	<0.5	<0.1	<0.5	8.4	
Tr 1581	93	174	2345-236	<0.5	<0.1	<0.5	24.	
Tr (GC/EC)	91	167	245-345	<0.5	<0.1	<0.5	<1.	Not PCB
1568	89	128	234-234	7.2	0.4	29.	240.	
Tr 1557	88	187	2356-245	<0.5	<0.1	<0.5	<1.	
1552	85	178	2356-235	19.	0.94	22.	26.	
1545	83	158	2346-34	<0.5	<0.1	<0.5	43.	
1535	82	138	234-245	120.	5.9	260.	1430.	7.3
1528	80	137	2345-24	<0.5	<0.1	<0.5	60.	
1525	79	130	234-235	<0.5	<0.1	13.	110.	
*1521	78	179	2356-236	<0.5	<0.1	<0.5	<1.	
1521			Not PCB					
1516	77	141	2345-25	<0.5	<0.1	8.8	170.	
1509	74'	105	234-34	<0.5	<0.1	35.	720.	1.9
1507	74	132	234-236	<0.5	<0.1	27.	380.	

GC/MS Scan # [1]	DB-5 Peak #	BZ# [2]	Congener Structure[3]	NBH 110-02 (JJ 1006)	NBH 105/106 (JJ 1004/5)	NBH 111-01 (JJ 1007)	NBH 112-02 (JJ 1008)	NBH 113-01/024 (JJ 1009/10)
1500	75	153	245-245	260.	11.	360.	1000.	5.0
1494	73	188	2356-246		Retention Time/Congener Standard			
1493	73'	146	235-245	40.	1.5	52.	220.	
1490	72'	122	345-23	<0.5	<0.1	<0.5	49.	
1487	71	134	2356-23	24.	<0.1	22.	100.	
1475	69'	118	245-34	250.	7.4	580.	2170.	12.
1473	69	149	236-245	320.	18.	320.	1020.	3.4
1469	67	107	235-34	<0.5	<0.1	39.	230.	
1465	65	135 144	235-236 2346-25	27.	1.5	36.	200.	Not PCB
1461	63	82	234-23	<0.5	<0.1	<0.5	240.	
1459	64	151	2356-25	50.	2.4	52.	170.	0.8
1447	61'	77	34-34	<0.5	<0.1	<0.5	3.5	
1446	61	110	236-34	450.	32.	790.	2900.	16.
1444	60	136	236-236	90.	4.1	65.	260.	0.8
1440	59	85	234-24	<0.5	<0.1	14.	490.	
1434	58 58	87 115	234-25 2346-4	21.	0.81	68.	970.	
1427	57	97	245-23	34.	2.4	170.	760.	3.9
1420	56 56 56'	83 109 78	235-23 2346-3 345-3	<0.5 <0.5	<0.1 <0.1	27. <0.5	110. <1.	
*1417	55'	150	236-246	3.1	<0.1	<0.5	<1.	

*Found in samples but not in standards

GC/MS Scan # [1]	DB-5 Peak #	BZ# [2]	Congener Structure[3]	NBH 110-02 (JJ 1006)	NBH 105/106 (JJ 1004/5)	NBH 111-01 (JJ 1007)	NBH 112-02 (JJ 1008)	NBH 113-01/024 (JJ 1009/10)
*1415	55	119	246-34	120.	3.9	57.	<1.	
1406	54	99	245-24	380.	11.	500.	1180.	6.0
1399	53	101	245-25	380.	16.	780.	3260.	15.
	53	90	235-24					
1394	50	56	23-34	<0.5	<0.1	140.	1300.	1.0
	50	60	234-4					
1392	51	84	236-23	70.	2.7	100.	420.	
	51	92	235-25					
1382	49	91	236-24	340.	12.	190.	400.	2.4
1374	48'	95	236-25	410.	24.	480.	2020.	8.0
1373	48	66	24-34	67.	4.6	500.	1600.	4.7
1367	47	70	25-34	31.	2.4	720.	2230.	4.7
1362	46	74	245-4	23.	3.5	<0.5	1390.	8.4
1351	44'	67	245-3	Tr	Tr	29.	<1.	
	44	100	246-24	7.8	0.5	0.68	<1.	
1345	42	40	23-23	<0.5	<0.1	56.	220.	Not PCB
1342	41	96	236-26	12.	0.81	<0.5	<1.	
1335	39	64	236-4	580.	45.	370.	1670.	4.1
	39	41	234-2					
	39	71	26-34					
	39	72	25-35					
1325	38	42	23-24	120.	8.7	180.	450.	
	38	59	236-3					
	38'	37	34-4	<0.5	0.94	82.	580.	
1319	37	44	23-25	230.	26.	390.	1520.	5.0
1315	36'	104	246-26		Retention Time/Congener Marker			

'Found in samples but not in standards.

GC/MS Scan # [1]	DB-5 Peak #	BZ# [2]	Congener Structure[3]	NBH 110-02 (JJ 1006)	NBH 105/106 (JJ 1004/5)	NBH 111-01 (JJ 1007)	NBH 112-02 (JJ 1008)	NBH 113-01/024 (JJ 1009/10)
1302	33	48	245-2	280.	18.	330.	760.	3.2
	33	75	246-4					
	33	47	24-24					
1297	32	49	24-25	1020.	81.	720.	1400.	9.2
1292	31	73	26-35	1650.	110.	890.	2370.	13.
	31	52	25-25					
1280	27	45	236-2	<0.5	3.0	39.	240.	
1273	26	22	23-4	<0.5	3.2	160.	940.	0.8
1268	26'	51	24-26	95.	1.9	<0.5	68.	
1262	25'	53	25-26	350.	5.6	52.	260.	
	25	20	23-3	<0.5	1.5	250.	1790.	0.6
	25	33	34-2					
1249	24	28	24-4	65.	46.	500.	2080.	
Tr 1247	24'	50	246-2	<0.5	<0.1	<0.5	<1.	
1246	23	31	25-4	68.	58.	490.	2780.	6.9
1239	22	25	24-3	230.	28.	130.	140.	1.6
1235	21	26	25-3	930.	74.	270.	520.	5.1
1230	20	29	245-	<0.5	<0.1	<0.5	<1.	
*1223	19	34	35-2	2.6	0.1	<0.5	<1.	
1213	17	32	26-4	90.	14.	240.	1360.	0.4
	17	16	23-2					
1201	16	27	26-3	85.	5.2	36.	180.	
	16	24	236-					
*1196	Phenanthrene (Tentative ID)					Present		

*Found in samples but not in standards.

GC/MS Scan # [1]	DB-5 Peak #	BZ# [2]	Congener Structure[3]	NBH 110-02 (JJ 1006)	NBH 105/106 (JJ 1004/5)	NBH 111-01 (JJ 1007)	NBH 112-02 (JJ 1008)	NBH 113-01/024 (JJ 1009/10)
1191	15	17	24-2	<0.5	15.	110.	560.	
	15'	15	4-4		6.9	91.	910.	
1187	14	18	25-2	140.	44.	530.	2780.	2.2
*1183	13	13	3-4	<0.5	11.	39.	150.	
	13	12	34-					
*1174	Trichloronapthalene			Present	Absent	Absent	Absent	Present
Tr*1173	12	11	3-3	<0.5	2.3	<0.5	7.0	
1158	10	19	26-2	12.	3.0	29.	170.	
*1157	Trichloronapthalene			Present	Present	Present	Present	Present
*1149	Trichloronapthalene			Present	Absent	Absent	Absent	Present
1130	8	5	23-	9.5	36.	310.	2750.	1.8
	8	8	2-4					
1120	7	6	2-3	26.	40.	140.	570.	0.8
1104	6	9	25-	<0.5	2.3	22.	310.	
	6	7	24-					
1070	5	4	2-2	5.1	13.	68.	800.	0.6
	5	10	26-					
1038	4	3	4-	<0.5	<0.1	<0.5	66.	
1032	3	2	3-	<0.5	<0.1	<0.5	14.	
*1029	Dichloronaphthalene			Present	Present	Present	Present	Present
977	2	1	2-	<0.5	0.40	0.03	190.	
*878	Chloronapthalene			Present	Absent	Absent	Absent	Absent
877	1	0	Biphenyl	<0.5	<0.1	<0.5	930.	
TOTAL PCBs (ppm, dry basis)				9550.	874.	13000.	58000.	157.

*Found in samples, but not in standards.

Table 3. Congener-specific Analysis of Task 18 Sedimen
Samples from NBH

Note 1. When a peak was detected by GC/EC but not by t
sensitive GC/MS procedure, it is listed as Tr
instead of the GC/MS scan number.

Note 2. The BZ# is according to the system of Ballschm
and Zell (1980).

Note 3. Congener structure notation follows the practi
Brown et al. (1987) whereby the numbers indica
substitution pattern on each ring are given se
ly, separated by a dash. For example, congene
BZ#105 (2,3,3',4,4'-pentachlorobiphenyl) will
listed as 234-34. It is easier to follow the
wise dechlorination pathways when this notatio
used.

Note 4. Because of the high background and low PCB sig
for this sample, only those peaks which were c
firmed as being PCBs were quantitated and repo

REFERENCES - Table 3

Ballschmiter, K. and M. Zell. 1980. Analysis of Polychlorinated Biphenyls (PCB) by Glass Capillary Gas Chromatography: Composition of Technical Aroclor-and Cl Mixtures. Fresenius Zeitschrift fur Analytische Chemie, Vol 302:210-31.

Brown, J. F., Jr., R. E. Wagner, H. Feng, D. L. Bedard, Brennan, J. C. Carnahan, and R. J. May. 1987. Environm Dechlorination of PCBs. Environ. Tox. and Chem. Vol 6: 579-593.

Table 5. Comparative PCB Data for Phase II Samples

Sample	Total PCBs, mg/kg (ppm), dry basis	
	Table 1 (as Aroclors)	Table 4 (as individual congeners)
NBH-105/106 (JJ 1004/5)	620.	874.
NBH-110-02 (JJ 1006)	2800.	9550.
NBH 111-01 (JJ 1007)	9100.	13,000.
NBH-112-02 (JJ 1008)	41,000.	58,000.
NBH-113-01/02 (JJ 1009/10)	150.	157

Table 6. Relative Abundance of PCB Congeners in Selected NBH Sediments and Aroclor Standards

Results are expressed as Wt. % Total PCBs present. Sediment Results are calculated on dry (105oC) basis.

GC/MS Scan #[1]	DB-5 Peak #	BZ#[2]	Congener Structure[3]	Sample Identifications					
				NBH 110-02	NBH105/106	NBH 111-01	NBH 112-02	Aroclor 1254	Aroclor 1242
Tr (GC/EC)	110	203	23456-245	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	110	196	2345-2346						
Tr (GC/EC)	109	201	2345-2356	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
1645	106	170	2345-234	<0.01	<0.01	0.04	0.06	0.20	<0.01
	106	190	23456-34						
1610	102	180	2345-245	0.04	<0.01	0.21	0.14	0.38	<0.01
Tr (GC/EC)	99	200	2346-2356	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
1593	95	156	2345-34	<0.01	<0.01	<0.01	0.26	0.84	<0.01
	95'	171	2346-234	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Tr 1587	94	177	2356-234	<0.01	<0.01	<0.01	0.01	<0.01	<0.01
Tr 1581	93	174	2345-236	<0.01	<0.01	<0.01	0.04	0.07	<0.01
Tr (GC/EC)	91	167	245-345	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
1568	89	128	234-234	0.07	0.05	0.22	0.43	1.34	<0.01
Tr 1557	88	187	2356-245	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
1552	85	178	2356-235	0.20	0.11	0.18	0.05	0.12	<0.01
1545	83	158	2346-34	<0.01	<0.01	<0.01	0.08	0.27	<0.01
1535	82	138	234-245	1.25	0.68	2.01	2.53	7.76	<0.01
1528	80	137	2345-24	<0.01	<0.01	<0.01	0.10	0.25	<0.01
1525	79	130	234-235	<0.01	<0.01	0.10	0.19	0.30	<0.01
Tr 1521	78	179	2356-236	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
1516	77	141	2345-25	<0.01	<0.01	0.07	0.33	0.87	<0.01
1509	74'	105	234-34	<0.01	<0.01	0.27	1.27	2.97	0.17
1507	74	132	234-236	<0.01	<0.01	0.21	0.68	1.78	<0.01

GC/MS Scan # [1]	DB-5 Peak #	BZ# [2]	Congener Structure[3]	Sample Identifications					
				NBH 110-02	NBH105/106	NBH 111-01	NBH 112-02	Aroclor 1254	Aroclor 1242
1500	75	153	245-245	2.70	1.24	2.80	1.77	4.20	<0.01
1493	73'	146	235-245	0.42	0.17	0.40	0.38	0.62	<0.01
1490	72'	122	345-23	<0.01	<0.01	<0.01	0.08	0.17	<0.01
1487	71	134	2356-23	0.25	<0.01	0.18	0.19	0.21	<0.01
1475	69'	118	245-34	2.60	0.85	4.49	3.85	8.14	0.37
1473	69	149	236-245	3.32	2.08	2.48	1.80	3.87	<0.01
1469	67	107	235-34	<0.01	<0.01	0.31	0.40	0.44	<0.01
1465	65	135 144	235-236 2346-25	0.28	0.17	0.28	0.35	0.64	<0.01
1461	63	82	234-23	<0.01	<0.01	<0.01	0.40	1.10	<0.01
1459	64	151	2356-25	0.52	0.28	0.40	0.30	0.55	<0.01
1447	61'	77	34-34	<0.01	<0.01	<0.01	0.01	<0.01	0.20
1446	61	110	236-34	4.67	3.71	6.12	5.13	10.10	0.55
1444	60	136	236-236	0.93	0.47	0.50	0.44	0.80	<0.01
1440	59	85	234-24	<0.01	<0.01	0.11	0.86	0.98	<0.01
1434	58 58	87 115	234-25 2346-4	0.22	0.09	0.53	1.73	3.94	0.35
1427	57	97	245-23	0.35	0.27	1.32	1.34	2.04	0.12
1420	56 56	83 109	235-23 2346-3	<0.01	<0.01	0.20	0.19	0.26	<0.01
	56'	78	345-3	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
1417	55'	150	236-246	0.03	<0.01	<0.01	<0.01	<0.01	<0.01
1415	55	119	246-34	1.25	0.45	0.44	<0.01	<0.01	<0.01
1406	54	99	245-24	3.95	1.24	3.91	2.09	2.72	0.13

GC/MS Scan # [1]	DB-5 Peak #	BZ# [2]	Congener Structure[3]	Sample Identifications					
				NBH 110-02	NBH105/106	NBH 111-01	NBH 112-02	Aroclor 1254	Aroclor 1242
1399	53	101	245-25	3.95	1.85	6.02	5.79	9.62	0.51
	53	90	235-24						
1394	50	56	23-34	<0.01	<0.01	1.06	2.31	0.76	3.12
	50	60	234-4						
1392	51	84	236-23	0.73	0.31	0.79	0.75	1.10	<0.01
	51	92	235-25						
1382	49	91	236-24	3.53	1.39	1.48	0.70	0.68	0.04
1374	48'	95	236-25	4.26	2.78	3.74	3.58	5.76	0.27
1373	48	66	24-34	0.70	0.53	3.91	2.83	1.71	4.06
1367	47	70	25-34	0.32	0.27	3.47	3.95	6.10	4.59
1362	46	74	245-4	0.24	0.40	1.70	2.47	1.21	2.62
1351	44'	67	245-3	Tr	Tr	0.22	<0.01	<0.01	<0.01
	44	100	246-24	0.08	0.06	0.01	<0.01	<0.01	<0.01
1345	42	40	23-23	<0.01	<0.01	0.44	0.38	<0.01	0.38
1342	41	96	236-26	0.12	0.09	<0.01	<0.01	<0.01	<0.01
1335	39	64	236-4	6.02	5.17	2.85	2.95	1.06	4.34
	39	41	234-2						
	39	71	26-34						
	39	72	25-35						
1325	38	42	23-24	1.25	1.00	1.38	0.79	<0.01	1.25
	38	59	236-3						
	38'	37	34-4	<0.01	0.11	0.63	1.04	<0.01	1.78
1319	37	44	23-25	2.39	2.94	3.01	2.69	2.68	3.33
1302	33	48	245-2	2.91	2.08	2.53	1.34	0.09	2.30
	33	75	246-4						
	33	47	24-24						
1297	32	49	24-25	10.6	9.28	5.60	2.44	1.52	2.93

GC/MS Scan # [1]	DB-5 Peak #	BZ# [2]	Congener Structure[3]	Sample Identifications					
				NBH 110-02	NBH105/106	NBH 111-01	NBH 112-02	Aroclor 1254	Aroclor 1242
1292	31	73	26-35	17.1	12.40	6.88	4.20	8.76	4.14
	31	52	25-25						
1280	27	45	236-2	<0.01	0.35	0.31	0.40	<0.01	0.77
1273	26	22	23-4	<0.01	0.36	1.27	1.66	<0.01	3.12
1268	26'	51	24-26	0.99	0.22	<0.01	<0.01	<0.01	<0.01
1262	25'	53	25-26	3.63	0.65	0.41	0.47	0.04	0.70
	25	20	23-3	<0.01	0.17	1.95	3.17	<0.01	6.27
	25	33	34-2						
1249	24	28	24-4	0.67	5.33	3.91	3.68	<0.01	7.50
1247	24'	50	246-2	<0.01	<0.01	<0.01	<0.01	0.14	<0.01
1246	23	31	25-4	0.71	6.65	3.80	4.93	<0.01	9.41
1239	22	25	24-3	2.39	3.25	1.00	0.24	<0.01	0.56
1235	21	26	25-3	9.66	8.47	2.11	0.93	<0.01	1.39
1230	20	29	245-	<0.01	<0.01	<0.01	<0.01	<0.01	0.10
1223	19	34	35-2	0.03	0.01	<0.01	<0.01	<0.01	<0.01
1213	17	32	26-4	0.93	1.62	1.85	2.42	<0.01	3.81
	17	16	23-2						
1201	16	27	26-3	0.88	0.60	0.28	0.32	<0.01	0.55
	16	24	236-						
1191	15	17	24-2	<0.01	1.72	0.85	0.99	<0.01	1.95
	15'	15	4-4	<0.01	0.79	0.71	1.61	<0.01	2.33
1187	14	18	25-2	1.45	5.09	3.33	3.95	<0.01	6.91
1183	13	13	3-4	<0.01	1.31	0.31	0.26	<0.01	0.26
1173	12	11	3-3	<0.01	0.26	<0.01	0.01	<0.01	<0.01
1158	10	19	26-2	0.12	0.35	0.22	0.31	<0.01	0.49

GC/MS Scan #[1]	DB-5 Peak #	BZ#[2]	Congener Structure[3]	Sample Identifications					
				NBH 110-02	NBH105/106	NBH 111-01	NBH 112-02	Aroclor 1254	Aroclor 1242
1130	8 8	5 8	23- 2-4	0.10	4.17	2.43	4.87	<0.01	9.05
1120	7	6	2-3	0.27	4.63	1.06	1.01	<0.01	1.62
1104	6 6	9 7	25- 24-	<0.01	0.26	0.17	0.56	<0.01	0.68
1070	5 5	4 10	2-2 26-	0.05	1.46	0.53	1.42	<0.01	2.57
1035	4	3	4-	<0.01	<0.01	<0.01	0.12	<0.01	0.10
1032	3	2	3-	<0.01	<0.01	<0.01	0.03	<0.01	<0.01
977	2	1	2-	<0.01	0.05	0.03	0.33	<0.01	0.57
877	1	0	Biphenyl	<0.01	<0.01	<0.01	1.64	<0.01	0.01
Extent of Dechlorination Observed				Advanced	Advanced	Moderate	Slight		

Table 2. Relative Abundance of PCB Congeners in Selected NBH Sediments and Aroclor Standards

Note 1. When a peak was detected by GC/EC but not by the less sensitive GC/MS procedure, it is listed as Tr (GC/EC) instead of the GC/MS scan number.

Note 2. The BZ# is according to the system of Ballschmiter and Zell (1980).

Note 3. Congener structure notation follows the practice of Brown et al. (1987) whereby the numbers indicating the substitution pattern on each ring are given separately, separated by a dash. For example, congener BZ# 105 (2,3,3',4,4'-pentachlorobiphenyl) will be listed as 234-34. It is easier to follow the stepwise dechlorination pathways when this notation is used.

REFERENCES

Ballschmiter, K. and M. Zell. 1980. Analysis of Polychlorinated Biphenyls (PCB) by Glass Capillary Gas Chromatography: Composition of Technical Aroclor-and Clophen-PCB Mixtures. Fresenius Zeitschrift fur Analytische Chemie, Vol 302:210-31.

Brown, J. F., Jr., R. E. Wagner, H. Feng, D. L. Bedard, M. J. Brennan, J. C. Carnahan and R. J. May. 1987. Environmental Dechlorination of PCBs. Environ. Tox. and Chem. Vol 6: 675-693.

TABLE 7.

HALF-LOSS DATA AND DECHLORINATION RATE CONSTANTS FOR PCB CONGENERS
SELECTED SAMPLES EXHIBITING ADVANCED DECHLORINATION

DB-5 PEAK #	SAMPLE ID NBH 110-02 (JJ 1006) (C)	A1254 (Co)	# OF HALF-LOSSES	HALF-LOSS t1/2(yrs)	RATE CONSTANT k(yrs-1)	% REMOVED/ FORMED		DB-5 PEAK #	SAMPLE ID NBH 105/106 (JJ 1004/5) (C)	A1242+ A1254 (Co)	# OF HALF-LOSSES	HALF-LOSS t1/2(yrs)	RATE CONSTANT k(yrs-1)	% REMOVED/ FORMED	
74'	0.01	2.97	8.22	3.65	0.190	99.7	R	50	0.01	2.32	7.86	2.93	0.237	99.6	R
74	0.01	1.78	7.48	4.01	0.173	99.4	R	74'	0.01	1.12	6.81	4.41	0.157	99.1	R
63	0.01	1.10	6.78	4.42	0.157	99.1	R	74	0.01	0.61	5.92	5.07	0.137	98.3	R
59	0.01	0.98	6.62	4.53	0.153	99.0	R	63	0.01	0.37	5.23	5.74	0.121	97.3	R
77	0.01	0.87	6.44	4.66	0.149	98.9	R	59	0.01	0.33	5.06	5.93	0.117	97.0	R
50	0.01	0.76	6.25	3.68	0.188	98.7	R	77	0.01	0.30	4.91	6.13	0.113	96.7	R
67	0.01	0.44	5.46	5.49	0.126	97.7	R	95	0.01	0.29	4.86	6.20	0.112	96.6	R
79	0.01	0.30	4.91	6.11	0.113	96.7	R	42	0.01	0.25	4.65	4.95	0.140	96.0	R
83	0.01	0.27	4.76	6.30	0.110	96.3	R	25	0.17	4.14	4.61	4.99	0.139	95.9	R
56	0.01	0.26	4.70	6.38	0.109	96.2	R	47	0.27	5.10	4.24	5.42	0.128	94.7	R
80	0.01	0.25	4.64	6.47	0.107	96.0	R	58	0.09	1.57	4.13	7.26	0.095	94.3	R
106	0.01	0.20	4.32	6.94	0.100	95.0	R	67	0.01	0.15	3.90	7.69	0.090	93.3	R
89	0.07	1.34	4.26	7.04	0.098	94.8	R	61'	0.01	0.13	3.72	6.18	0.112	92.4	R
47	0.32	6.10	4.25	5.41	0.128	94.8	R	102	0.01	0.13	3.70	8.13	0.085	92.3	R
58	0.22	3.94	4.16	7.21	0.096	94.4	R	38'	0.11	1.17	3.42	6.73	0.103	90.6	R
72'	0.01	0.17	4.09	7.33	0.094	94.1	R	79	0.01	0.10	3.32	8.96	0.077	90.0	R
24'	0.01	0.14	3.81	6.04	0.115	92.9	R	89	0.05	0.46	3.20	9.40	0.074	89.1	R
102	0.04	0.38	3.25	9.23	0.075	89.5	R	83	0.01	0.09	3.17	9.38	0.074	88.9	R
95	0.10	0.84	3.07	9.77	0.071	88.1	R	80	0.01	0.09	3.17	9.71	0.071	88.9	R
93	0.01	0.07	2.81	10.68	0.065	85.7	R	56	0.01	0.09	3.14	9.55	0.073	88.7	R
82	1.25	7.76	2.63	11.41	0.061	83.9	R	2	0.05	0.38	2.91	7.90	0.088	86.7	R
57	0.35	2.04	2.54	11.81	0.059	82.8	R	71	0.01	0.07	2.84	10.56	0.066	86.0	R
46	0.24	1.21	2.33	9.87	0.070	80.2	R	106	0.01	0.07	2.81	10.83	0.064	85.7	R
69'	2.60	8.14	1.65	18.18	0.038	68.1	R	4	0.01	0.07	2.72	8.46	0.082	84.9	R
48	0.70	1.71	1.29	17.83	0.039	59.1	R	20	0.01	0.07	2.72	8.46	0.082	84.9	R
53	3.95	9.62	1.28	23.44	0.030	58.9	R	48	0.53	3.26	2.62	8.78	0.079	83.8	R
65	0.28	0.64	1.19	25.21	0.027	56.3	R	26	0.36	2.10	2.54	9.06	0.077	82.9	R
61	4.67	10.10	1.11	27.03	0.026	53.8	R	72'	0.01	0.06	2.53	11.86	0.058	82.7	R
75	2.70	4.20	0.64	46.88	0.015	35.7	R	46	0.40	2.14	2.42	9.50	0.073	81.3	R
51	0.73	1.10	0.59	50.85	0.014	33.6	R	24'	0.01	0.05	2.25	10.22	0.068	79.0	R
73'	0.42	0.62	0.56	53.57	0.013	32.3	R	82	0.68	2.64	1.96	15.31	0.045	74.2	R
48'	4.26	5.76	0.44	68.18	0.010	26.0	R	69'	0.85	3.01	1.82	16.48	0.042	71.8	R
69	3.32	3.87	0.22	136.36	0.005	14.2	R	57	0.27	0.77	1.52	19.74	0.035	65.1	R
37	2.39	2.68	0.17	135.29	0.005	10.8	R	6	0.26	0.58	1.16	19.83	0.035	55.2	R
64	0.52	0.55	0.08	375.00	0.002	5.5	R	93	0.01	0.02	1.00	24.00	0.029	50.0	R
60	0.93	0.80	-0.22			16.3	F	53	1.85	3.61	0.96	31.25	0.022	48.7	R

NOTES: 1) A NEGATIVE VALUE FOR # OF HALF-LOSSES INDICATES PEAK FORMATION (DOUBLING).
2) ASSUMES AN ENVIRONMENTAL EXPOSURE PERIOD OF 30 YEARS FOR PENTA- AND HIGHER CONGENERS, AND 23 YEARS FOR TETRA- AND LOWER CONGENERS.
3) CONCENTRATIONS EXPRESSED AS WEIGHT % OF TOTAL PCBS PRESENT.
4) IN CASES WHERE A CONGENER WAS NOT DETECTED IN THE SAMPLE YET WAS PRESENT IN THE AROCLOR MIXTURE, THE SAMPLE WAS ASSIGNED A VALUE OF 0.01 FOR CALCULATION PURPOSES. LIKEWISE FOR CASES WHERE THE CONGENER WAS PRESENT IN THE SAMPLE AND NOT IN THE AROCLOR.

TABLE 7 (cont.)

HALF-LOSS DATA AND DECHLORINATION RATE CONSTANTS FOR PCB CONGENERS
SELECTED SAMPLES EXHIBITING ADVANCED DECHLORINATION

DB-5 PEAK #	SAMPLE ID NBH 110-02 (JJ 1006) (C)	A1254 (Co)	# OF HALF-LOSSES	HALF-LOSS t1/2(yrs)	RATE CONSTANT k(yrs-1)	% REMOVED/ FORMED
71	0.25	0.21	-0.25			19.0 F
54	3.95	2.72	-0.54			45.2 F
85	0.20	0.12	-0.74			66.7 F
31	17.10	8.76	-0.97			95.2 F
19	0.03	0.01	-1.59			200 F
55'	0.03	0.01	-1.59			200 F
5	0.05	0.01	-2.32			400 F
49	3.53	0.68	-2.38			419 F
39	6.02	1.06	-2.51			468 F
32	10.60	1.52	-2.80			597 F
44	0.08	0.01	-3.00			700 F
8	0.10	0.01	-3.32			900 F
10	0.12	0.01	-3.59			1100 F
41	0.12	0.01	-3.59			1100 F
7	0.27	0.01	-4.76			2600 F
33	2.91	0.09	-5.02			3133 F
24	0.67	0.01	-6.07			6600 F
23	0.71	0.01	-6.15			7000 F
16	0.88	0.01	-6.46			8700 F
25'	3.63	0.04	-6.51			8975 F
17	0.93	0.01	-6.54			9200 F
26'	0.99	0.01	-6.63			9800 F
55	1.25	0.01	-6.97			12400 F
38	1.25	0.01	-6.97			12400 F
14	1.45	0.01	-7.18			14400 F
22	2.39	0.01	-7.90			23800 F
21	9.66	0.01	-9.92			96500 F
25	<0.01	<0.01				
6	<0.01	<0.01				
13	<0.01	<0.01				
15'	<0.01	<0.01				
12	<0.01	<0.01				
20	<0.01	<0.01				
110	<0.01	<0.01				
15	<0.01	<0.01				
109	<0.01	<0.01				

DB-5 PEAK #	SAMPLE ID NBH 105/106 (JJ 1004/5) (C)	A1242+ A1254 (Co)	# OF HALF-LOSSES	HALF-LOSS t1/2(yrs)	RATE CONSTANT k(yrs-1)	% REMOVED/ FORMED
15'	0.79	1.54	0.96	23.96	0.029	48.6 R
17	1.62	2.51	0.63	36.51	0.019	35.6 R
27	0.35	0.51	0.54	42.59	0.016	31.1 R
8	4.17	5.97	0.52	44.23	0.016	30.2 R
65	0.17	0.22	0.36	83.33	0.008	21.9 R
73'	0.17	0.21	0.31	96.77	0.007	19.4 R
51	0.31	0.37	0.27	111.11	0.006	17.1 R
5	1.46	1.70	0.22	104.55	0.007	13.9 R
75	1.24	1.43	0.20	150.00	0.005	13.2 R
37	2.94	3.11	0.08	287.50	0.002	5.4 R
61	3.71	3.80	0.03	1000.00	0.001	2.4 R
19	0.01	0.01	0.00			0.0
44'	0.01	<0.01	-0.01			0.7 F
23	6.65	6.21	-0.10			7.1 F
24	5.33	4.95	-0.11			7.7 F
10	0.35	0.32	-0.11			8.2 F
14	5.09	4.56	-0.16			11.6 F
38	1.00	0.83	-0.28			21.2 F
54	1.24	1.01	-0.30			23.0 F
48'	2.78	2.11	-0.40			32.0 F
15	1.72	1.29	-0.42			33.6 F
33	2.08	1.55	-0.43			34.3 F
25'	0.65	0.48	-0.45			36.7 F
64	0.28	0.19	-0.58			49.7 F
1	0.01	0.01	-0.60			51.5 F
69	2.08	1.32	-0.66			58.1 F
39	5.17	3.22	-0.68			60.3 F
16	0.60	0.36	-0.73			65.3 F
60	0.47	0.27	-0.79			72.8 F
31	12.40	5.71	-1.12			117 F
85	0.11	0.04	-1.46			175 F
32	9.28	2.45	-1.92			279 F
7	4.63	1.07	-2.11			333 F
49	1.39	0.26	-2.43			440 F
44	0.06	0.01	-2.59			500 F
13	1.31	0.17	-2.93			663 F

NOTES: 1) A NEGATIVE VALUE FOR # OF HALF-LOSSES INDICATES PEAK FORMATION (DOUBLING).
2) ASSUMES AN ENVIRONMENTAL EXPOSURE PERIOD OF 30 YEARS FOR PENTA- AND HIGHER CONGENERS, AND 23 YEARS FOR TETRA- AND LOWER CONGENERS.
3) CONCENTRATIONS EXPRESSED AS WEIGHT % OF TOTAL PCBS PRESENT.
4) IN CASES WHERE A CONGENER WAS NOT DETECTED IN THE SAMPLE YET WAS PRESENT IN THE AROCLOR MIXTURE, THE SAMPLE WAS ASSIGNED A VALUE OF 0.01 FOR CALCULATION PURPOSES. LIKEWISE FOR CASES WHERE THE CONGENER WAS PRESENT IN THE SAMPLE AND NOT IN THE AROCLOR.

TABLE 7 (cont.)

HALF-LOSS DATA AND DECHLORINATION RATE CONSTANTS FOR PCB CONGENERS
SELECTED SAMPLES EXHIBITING ADVANCED DECHLORINATION

DB-5 PEAK #	SAMPLE ID NBH 110-02 (JJ 1006) (C)	A1254 (Co)	# OF HALF-LOSSES	HALF-LOSS t1/2(yrs)	RATE CONSTANT k(yrs-1)	% REMOVED/ FORMED
44'	<0.01	<0.01				
99	<0.01	<0.01				
26	<0.01	<0.01				
95'	<0.01	<0.01				
56'	<0.01	<0.01				
94	<0.01	<0.01				
38'	<0.01	<0.01				
61'	<0.01	<0.01				
42	<0.01	<0.01				
4	<0.01	<0.01				
27	<0.01	<0.01				
3	<0.01	<0.01				
91	<0.01	<0.01				
88	<0.01	<0.01				
78	<0.01	<0.01				
2	<0.01	<0.01				
1	<0.01	<0.01				

DB-5 PEAK #	SAMPLE ID NBH 105/106 (JJ 1004/5) (C)	A1242+ A1254 (Co)	# OF HALF-LOSSES	HALF-LOSS t1/2(yrs)	RATE CONSTANT k(yrs-1)	% REMOVED/ FORMED
22	3.25	0.37	-3.14			779 F
41	0.09	0.01	-3.17			800 F
21	8.47	0.92	-3.21			823 F
26'	0.22	0.01	-4.46			2100 F
12	0.26	0.01	-4.70			2500 F
55	0.45	0.01	-5.49			4400 F
78	<0.01	<0.01				
110	<0.01	<0.01				
109	<0.01	<0.01				
91	<0.01	<0.01				
99	<0.01	<0.01				
88	<0.01	<0.01				
3	<0.01	<0.01				
55'	<0.01	<0.01				
95'	<0.01	<0.01				
56'	<0.01	<0.01				
94	<0.01	<0.01				

NOTES: 1) A NEGATIVE VALUE FOR # OF HALF-LOSSES INDICATES PEAK FORMATION (DOUBLING).
2) ASSUMES AN ENVIRONMENTAL EXPOSURE PERIOD OF 30 YEARS FOR PENTA- AND HIGHER CONGENERS, AND 23 YEARS FOR TETRA- AND LOWER CONGENERS.
3) CONCENTRATIONS EXPRESSED AS WEIGHT % OF TOTAL PCBS PRESENT.
4) IN CASES WHERE A CONGENER WAS NOT DETECTED IN THE SAMPLE YET WAS PRESENT IN THE AROCLOR MIXTURE, THE SAMPLE WAS ASSIGNED A VALUE OF 0.01 FOR CALCULATION PURPOSES. LIKEWISE FOR CASES WHERE THE CONGENER WAS PRESENT IN THE SAMPLE AND NOT IN THE AROCLOR.

TABLE 8.

HALF-LOSS DATA AND DECHLORINATION RATE CONSTANTS FOR PCB CONGENERS
SELECTED SAMPLES EXHIBITING EARLY TO MODERATE DECHLORINATION

DB-5 PEAK #	SAMPLE ID NBH 111-01 (JJ 1007) (C)	A1242+ A1254 (Co)	# OF HALF-LOSSES	HALF-LOSS t1/2(yrs)	RATE CONSTANT k(yrs-1)	% REMOVED/ FORMED	DB-5 PEAK #	SAMPLE ID NBH 112-02 (JJ 1008) (C)	A1242+ A1254 (Co)	# OF HALF-LOSSES	HALF-LOSS t1/2(yrs)	RATE CONSTANT k(yrs-1)	% REMOVED/ FORMED
63	0.01	0.61	5.92	5.07	0.137	98.3 R	61'	0.01	0.12	3.61	6.37	0.109	91.8 R
95	0.01	0.46	5.53	5.42	0.128	97.8 R	20	0.01	0.06	2.61	8.81	0.079	83.6 R
80	0.01	0.17	4.05	7.41	0.094	93.9 R	24'	0.01	0.05	2.45	9.39	0.074	81.7 R
83	0.01	0.15	3.89	7.71	0.090	93.3 R	22	0.24	0.34	0.51	45.10	0.015	29.7 R
72'	0.01	0.09	3.23	9.29	0.075	89.3 R	31	4.20	5.94	0.50	46.00	0.015	29.3 R
61'	0.01	0.09	3.17	7.26	0.096	88.9 R	83	0.08	0.11	0.40	75.00	0.009	24.0 R
2	0.03	0.26	3.10	7.42	0.093	88.3 R	47	3.95	5.18	0.39	58.97	0.012	23.7 R
24'	0.01	0.08	2.95	7.80	0.089	87.0 R	106	0.06	0.08	0.38	78.95	0.009	23.1 R
77	0.07	0.48	2.77	10.83	0.064	85.4 R	95	0.26	0.33	0.33	90.91	0.008	20.6 R
74'	0.27	1.71	2.66	11.28	0.061	84.2 R	24	3.68	4.58	0.31	74.19	0.009	19.6 R
59	0.11	0.54	2.29	13.10	0.053	79.6 R	89	0.43	0.52	0.28	107.14	0.006	17.7 R
74	0.21	0.98	2.22	13.51	0.051	78.6 R	25	3.17	3.82	0.27	85.19	0.008	17.1 R
20	0.01	0.05	2.17	10.60	0.065	77.8 R	15	0.99	1.19	0.26	88.46	0.008	16.8 R
4	0.01	0.05	2.17	10.60	0.065	77.8 R	82	2.53	3.03	0.26	115.38	0.006	16.4 R
58	0.53	2.32	2.13	14.08	0.049	77.2 R	27	0.40	0.47	0.23	100.00	0.007	14.8 R
93	0.01	0.04	1.95	15.38	0.045	74.0 R	26	1.66	1.94	0.22	104.55	0.007	14.4 R
89	0.22	0.74	1.74	17.24	0.040	70.2 R	23	4.93	5.74	0.22	104.55	0.007	14.1 R
106	0.04	0.11	1.46	20.55	0.034	63.6 R	37	2.69	3.08	0.19	121.05	0.006	12.6 R
6	0.17	0.40	1.22	18.85	0.037	57.1 R	8	4.87	5.52	0.18	127.78	0.005	11.8 R
5	0.53	1.16	1.13	20.35	0.034	54.2 R	48	2.83	3.14	0.15	153.33	0.005	10.0 R
82	2.01	4.27	1.09	27.52	0.025	52.9 R	5	1.42	1.57	0.14	164.29	0.004	9.4 R
79	0.10	0.20	0.99	30.30	0.023	49.5 R	33	1.34	1.44	0.10	230.00	0.003	6.8 R
37	3.01	5.25	0.80	28.75	0.024	42.7 R	63	0.40	0.43	0.10	300.00	0.002	6.8 R
50	1.06	1.82	0.78	29.49	0.024	41.8 R	14	3.95	4.22	0.09	255.56	0.003	6.3 R
8	2.43	4.07	0.75	30.67	0.023	40.3 R	102	0.14	0.15	0.08	375.00	0.002	5.5 R
47	3.47	5.42	0.64	35.94	0.019	36.0 R	2	0.33	0.35	0.08	287.50	0.002	5.1 R
15'	0.71	1.05	0.56	41.07	0.017	32.3 R	16	0.32	0.34	0.07	328.57	0.002	4.6 R
25	1.95	2.82	0.53	43.40	0.016	30.9 R	38'	1.04	1.09	0.06	383.33	0.002	4.2 R
38'	0.63	0.80	0.35	65.71	0.011	21.4 R	39	2.95	3.06	0.05	460.00	0.002	3.6 R
65	0.28	0.35	0.33	90.91	0.008	20.5 R	77	0.33	0.34	0.04	750.00	0.001	2.7 R
26	1.27	1.43	0.17	135.29	0.005	11.3 R	74	0.68	0.69	0.03	1000.00	0.001	2.0 R
27	0.31	0.35	0.16	143.75	0.005	10.5 R	58	1.73	1.75	0.02	1500.00	0.0005	1.1 R
23	3.80	4.23	0.16	143.75	0.005	10.3 R	12	0.01	0.01	0.00			0.0
46	1.70	1.84	0.12	191.67	0.004	7.8 R	94	0.01	0.01	0.00			0.0

NOTES: 1) A NEGATIVE VALUE FOR # OF HALF-LOSSES INDICATES PEAK FORMATION (DOUBLING).
2) ASSUMES AN ENVIRONMENTAL EXPOSURE PERIOD OF 30 YEARS FOR PENTA- AND HIGHER CONGENERS, AND 23 YEARS FOR TETRA- AND LOWER CONGENERS.
3) CONCENTRATIONS EXPRESSED AS WEIGHT % OF TOTAL PCBS PRESENT.
4) IN CASES WHERE A CONGENER WAS NOT DETECTED IN THE SAMPLE YET WAS PRESENT IN THE AROCLOR MIXTURE, THE SAMPLE WAS ASSIGNED A VALUE OF 0.01 FOR CALCULATION PURPOSES. LIKEWISE FOR CASES WHERE THE CONGENER WAS PRESENT IN THE SAMPLE AND NOT IN THE AROCLOR.

TABLE 8 (cont.)

HALF-LOSS DATA AND DECHLORINATION RATE CONSTANTS FOR PCB CONGENERS
SELECTED SAMPLES EXHIBITING EARLY TO MODERATE DECHLORINATION

DB-5 PEAK #	SAMPLE ID NBH 111-01 (JJ 1007) (C)	A1242+ A1254 (Co)	# OF HALF-LOSSES	HALF-LOSS t1/2(yrs)	RATE CONSTANT k(yrs-1)	% REMOVED/ FORMED
69'	4.49	4.64	0.05	600.00	0.001	3.3 R
15	0.85	0.88	0.05	460.00	0.002	3.1 R
10	0.22	0.22	0.003	7666.67	0.0001	0.2 R
44	0.01	0.01	0.00			0.0
102	0.21	0.209	-0.01			0.5 F
31	6.88	6.68	-0.04			3.0 F
61	6.12	5.80	-0.08			5.5 F
14	3.33	3.11	-0.10			7.1 F
17	1.85	1.71	-0.11			7.9 F
53	6.02	5.52	-0.12			9.0 F
57	1.32	1.18	-0.17			12.2 F
39	2.85	2.54	-0.17			12.4 F
16	0.28	0.25	-0.18			13.1 F
60	0.50	0.44	-0.18			13.6 F
48'	3.74	3.29	-0.19			13.7 F
24	3.91	3.38	-0.21			15.9 F
69	2.48	2.13	-0.22			16.5 F
73'	0.40	0.34	-0.23			17.3 F
75	2.80	2.31	-0.28			21.2 F
25'	0.41	0.34	-0.28			21.7 F
67	0.31	0.24	-0.36			28.1 F
51	0.79	0.61	-0.38			30.6 F
64	0.40	0.30	-0.40			32.2 F
56	0.20	0.14	-0.48			39.9 F
48	3.91	2.77	-0.50			41.3 F
7	1.06	0.73	-0.54			45.4 F
71	0.18	0.12	-0.64			55.8 F
1	0.01	0.005	-1.15			122 F
33	2.53	1.08	-1.22			133 F
38	1.38	0.56	-1.30			145 F
54	3.91	1.55	-1.33			152 F
42	0.44	0.17	-1.36			157 F
32	5.60	2.15	-1.38			160 F
13	0.31	0.12	-1.41			165 F

DB-5 PEAK #	SAMPLE ID NBH 112-02 (JJ 1008) (C)	A1242+ A1254 (Co)	# OF HALF-LOSSES	HALF-LOSS t1/2(yrs)	RATE CONSTANT k(yrs-1)	% REMOVED/ FORMED
19	0.01	0.01	0.00			0.0
74'	1.27	1.26	-0.01			0.6 F
7	1.01	0.99	-0.03			2.2 F
32	2.44	2.38	-0.04			2.5 F
80	0.10	0.10	-0.04			2.6 F
38	0.79	0.76	-0.05			3.6 F
10	0.31	0.30	-0.05			3.7 F
17	2.42	2.32	-0.06			4.1 F
6	0.56	0.54	-0.06			4.3 F
50	2.31	2.20	-0.07			5.0 F
25'	0.47	0.44	-0.09			6.2 F
85	0.05	0.05	-0.10			6.8 F
75	1.77	1.64	-0.11			8.1 F
21	0.93	0.85	-0.13			9.7 F
69'	3.85	3.40	-0.18			13.2 F
15'	1.61	1.42	-0.18			13.3 F
69	1.80	1.51	-0.25			19.3 F
46	2.47	2.07	-0.25			19.3 F
61	5.13	4.27	-0.26			20.0 F
72'	0.08	0.07	-0.27			20.7 F
64	0.30	0.21	-0.48			39.9 F
65	0.35	0.25	-0.49			40.2 F
60	0.44	0.31	-0.50			41.0 F
53	5.79	4.06	-0.51			42.5 F
93	0.04	0.03	-0.55			46.5 F
48'	3.58	2.41	-0.57			48.5 F
57	1.34	0.87	-0.63			54.2 F
73'	0.38	0.24	-0.65			57.2 F
79	0.19	0.12	-0.70			62.4 F
13	0.26	0.16	-0.71			63.9 F
42	0.38	0.23	-0.71			63.9 F
51	0.75	0.43	-0.81			74.8 F
54	2.09	1.14	-0.87			83.3 F
56	0.19	0.10	-0.91			87.4 F

NOTES: 1) A NEGATIVE VALUE FOR # OF HALF-LOSSES INDICATES PEAK FORMATION (DOUBLING).
2) ASSUMES AN ENVIRONMENTAL EXPOSURE PERIOD OF 30 YEARS FOR PENTA- AND HIGHER CONGENERS, AND 23 YEARS FOR TETRA- AND LOWER CONGENERS.
3) CONCENTRATIONS EXPRESSED AS WEIGHT % OF TOTAL PCBS PRESENT.
4) IN CASES WHERE A CONGENER WAS NOT DETECTED IN THE SAMPLE YET WAS PRESENT IN THE AROCLOR MIXTURE, THE SAMPLE WAS ASSIGNED A VALUE OF 0.01 FOR CALCULATION PURPOSES. LIKEWISE FOR CASES WHERE THE CONGENER WAS PRESENT IN THE SAMPLE AND NOT IN THE AROCLOR.

TABLE 8 (cont.)

HALF-LOSS DATA AND DECHLORINATION RATE CONSTANTS FOR PCB CONGENERS
SELECTED SAMPLES EXHIBITING EARLY TO MODERATE DECHLORINATION

DB-5 PEAK #	SAMPLE ID NBH 111-01 (JJ 1007) (C)	A1242+ A1254 (Co)	# OF HALF-LOSSES	HALF-LOSS t1/2(yrs)	RATE CONSTANT k(yrs-1)	% REMOVED/ FORMED
85	0.18	0.07	-1.45			173 F
21	2.11	0.63	-1.75			237 F
49	1.48	0.39	-1.92			278 F
22	1.00	0.25	-1.99			297 F
44'	0.22	0.01	-4.46			2100 F
55	0.44	0.01	-5.46			4300 F
19	<0.01	<0.01				
26'	<0.01	<0.01				
88	<0.01	<0.01				
99	<0.01	<0.01				
91	<0.01	<0.01				
3	<0.01	<0.01				
41	<0.01	<0.01				
12	<0.01	<0.01				
78	<0.01	<0.01				
56'	<0.01	<0.01				
110	<0.01	<0.01				
94	<0.01	<0.01				
95'	<0.01	<0.01				
109	<0.01	<0.01				
55'	<0.01	<0.01				

DB-5 PEAK #	SAMPLE ID NBH 112-02 (JJ 1008) (C)	A1242+ A1254 (Co)	# OF HALF-LOSSES	HALF-LOSS t1/2(yrs)	RATE CONSTANT k(yrs-1)	% REMOVED/ FORMED
4	0.12	0.06	-0.98			96.7 F
59	0.86	0.38	-1.17			125 F
71	0.19	0.08	-1.21			132 F
67	0.40	0.17	-1.22			133 F
49	0.70	0.29	-1.27			142 F
3	0.03	0.01	-1.59			200 F
44	0.06	0.01	-2.59			500 F
41	0.09	0.01	-3.17			800 F
55	0.45	0.01	-5.49			4400 F
1	1.64	0.01	-8.07			26785 F
78	<0.01	<0.01				
99	<0.01	<0.01				
26'	<0.01	<0.01				
95'	<0.01	<0.01				
91	<0.01	<0.01				
88	<0.01	<0.01				
44'	<0.01	<0.01				
56'	<0.01	<0.01				
55'	<0.01	<0.01				
109	<0.01	<0.01				
110	<0.01	<0.01				

NOTES: 1) A NEGATIVE VALUE FOR # OF HALF-LOSSES INDICATES PEAK FORMATION (DOUBLING).
2) ASSUMES AN ENVIRONMENTAL EXPOSURE PERIOD OF 30 YEARS FOR PENTA- AND HIGHER CONGENERS, AND 23 YEARS FOR TETRA- AND LOWER CONGENERS.
3) CONCENTRATIONS EXPRESSED AS WEIGHT % OF TOTAL PCBS PRESENT.
4) IN CASES WHERE A CONGENER WAS NOT DETECTED IN THE SAMPLE YET WAS PRESENT IN THE AROCLOR MIXTURE, THE SAMPLE WAS ASSIGNED A VALUE OF 0.01 FOR CALCULATION PURPOSES. LIKEWISE FOR CASES WHERE THE CONGENER WAS PRESENT IN THE SAMPLE AND NOT IN THE AROCLOR.

TABLE 9.

PCB CONGENERS WITH SPECIAL PHARMACOLOGICAL SIGNIFICANCE IN NBH SAMPLES
EXHIBITING EARLY AND ADVANCED STAGES OF DECHLORINATION

BZ #	CHLORINE SUBSTITUTION PATTERN	COMPOSITION IN AROCLOR (AS WEIGHT PERCENTAGE, %)		COMPOSITION IN SAMPLE (AS WEIGHT PERCENTAGE OF TOTAL PCBs PRESENT)		DECHLORINATION HALF-LOSSES	
		1254	1242	NBH 112-02 (JJ 1008) EARLY	NBH 105/106 (JJ 1004/5) ADVANCED	NBH 112-02 (JJ 1008) EARLY	NBH 105/106 (JJ 1004/5) ADVANCED
37	3,4,4'-	<0.01	1.78	1.04	0.11	0.06	3.42
77	3,3',4,4'-	<0.01	0.20	0.01	<0.01	3.61	3.72
81	3,4,4',5-	<0.01	<0.01	<0.01	<0.01	ND	ND
105	2,3,3'4,4'-	2.97	0.17	1.27	<0.01	-0.01	6.81
114	2,3,4,4',5-	<0.01	<0.01	<0.01	<0.01	ND	ND
118	2,3',4,4',5-	8.14	0.37	3.85	0.85	-0.18	1.82
123	2',3,4,4',5-	<0.01	<0.01	<0.01	<0.01	ND	ND
126	3,3',4,4',5-	<0.01	<0.01	<0.01	<0.01	ND	ND
156	2,3,3',4,4',5-	0.84	<0.01	0.26	<0.01	0.33	4.86
157	2,3,3',4,4',5'-	<0.01	<0.01	<0.01	<0.01	ND	ND
167	2,3',4,4',5,5'-	<0.01	<0.01	<0.01	<0.01	ND	ND
169	3,3',4,4',5,5'-	<0.01	<0.01	<0.01	<0.01	ND	ND
189	2,3,3',4,4',5,5'-	<0.01	<0.01	<0.01	<0.01	ND	ND

NOTES: 1) A NEGATIVE HALF-LOSS VALUE INDICATES PEAK FORMATION (DOUBLING).
2) THE ANALYSIS LIMIT IS 0.01% OF THE TOTAL PCBs PRESENT IN THE SAMPLE.

TABLE 10.

COMPARISON OF DECHLORINATION LOSSES BETWEEN NBH SEDIMENTS EXHIBITING EARLY AND ADVANCED DECHLORINATION LOSSES FOR NON-ORTHO (CO-PLANAR) CONGENERS.

		CONC. IN SAMPLE (PPM)		% OF TOTAL PCBS		% OF TOTAL PCBS		# OF HALF-LOSSES	
BZ #	CHLORINE SUBSTITUTION PATTERN	JJ 1004/5 ADVANCED	JJ 1008 EARLY	JJ 1004/5 ADVANCED	JJ 1008 EARLY	AROCLOR 1242	AROCLOR 1254	JJ 1004/5 ADVANCED	JJ 1008 EARLY
2	3-	ND(0.1)	14	<0.01	0.02	<0.01	<0.01	ND	-1.59
3	4-	ND(0.1)	66	<0.01	0.11	0.1	<0.01	>2.72	-0.98
11	3-3'-	2.3	7	0.26	0.01	<0.01	<0.01	-4.7	-0.01
12	3,4-								
		(11	(150	(1.26	(0.26	(0.16	(<0.01	-2.93	-0.71
13	3,4'-								
14	3,5-	ND(0.1)	ND(1)	<0.01	<0.01	<0.01	<0.01	ND	ND
15	4,4'-	6.9	910	0.29	1.57	2.33	<0.01	0.96	-0.18
35	3,3',4-	ND(0.1)	ND(1)	<0.01	<0.01	<0.01	<0.01	ND	ND
36	3,3',5-	ND(0.1)	ND(1)	<0.01	<0.01	<0.01	<0.01	ND	ND
37	3,4,4'-	0.94	580	0.11	1.00	1.77	<0.01	3.42	0.06
38	3,4,5-	ND(0.1)	ND(1)	<0.01	<0.01	0.18	<0.01	ND	ND
39	3,4',5-	ND(0.1)	ND(1)	<0.01	<0.01	<0.01	<0.01	ND	ND
77	3,3',4,4'-	ND(0.1)	3.5	<0.01	0.01	0.18	<0.01	3.72	3.61
78	3,3',4,5-	ND(0.1)	ND(1)	<0.01	<0.01	<0.01	<0.01	ND	ND
79	3,3',4,5'-	ND(0.1)	ND(1)	<0.01	<0.01	<0.01	<0.01	ND	ND
80	3,3',5,5'-	* (<4.6)	* (<1600)	* (<0.53)	* (<2.76)	* (<4.06)	* (<1.71)	2.62	0.19
81	3,4,4',5-	ND(0.1)	ND(1)	<0.01	<0.01	<0.01	<0.01	ND	ND
126	3,3',4,4',5-	ND(0.1)	ND(1)	<0.01	<0.01	<0.01	<0.01	ND	ND
127	3,3',4,5,5'-	ND(0.1)	ND(1)	<0.01	<0.01	<0.01	<0.01	ND	ND
169	3,3',4,4',5,5'-	ND(0.1)	ND(1)	<0.01	<0.01	<0.01	<0.01	ND	ND

NOTES: 1) ND(0.1) INDICATES CONGENER NOT DETECTED AT ANALYSIS LIMIT OF 0.1 PPM.
2) A NEGATIVE HALF-LOSS VALUE INDICATES PEAK FORMATION (DOUBLING).
3) * C80 CO-ELUTES WITH ANOTHER TETRACHLORO- ISOMER, C66, KNOWN TO BE PRESENT IN BOTH AROCLORS 1242 AND 1254. VALUE IN ( ) IS VALUE FOR BOTH C80, IF PRESENT, PLUS C66.
4) (INDICATES SUM OF BZ 12 AND 13 WHICH CO-ELUTE ON THE DB-5 COLUMN.

TABLE 11.

COMPARISON OF DECHLORINATION LOSSES BETWEEN NBH SEDIMENTS EXHIBITING EARLY AND ADVANCED DECHLORINATION LOSSES FOR MONO-ORTHO CONGENERS

BZ #	CHLORINE SUBSTITUTION PATTERN	CONC. IN SAMPLE (PPM) JJ 1004/5 ADVANCED	CONC. IN SAMPLE (PPM) JJ 1008 EARLY	% OF TOTAL PCBS JJ 1004/5 ADVANCED	% OF TOTAL PCBS JJ 1008 EARLY	% OF TOTAL PCBS AROCLOR 1242	% OF TOTAL PCBS AROCLOR 1254	# OF HALF-LOSSES JJ 1004/5 ADVANCED	# OF HALF-LOSSES JJ 1008 EARLY
1	2-	0.04	190	0.05	0.03	0.57	<0.01	2.91	0.08
7	2,4-								
		(2.3	(310	(0.26	(0.56	(0.88	(<0.01	(1.16	(-0.06
9	2,5-								
6	2,3'-	40	570	4.63	1.01	1.62	<0.01	-2.11	-0.03
8	2,4'-								
		(36	(2750	(4.17	(4.87	(9.05	<0.01	0.52	0.18
5	2,3-								
23	2,3,5-	ND(0.1)	ND(1.0)	<0.01	<0.01	<0.01	<0.01	ND	ND
34	2',3,5-	0.1	ND(1.0)	0.01	<0.01	<0.01	<0.01	-0.01	-0.01
29	2,4,5-	ND(0.1)	ND(1.0)	<0.01	<0.01	0.1	<0.01	2.72	2.61
26	2,3',5-	74	520	8.74	0.93	1.39	<0.01	-3.21	-0.13
25	2,3',4-	20	140	3.25	0.24	0.56	<0.01	-3.14	0.51
31	2,4',5-	58	2780	6.65	4.93	9.41	<0.01	-0.1	0.22
28	2,4,4'-	46	2080	5.33	3.68	7.5	<0.01	-0.11	0.31
21	2,3,4-	ND(0.1)	ND(1.0)	<0.01	<0.01	<0.01	<0.01	ND	ND
33	2',3,4-								
		(1.5	(1790	(0.17	(3.17	(6.27	(<0.01	4.61	0.27
20	2,3,3'-								
22	2,3,4'-	3.2	940	0.36	1.66	3.18	<0.01	2.54	0.22
72	2,3',5,5'-	SEE NOTE 4)							

NOTES: 1) ND(0.1) INDICATES CONGENER NOT DETECTED AT ANALYSIS LIMIT OF 0.1 PPM.
2) A NEGATIVE HALF-LOSS VALUE INDICATES PEAK FORMATION (DOUBLING).
3) (INDICATES SUM OF TWO CONGENERS WHICH CO-ELUTE ON THE DB-5 COLUMN.
4) CORRESPONDS TO FOUR CO-ELUTING AND/OR UNRESOLVED TETRACHLORO-PCB ISOMERS. ACCORDING TO SCHLUZ et. al., C72 IS NOT PRESENT IN AROCLOR 1242 OR 1254. TRANSFORMATION REACTIONS: 2,2',3'5- (C72) GOES TO 2,3',5- (C26) AND 2',3,5- (C34), C26 WAS COMPLETELY REMOVED, C34 DETECTED IN ONE SAMPLE.

TABLE 11 (cont.)

COMPARISON OF DECHLORINATION LOSSES BETWEEN NBH SEDIMENTS EXHIBITING EARLY AND ADVANCED DECHLORINATION LOSSES FOR MONO-ORTHO CONGENERS

BZ #	CHLORINE SUBSTITUTION PATTERN	CONC. IN SAMPLE (PPM) JJ 1004/5 ADVANCED	CONC. IN SAMPLE (PPM) JJ 1008 EARLY	% OF TOTAL PCBS JJ 1004/5 ADVANCED	% OF TOTAL PCBS JJ 1008 EARLY	% OF TOTAL PCBS AROCLOR 1242	% OF TOTAL PCBS AROCLOR 1254	# OF HALF-LOSSES JJ 1004/5 ADVANCED	# OF HALF-LOSSES JJ 1008 EARLY
68	2,3',4,5'-	ND(0.1)	ND(1.0)	<0.01	<0.01	<0.01	<0.01	ND	ND
57	2,3,3',5-	ND(0.1)	ND(1.0)	<0.01	<0.01	<0.01	<0.01	ND	ND
67	2,3',4,5-	TR(0.1)	ND(1.0)	>0.01	<0.01	<0.01	<0.01	-0.01	ND
58	2,3,3',5-	ND(0.1)	ND(1.0)	<0.01	<0.01	<0.01	<0.01	ND	ND
63	2,3,4',5-	ND(0.1)	ND(1.0)	<0.01	<0.01	<0.01	<0.01	ND	ND
61	2,3,4,5-	ND(0.1)	ND(1.0)	<0.01	<0.01	<0.01	<0.01	ND	ND
74	2,4,4',5-	3.5	1390	0.4	2.47	2.62	1.21	2.42	-0.25
70	2,3',4',5-	2.4	2230	0.27	3.95	4.59	6.1	4.24	0.39
76	2',3,4,5-	ND(0.1)	ND(1.0)	<0.01	<0.01	<0.01	<0.01	ND	ND
66	2,3',4,4'-	4.6	1600	0.53	2.83	4.06	1.71	2.62	0.15
55	2,3,3',4-	ND(0.1)	ND(1.0)	<0.01	<0.01	<0.01	<0.01	ND	ND
56	2,3,3',4'-								
		< ND(0.1)	< 1300	< <0.01	< 2.31	< 3.12	< 0.76	< 7.86	< -0.07
60	2,3,4,4'-								
111	2,3,3',5,5'-	ND(0.1)	ND(1.0)	<0.01	<0.01	<0.01	<0.01	ND	ND
120	2,3',4,5,5'-	ND(0.1)	ND(1.0)	<0.01	<0.01	<0.01	<0.01	ND	ND
124	2',3,4,5,5'-	ND(0.1)	ND(1.0)	<0.01	<0.01	<0.01	<0.01	ND	ND
108	2,3,3',4,5'-	ND(0.1)	ND(1.0)	<0.01	<0.01	<0.01	<0.01	ND	ND
107	2,3,3',4',5-	ND(0.1)	230	<0.01	0.40	<0.01	0.44	3.9	-1.22

NOTES: 1) ND(0.1) INDICATES CONGENER NOT DETECTED AT ANALYSIS LIMIT OF 0.1 PPM.
2) A NEGATIVE HALF-LOSS VALUE INDICATES PEAK FORMATION (DOUBLING).
3) < INDICATES SUM OF TWO CONGENERS WHICH CO-ELUTE ON THE DB-5 COLUMN.
4) TR(0.1) INDICATES TRACE CONCENTRATION DETECTED BELOW 0.1 PPM DETECTION LIMIT.

TABLE 11 (cont.)

COMPARISON OF DECHLORINATION LOSSES BETWEEN NBH SEDIMENTS EXHIBITING EARLY AND ADVANCED DECHLORINATION LOSSES FOR MONO-ORTHO CONGENERS

BZ #	CHLORINE SUBSTITUTION PATTERN	CONC. IN SAMPLE (PPM) JJ 1004/5 ADVANCED	CONC. IN SAMPLE (PPM) JJ 1008 EARLY	% OF TOTAL PCBS JJ 1004/5 ADVANCED	% OF TOTAL PCBS JJ 1008 EARLY	% OF TOTAL PCBS AROCLOR 1242	% OF TOTAL PCBS AROCLOR 1254	# OF HALF-LOSSES JJ 1004/5 ADVANCED	# OF HALF-LOSSES JJ 1008 EARLY
123	2',3,4,4',5-	ND(0.1)	ND(1.0)	<0.01	<0.01	<0.01	<0.01	ND	ND
106	2,3,3',4,5-	ND(0.1)	ND(1.0)	<0.01	<0.01	<0.01	<0.01	ND	ND
118	2,3',4,4',5-	7.4	2170	0.85	3.85	0.37	8.14	1.82	-0.18
114	2,3,4,4',5-	ND(0.1)	ND(1.0)	<0.01	<0.01	<0.01	<0.01	ND	ND
122	2',3,3',4,5-	ND(0.1)	49	<0.01	0.08	<0.01	0.17	2.53	-0.27
105	2,3,3',4,4'-	ND(0.1)	720	<0.01	1.27	0.17	2.97	6.81	-0.01
159	2,3,3',4,5,5'-	ND(0.1)	ND(1.0)	<0.01	<0.01	<0.01	<0.01	ND	ND
162	2,3,3',4',5,5'-	ND(0.1)	ND(1.0)	<0.01	<0.01	<0.01	<0.01	ND	ND
167	2,3',4,4',5,5'-	ND(0.1)	ND(1.0)	<0.01	<0.01	<0.01	<0.01	ND	ND
156	2,3,3',4,4',5-	ND(0.1)	150	<0.01	0.26	<0.01	0.84	4.86	0.33
157	2,3,3',4,4',5'-	ND(0.1)	ND(1.0)	<0.01	<0.01	<0.01	<0.01	ND	ND
189	2,3,3',4,4',5,5'-	ND(0.1)	ND(1.0)	<0.01	<0.01	<0.01	<0.01	ND	ND

NOTES: 1) ND(0.1) INDICATES CONGENER NOT DETECTED AT ANALYSIS LIMIT OF 0.1 PPM.
2) A NEGATIVE HALF-LOSS VALUE INDICATES PEAK FORMATION (DOUBLING).

Volume VI of RFAS

Table 2
Occupational PCB Exposures

Study	PCB Mixtures Used at Facility	Comments and Measured Air Concentrations
Ouw et al., 1976	Aroclor 1242	The initial 1974 air concentrations of the capacitor impregnation room were measured in 4 different areas. The reported levels were: 320, 1080, 1440 and 2220 jug/m3.
Fischbein et al.,	Aroclors 1254, 1242, 1221 & 1016	The air concentrations of the capacitor manufacturing workers were divided into four categories: none (0-70 ug/m3), low (71-410 ug/m3), medium (411-600 ug/m3), and high (600-11,000 ug/m3).
Maroni et al., 1981a	French and Italian PCB mixtures of 54% and 42% chlorine content	Plant A workroom air concentrations were measured as: an average of 154 ug/m3 (with a range of 80-255) in areas where high power capacitors were made; an average of 193 ug/m3 (with a range of 149-275) for areas of low power capacitor assembly; and an average of 59 ug/m3 (with a range of 49-70) in the filter department.
Smith et al., 1982	Aroclors 1242 & 1016	The air concentrations at a capacitor manufacturing plant were measured in the capacitor processing and maintenance areas and found to average 81 ug/m3 (with a range of 0-264).

Table 2 (continued)

Study	PCB Mixtures Used at Facility	Comments and Measured Air Concentrations
Lawton et al., 1985	Aroclors 1254, 1242 & 1016	The authors reported that earlier workroom air concentrations were at least the 690 ug/m3 measured in 1976 at these two capacitor plants.
Fischbein, 1985	Aroclors 1254, 1242, 1016 & 1221	This apparent second reporting of the population previously discussed in 1979 lists the mean air concentration as 7 ug/m3 in the lowest exposure area and 410 ug/m3 in the equipment and quality control areas, while levels of 900 and 11,000 ug/m3 were measured in the areas where the capacitors were filled and washed.
Smith and Brown, 1986	PCB mixtures not specified	The mean air concentrations taken from personal monitoring samples were 154 ug/m3 for capacitor repairmen, 147 ug/m3 for the solderer/hanger, and 127 ug/m3 in the miscellaneous assembly areas.
Smith and Brown, 1986	Primarily Aroclors 1254, 1242,1016	Air measurements taken in the mid to late 1970's ranged from 161-1260 ug/m3 in the capacitor impregnation rooms of two small capacitor plants while the maintenance area was reported to be 150 ug/m3. In a larger capacitor plant the impregnation rooms ranged from 50-299 ug/m3.

Volume VII of RFAS

VII ECOLOGICAL IMPACT

BACKGROUND PCB CONCENTRATIONS

1. Attachment Q.VII.001A is a true and accurate copy of an article entitled "A Study of the Distribution of Polychlorinated Biphenyls in the Aquatic Environment." The article is coauthored by Hans J. Crump-Wiesner, Herman R. Feltz, and Marvin L. Yates and was published in the professional journal, Pesticides Monitoring Journal, Volume 8, No. 3, 1974.

2. The Crump-Wiesner et al. (1974) study is based upon PCB data collected from the National Monitoring Program discussed in the report performed in January 1971 and subsequent analyses performed in 1973 and 1974.

3. Many of the locations selected for analysis were based upon a U.S. Geological Survey benchmark network which provides basic data on selected stream basins throughout the United States.

4. Many of the U. S. Geological Survey locations selected for analysis were originally chosen to ensure minimum interference by humans.

5. Many of the U.S. Geological Survey locations selected for analysis were originally chosen in state parks, national forests, and areas set aside for scientific study.

6. Data presented in the Crump-Wiesner et al. (1974) report indicate that significant concentrations of PCBs are widespread in the nation's water resources.

7. Preliminary data presented in the Crump-Wiesner et al., (1974) report indicate that, in unfiltered water samples collected from 12 of 35 states in the study, PCB concentrations ranged from 0.1 to 4.0 micrograms per liter or parts per billion (ppb).

8. Preliminary data presented in the Crump-Wiesner et al., (1974) report indicate that significant concentrations in sediments of PCBs are indicated in sediments from areas generally located away from industrial centers.

9. Preliminary data presented in the Crump-Wiesner et

al., (1974) report indicate that in 13 of 16 states surveyed, PCB concentrations in sediments ranged from 5.0 to 2,400 micrograms per kilogram or parts per billion (ppb).

10. Attachment Q.VII.0001 is a true and accurate copy of an article entitled "Toxic Contaminants in Rainfall in Canada: 1984" authored by William M. J. Strachan and published in the professional journal, Environmental Toxicology and Chemistry, Volume 7, pages 871 - 877, 1988.

11. In the Strachan (1988) report, triplicate rain samples were collected from Caribou Island in eastern Lake Superior, Agawa Bay in Lake Superior Provincial Park, the Cree Lake Research Station in northern Saskatchewan and Kouchibouguac National Park in New Brunswick.

12. In Table 5 of the Strachan (1988) report, total PCB concentrations in rainfall were reported at ranges of 1.7 to 23.0 nanograms per liter (ng/l or ppt) in various locations near Lake Superior, 1.1 ng/l in Kouchibouguac National Park and 3.1 ng/l (or ppt) in Cree Lake Research Station.

13. Attachment Q.VII.0002 is a true and accurate copy of the article entitled "Evidence of Deposition of Anthropogenic Pollutants in Remote Rocky Mountain Lakes", coauthored by Merrill Heit, Catherine Klusek, and Jill Baron, published in the professional journal, Water, Air and Soil Pollution, Volume 22, pages 403 - 416, 1984.

14. In the study by Heit, et al., (1984), sediment samples were collected from four high altitude lakes in Rocky Mountain National Park during 1981.

15. The four high altitude Rocky Mountain lakes in the Heit, et al., (1984) study included Lake Louise, Lake Husted, Lake Haiyaha, and The Loch.

16. Lake Louise, Lake Hustad, Lake Haiyaha, and The Loch are not directly affected by any point sources of pollution such as the presence of dwellings, sewage, or roads.

17. Table 3 in the Heit, et al., (1984) report indicates mean total PCB concentrations in surface sediments of 310 nanograms per gram or parts per billion (ppb) in Lake Louise, 540 ppb in Lake Husted, 160 ppb in Lake Haiyaha, and 98 ppb in The Loch.

18. Evidence is presented in the Heit, et al., (1984) paper which indicates that remote high altitude lakes in the Rocky Mountain National Park have received inputs of anthropogenic pollutants such as PCBs.

19. The levels of PCBs in surface sediments of the four lakes studied in the Heit, et al., (1984) report are typical of values reported elsewhere in the literature for other remote lakes and rural aquatic systems.

20. Surface sediment sample analyses performed as part of the Heit, et al., (1984) study were based on composite samples collected from several cores within each lake from the top 2 centimeters of the sediments.

21. Attachment Q.VII.0003 is a true and accurate copy of an article entitled "PCBs and Chlorinated Hydrocarbon Pesticides in Antarctic Atmosphere and Hydrosphere," coauthored by Shinsuke Tanabe, Hideo Hidaka and Ryo Tatsukawa, and published in the professional journal, Chemosphere, Volume 12, No. 2, pages 277 - 288, 1983.

22. PCBs were measured in air, water, ice, and snow samples collected in the vicinity of the Japanese Research Stations in Antarctica and in adjacent oceans during December 1980 to March 1982 in the Tanabe, et al., (1983) study.

23. Cross contamination from sampling equipment, glassware absorbents, and solvents were checked preliminarily and were found to be negligible.

24. Data shown in Table 2 of the Tanabe, et al., (1983) study indicate that PCBs were detected in the vicinity of Antarctica at concentrations ranging from 160 to 1,000 picograms per liter (i.e., 0.16 to 1.0 nanograms per liter or ppt) in snow pack samples, 52 to 72 picograms per liter (i.e., 0.52 to 0.72 ppt) in seawater samples, 310 to 610 picograms per liter (i.e., 0.31 to 0.61 ppt) in ice samples, and 48 picograms per liter (i.e., 0.048 ppt) in lake water samples.

25. Significant differences were not found between PCB concentrations detected in samples of surficial snow and deep snow in the Tanabe, et al., (1983) study.

26. The fact that significant differences were not detected between PCB concentrations detected in samples of surficial snow and deep snow suggests that a steady load of PCBs has been transported to Antarctica over the period the sample snow pack was deposited (Tanabe, et al., 1983).

27. Significant concentrations of PCBs have been found in air samples collected from the Antarctic Ocean which suggest the aerial transport of PCBs to Antarctica.

28. Attachment Q.VII.0004 is a true and accurate copy of the paper, "Chlorinated Hydrocarbons in the North Pacific and Indian Oceans," coauthored by Shinsuke Tanabe and Ryo Tatsukawa, and published in the professional journal, Journal of the Oceanograpical Society of Japan, Volume 36, pages 217-226, 1980.

29. PCB concentrations detected in the surface water of the North Pacific and Indian Oceans showed a uniform distribution within a range of 0.23 to 1.11 nanograms per liter (ng/l or ppt).

30. PCB concentrations detected in surface water samples from the North Pacific and Indian Oceans were less than concentrations previously reported for surface water samples from the Atlantic Ocean.

31. Table 2 in the Tanabe & Tatsukawa (1980) study is an accurate representation of PCB surface water sampling data from the North Pacific and Indian Oceans.

32. Attachment Q.VII.0005 is a true and accurate copy of "Evidence of Atmospheric Transport and Deposition of Organochlorine Pesticides and Polychlorinated Biphenyls in Canadian Arctic Snow", authored by Dennis J. Gregor and William D. Gummer, published in the professional journal, Environmental Science and Technology, Volume 23, No. 5, pages 561-565, 1989.

33. Snowpack samples representing snow accumulation for the winter of 1985/1986 were collected at a total of 12 sites widely distributed throughout the Northwest Territories, Canada during the Spring of 1986 in the Gregor and Gummer (1989) study.

34. Total PCB concentrations in snowpack samples from the Northwest Territories, Canada ranged from 0.02 to 1.76 nanograms per liter (ng/l or ppt), with most of the sample concentrations less than 1.0 ng/l (or ppt).

35. Table III in the Gregor and Gummer (1989) study is a true and accurate representation of PCB sampling results for snowpack samples from the Northwest Territories.

2. Figure 1 in the Gregor and Gummer (1989) study is an accurate depiction of the northwest territories

snowpack sampling sites.

3. PCB compounds, which cannot be explained by the presence of local sources, are present in Canadian Arctic snow at measurable concentrations.

4. Release of PCBs to the Arctic aquatic environment and biota, undoubtedly occurs at the time of snowmelt.

5. The only reasonable source for PCB compounds in the Canadian Arctic environment is long-range atmospheric transport.

36. Attachment Q.VII.0006 is a true and accurate copy of the paper "Chlorinated Hydrocarbons in the Sargasso Sea Atmosphere and Surface Water", coauthored by T. F. Bidleman and C. E. Olney, and published in the professional journal, Science, Volume 183, pages 516-518, 1974.

37. Seawater samples were collected from the Sargasso Sea near Bermuda in the Bidleman and Olney (1974) study.

38. Seawater samples of the surface microlayer collected from the Sargasso Sea were analyzed and found to contain total PCB concentrations of up to 19.3 nanograms per liter (ng/l or ppt).

39. Seawater samples collected from the subsurface were analyzed and found to contain total PCB concentrations of up to 3.6 nanograms per liter (ng/l or ppt).

40. Chromatograms from analysis of seawater samples from the Sargasso Sea resembled patterns in Aroclor 41.254 or Aroclor 1260.

42. Attachment Q.VII.0007 is a true and accurate copy of the article "Polychlorinated Biphenyls in Sediments of the Tidal Hudson River, New York, co-authored by Richard F. Bopp, H. James Simpson, Curtis R. Olsen, and Nadia Kostyk, and published in the professional journal, Environmental Science and Technology, Volume 15, No. 2, pages 210-216, 1981.

43. In the Bopp et. al., (1981) study, PCB concentrations in recent fine-grained sediment samples from a number of large rivers and estuaries were compared.

44. In the Bopp et. al., (1981) study, PCBs in surficial sediments from Chesapeake Bay were reported as 0.07 ppm for Aroclor 1242 and 0.09 ppm for Aroclor 1254.

45. In the Bopp et. al., (1981) study, PCBs in surficial sediments from the Delaware River were reported as 0.32 ppm for Aroclor 1242 and 0.14 ppm for Aroclor 1254.

46. In the Bopp et. al., (1981) study, PCBs in surficial sediments from the Columbia River, Oregon were reported as 0.06 ppm for Aroclor 1242 and 0.04 for Aroclor 1254.

47. In the Bopp et al., (1981) study, PCBs in surficial sediments from the Mohawk River in new York were reported as 0.38 ppm for Aroclor 1242 and 0.32 ppm for Aroclor 1254.

48. PCB concentrations of 20 nanograms per liter (ng/l or ppt) have been reported from surface water in the New York Bight, 15 kilometers from the mouth of the Hudson River.

49. The mean concentration of Aroclor 1242 in the Hudson River recent fine-grained sediments is approximately 10 ppm.

50. The Hudson River sediments are more contaminated than in other rivers and estuaries evaluated in the Bopp et. al., (1981) study.

51. Table 1 is a summary table entitled "Background PCB Concentrations", which summarizes information on background concentrations in various environmental media.

52. Table 1 accurately summarizes the information presented in the references listed thereon as to background concentrations in various environmental media.

53. Table 1 is admissible in evidence as a summary of the information presented in the references listed thereon in background concentrations in various environmental media.

The concentration in the drinking water in New Bedford, Massachusetts has been measured to be greater than 2 ppb.

54. Because of the widespread distribution of PCB throughout the world at levels greater than 0.79 parts per trillion, it is unrealistic to use that criterion as a goal for the PCB water column concentration in New Bedford Harbor.

HISTOPATHOLOGICAL CONDITIONS

55. Attachment Q.VII.0008 is a true and accurate copy of an article entitled "Epizootic Neoplasia in Soft Shell clams collected from New Bedford Harbor" and is genuine. This article is coauthored by Carol L. Reinisch, Ann M. Charles and Amy M. Stone, all of whom were employed by the Department of Comparative Medicine, Tufts University School of Veterinary Medicine, Boston, MA (hereafter, Reinisch et al., (1985).

56. Reinisch, et al., (1985) study on epizootic neoplasia is a professional journal article published in Hazardous Waste, Volume 1, Number 1, 1985.

57. The work described in Reinisch et al. (1985) was undertaken by the authors pursuant to contract No. NA-82-FA-C-00048 awarded by the National Marine Fisheries Service.

58. Reinisch, et al., (1985) study on Epizootic Neoplasia contains the following statements in the abstract: "Soft shell clams (Mya arenaria) were collected from tidal flats in southeastern New England, and their hemolymph analyzed for the presence of neoplastic cells. The prevalence of neoplasia varied from 10 through 90 percent with the highest prevalence found in New Bedford Harbor, a site containing high levels of pollutants, including PCBs, could be detected in neoplastic cell extract's derived only from clams collected from New Bedford Harbor. These studies suggest an association between the high prevalence of disease and the location of soft shell clams at or near an industrially contaminated site."

59. According to statements contained in the Reinisch et al. (1985) study, the two predominant types of neoplasms are gonadal and hematopoietic.

60. According to statements contained in the Reinisch et al. (1985) study, atypical hemocytes can be found in both the connective tissues and the hemolymph in hematopoietic neoplasm (Hn).

61. As stated in the Reinisch et al. (1985) study, a "leukemic" aspect of Hn disease is indicated by the presence of large, round anaplastic cells with numerous mitotic figures proliferating in the hemolymph.

62. The prevalence of Hn disease in clams collected from the Cape Cod, Massachusetts area is between 10.8 and 27.5 percent, as presented in the Reinisch et al. (1985) study.

63. According to the Reinisch et al. (1985) study, the prevalence of Hn disease approaches 90 percent in Mya arenaria collected from the New Bedford Harbor, Massachusetts area.

64. New Bedford Harbor, Massachusetts is a site that is heavily contaminated with many industrial pollutants as well as polychlorinated biphenyls (PCBs).

65. Mya arenaria used in the Reinisch et al. (1985) study were labeled and maintained at the Marine Biological Laboratory, Woods Hole, Massachusetts.

66. Mya arenaria used in the Reinisch et al. (1985) study were collected at selected tidal flats in coastal southeastern New England. Hemolymph samples used to assess neoplasia in the Reinisch et al. (1985) study were obtained by withdrawing 0.1 ml of coelomic fluid from Mya arenaria specimens via the posterior adductor muscle.

67. In the Reinisch et al. (1985) study, the number of cells in the hemolymph were counted using a hemocytometer.

68. Permanent cell preparations in the Reinisch et al. (1985) study were made by placing hemolymph on poly-L-lysine coated slides.

69. The diagnosis of neoplasia in the Reinisch et al. (1985) study was based primarily upon cellular morphology, the number of circulating cells/ml, and the failure of neoplastic cells to adhere to uncoated glass slides.

70. According to observations in the Reinisch et al. (1985) study, neoplastic cells do not extend pseudopodia and fail to adhere to glass surfaces, while 90 percent of normal haemocytes adhere to glass surfaces within ten minutes.

71. According to the Reinisch et al. (1985) study the number of circulating haemocytes/ml in normal Mya arenaria is between 1 x 106 and 6 x 106 haemocytes/ml while the number of neoplastic cells/ml hemolymph in diseased clams can be as high as 5x108 cells/ml.

72. According to the Reinisch et al. (1985) study, the prevalence of clams with neoplasia was assessed at Tin Can Island (in New Bedford Harbor), Green Pond (East Falmouth, Massachusetts; 16 miles from New Bedford Harbor), and Tin Bridge (Pocasset, Massachusetts; 14 miles from New Bedford).

73. The Tin Can Island study area in the Reinisch et al. (1985) study is located in the Acushnet River between New Bedford and Fairhaven, Massachusetts.

74. According to data in the Reinisch et al. (1985) study, the prevalence of Hn disease was 66 to 88.2 percent at Tin Can Island and 10 to 20.4 percent in Green Pond and Tin Bridge.

75. According to data in the Reinisch et al. (1985) study, 77 percent of the clams from Tin Can Island had more than 105 neoplastic cells/ml of hemolymph while only 44 percent of the clams from Green Pond had more than 105 neoplastic cells/ml of hemolymph.

76. According to data in the Reinisch et al. (1985) study, the prevalence of clams with neoplasia was subsequently assessed at adjacent sites in or near New Bedford Harbor.

77. Sites in or near New Bedford Harbor which were selected for hematologic analysis in the Reinisch et al. (1985) study are shown in Figure 3 of the study.

78. Sites in or near New Bedford Harbor which were selected for hematologic analyses in the Reinisch et al. (1985) study included locations close to one reported site of PCB discharge (site no. 1), sites further down the Acushnet River (sites no. 2, no. 3), one site just outside the Hurricane Barrier (site no. 4), and one site to the east of the Acushnet River outflow at Hacker Street Flats (site no. 5).

79. At least 68 percent of the clams from four of the five sites in or near New Bedford Harbor were reported as neoplastic in the Reinisch et al. (1985) study.

80. According to the Reinisch et al. (1985) study, 90 percent of the clams at Hacker Street Flats were neoplastic.

81. According to statements in the Reinisch et al. (1985) study, a review of environmental studies indicated that a lagoon near the Hacker Street Flat site was heavily contaminated with a variety of industrial wastes,

including heavy metals, cyanides, acids, and solvents, as well as PCBs.

82. According to the Reinisch et al. (1985) study, 13 percent of the clams at the Hurricane Barrier site were neoplastic.

83. The data in the Reinisch et al., (1985) study, with the exception of those for the Hurricane Barrier, suggest an association between high prevalence of neoplasia and the location of Mya arenaria at, or near, PCB contaminated sites.

84. Normal haemocytes from 4 individual clams and neoplastic cells from six individuals were collected at Tin Can Island or Green Pond and were analyzed by packed column gas chromatographic technique for Aroclors 1242 and 1254 in the Reinisch et al. (1985) study.

85. In the Reinisch et al. (1985) study, Aroclor 1242 was detected at 45 ug/g (ppm) dry weight and Aroclor 1254 was detected at 53 ug/g (ppm) dry weight in neoplastic cells derived from Mya arenaria collected from Tin Can Island.

86. In the Reinisch et al. (1985) study, Aroclors were not detected at significant levels in haemocytes from normal clams of New Bedford origin or normal or neoplastic cells from clams collected from Green Pond.

87. It is emphasized in the Reinisch et al. (1985) paper that an unequivocal cause and effect relationship has not been established between pollution and neoplasia of Mya arenaria.

88. Reinisch et al., (1985) state that data from other studies linking prevalence of neoplasia or other molluscan tumors directly with pollution such as oil spills has been inconsistent.

89. The diagnosis of hematopoietic neoplasm in its early stages is difficult (Reinisch et al., 1985). Attachment Q.VII.0009 is a true and accurate copy of a paper entitled "Prevalence of Neoplasia in Ten New England Populations of the Soft-Shell Clam (Mya arenaria), coauthored by Robert S. Brown, Richard E. Wolke, Saul B. Saila, and Chris W. Brown, published in the professional journal, Annals of the New York Academy of Sciences, Volume 298, 1977 (hereafter, Brown et al., 1977).

90. Neoplasia has been reported infrequently, but consistently, in molluscs since 1887.

91. The frequency of reports of neoplasia in molluscs has increased dramatically during the last 10 years prior to the Brown, et al. (1977) publication.

92. According to the Brown et al. (1977) paper, neoplasia has been reported in 15 species of bivalve molluscs, including 4 species of oysters, 6 species of clams, and 5 species of mussels.

93. Reports suggest that multiple causes and factors may be involved in molluscan carcinogenesis.

94. The Brown, et al. (1977) study involved the collection of specimens from 10 locations with varying types and degrees of environmental pollution.

95. Locations selected for the collection of Mya arenaria and incidence of neoplasia are accurately presented in Table 1 of the Brown et al. (1977) study.

96. Locations selected for the collection of Mya arenaria specimens for the Brown, et al. (1977) study are shown in Table 1 of the report.

97. Mya arenaria specimens collected for the Brown et al. (1977) study were collected between January and September 1976.

98. Hematopoietic neoplasms have been found only in southern New England populations of Mya arenaria while gonadal neoplasms have been found predominately in northern New England populations.

99. Geographically isolated clam populations may be genetically susceptible to different types of neoplasms.

100. Environmental conditions for the 10 sites in the Brown et al. (1977) study are accurately summarized in Table 1.

101. Both types of neoplasms, hematopoietic and gonadal, are apparently malignant neoplasms based on their characteristic appearance, invasiveness, metastasis, mitotic activity, associated tissue necrosis, and mortality.

102. The detection of neoplasia in nominally polluted areas such as Sandy Point, Rickford, and Quonochontaug

suggest that neoplasia is not necessarily the result of exposure of clams to high concentrations of pollutants.

103. Neoplasia was not detected in clams from sites in Providence and Portland, while sites known to be polluted with petroleum hydrocarbons such as Bourne, Searsport, and Quonsett had a high prevalence of neoplasia.

104. Two histopathologic methods were employed to diagnose neoplasia in 1,325 Mya arenaria specimens in the Brown et al. (1977) study: light microscopic examination of all organ systems and microscopic examination of living, or stained and fixed, blood cells.

105. The prevalence of neoplasia in Mya arenaria varied widely among the 10 sites evaluated in the Brown, et al. (1977) study, ranging from 0 to 64 percent.

106. Epithelial hyperplasia was noted in clams from both polluted and non-polluted areas evaluated in the Brown et al. (1977) study.

107. Diseases such as neoplasms can occur in epizootics and are found in such widely geographically separated areas as the east and west coasts of the United States and in Australia.

108. Attachment Q.VI.0010 is a true and accurate copy of a paper entitled "A Comparison of the Incidence of Five Pathological Conditions in Soft-Shelled Clams, Mya arenaria, From Environments With Various Pollution Histories", coauthored by H. A. Walker, E. Lorda, and S. B. Saila, and published in the professional journal, Marine Environmental Research, Volume 5, 1981 (hereafter Walker, et al., 1981).

109. There appears to be a relationship between the pollution history of areas and incidence of pathological conditions in Mya arenaria populations surveyed.

110. Some recent field and laboratory work suggests that an infectious agent may be involved in the spread of neoplasia Mya arenaria populations and that various environmental factors as well as hydrocarbons may influence the progression of the disease.

111. Many factors complicate the analysis of data presented in the Walker et al. (1981) study, and the cause of neoplasia cannot be drawn from inferences.

112. Table 2 consists of a synopsis of the five pathological conditions evaluated in the Walker, et al. (1981) study.

113. Mya arenaria specimens used in the Walker, et al. (1981) study were collected in 1977 and 1978.

114. Figure 3 in the Walker et al. (1981) study is an accurate representation of the incidence of five disease conditions for Mya arenaria evaluated in 17 study locations.

115. As shown in Figure 3 of the Walker, et al. (1981) study, 52 percent of the Mya arenaria specimens collected from New Bedford Harbor were determined to have a condition described as hyperplasia.

116. As shown in Figure 3 of the Walker et al. (1981) study, 31 percent of the Mya arenaria specimens collected from West Falmouth, Massachusetts were determined to have a condition described as hyperplasia.

117. Hyperplasia is a condition in which there is an increase in the number of cells present, often leading to an increase of size.

118. Neoplasia is a benign or malignant condition characterized by uncontrollable, new growth of tissues.

119. Table 1 in the Walker et al. (1981) study is a summary of environmental conditions at the 17 study locations.

120. In the Walker et al. (1981) study, two percent of the Mya arenaria specimens from New Bedford Harbor were determined to have a condition identified as neoplasia.

121. As shown in Figure 3 of the Walker et al. (1981) study, 22 percent of the Mya arenaria specimens collected from the Winnipaug Pond, Rhode Island site were determined to have a condition described as hyperplasia.

122. The site at Winnipaug Pond, Rhode Island, has lower concentrations of PCBs and metals compared to the New Bedford Harbor site.

123. Attachment Q.VII.0011 is a true and accurate copy of the paper entitled "Proliferative Disorders in Bivalve

other than Heteromastus filiformis either feed within the upper layers of the sediment or they are suspension feeders.

217. The irrigated burrows produced by the polychaete, Nereis succinea, may effect the distribution and flux of substances in the sediments.

218. Benthic infaunal species diversity in estuarine systems is always reduced relative to deeper water environments due primarily to greater environmental stresses within the estuarine environments.

219. The references cited in Attachment Q.IX.0004 are articles written by authorities on the topic which the article addresses, and both the authors and the document are relied upon generally by experts in the field.

BENTHIC SPECIES COMPOSITION OF LOCAL NEW ENGLAND ESTUARIES

220. Attachment Q.VII.0013 is a true and accurate copy of a report entitled "New Haven Harbor Ecological Studies Summary Report, 1979," Section 7.0 Intertidal, prepared by Stephen Dudley and Katherine D. Harvell of Normandeau Associates, Inc. of Bedford, New Hampshire (NAI, 1979a).

221. New Haven Harbor is an urbanized estuary containing over 600 acres of intertidal habitat and soft substrate flats.

222. Industrial and municipal wastes are added to the fluctuating physical and chemical regime of New Haven Harbor.

223. Four sewage treatment plant outfalls empty into the inner New Haven Harbor.

224. Table 7-2 in the NAI (1979) report shows the dominant taxa collected at New Haven Harbor intertidal stations from 1971 through 1977.

225. Tables 7-2 of the NAI (1979) report is a true and accurate representation of the dominant taxa collected at the new Haven Harbor intertidal stations from 1971 through 1977.

226. The softshell clam, Mya arenaria is the most numerous bivalve sampled in the New Haven intertidal

community.

227. The bivalve, Gemma gemma is the second most numerous bivalve in New Haven Harbor intertidal samples.

228. The dominant gastropod collected in New Haven Harbor intertidal samples is the mud snail Ilyanassa obsoleta (previously, Nassarius obsoletus).

229. The most common large polychaete collected from New Haven Harbor intertidal samples is the sandworm, Nereis succinea.

230. Nerei succinea was common in New Haven Harbor in most years between 1971 and 1977 and at all benthic sampling stations.

231. In addition to Nereis succinea, Capitella capitata is common in New Haven Harbor.

232. Spionid polychaetes exhibited highly variable distributions and densities in the NAI (1979) study.

233. Spionid polychaetes such as Polydora sp. and Streblospio benedicti are also abundant in New Haven Harbor.

234. Dominant taxa collected in the New Haven Harbor intertidal area are characteristic "opportunistic" species.

235. Attachment Q.VII.0014 is a true and accurate copy of a report entitled "New Haven Harbor Ecological Study Report," 1979, Section 6.0 Subtidal Benthos, by David J. Hartzband, Andrew J. McCusker, Richard McGrath, Allen B. Michael, and Donald A. Rhoads, Normandeau Associates, Inc. of Bedford, New Hampshire.

236. Figure 6-1 is an accurate representation of the benthic sampling locations used for the New Haven Harbor Ecological Study Summary Report (1979).

237. The Quinnipiac River discharges into the New Haven Harbor. Benthic subtidal sampling for the NAI (1979b) report was performed using a ponar grab sampler.

238. Samples of benthic invertebrates consisted of five replicates collected at each of the locations between 1973 and 1977.

239. The subtidal benthos of New Haven Harbor is spatially and seasonally variable in terms of species

composition, faunal densities, and species richness.

240. The subtidal benthods in New Haven Harbor has been characterized by extreme year to year variability in species composition, faunal densities, and species richness.

241. The most abundant fauna in New Haven Harbor are either "opportunistic," have short live spans, or are highly mobile species that are rarely present during the full annual cycle.

242. Table 6-2 lists all benthic species collected over the course of the NAI (1979) study period of 1973 to 1977.

243. Table 6-2 in the NAI (1979) report lists approximately 300 identified taxa of benthic invertebrates.

244. The New Haven Harbor benthic sampling program performed by NAI (1979) is more extensive and extends over a greater number of years than benthic studies performed in other nearby estuaries.

245. Among the nearly 300 identified taxa of benthic invertebrates in New Haven Harbor, many species were encountered very rarely and in small numbers.

246. Rare species encountered during the New Haven Harbor benthic sampling program should not be considered representative of the area.

247. The magnitude of total species list encountered during New Haven Harbor benthic sampling program should not be considered indicative of a healthy estuarine benthic habitat.

248. Table 6-3 of the NAI (1979) report is an abridged list of benthic species occurring in one or more percent of combined replicate samples over the years 1973 to 1977.

249. Table 6-3 of the NAI (1979) report is an accurate representation of the New Haven Harbor benthic community.

250. Attachment Q.VII.0015 is a true and accurate copy of the report "New Haven Harbor Ecological Studies 1981, Summary Report Supplement 1977-1980," prepared by Normandeau Associates, Inc., Bedford, New Hampshire, June, 1981.

251. New Haven Harbor is a shallow estuary located on the highly developed southern shore of Connecticut.

252. The major source of fresh water to the New Haven Harbor is the Quinnipiac River.

253. The New Haven Harbor estuary has been impacted by intense urbanization and associated industrialization.

254. Three sewage treatment plants empty into the inner New Haven Harbor.

255. Water circulation in New Haven Harbor is normally driven by semi-diurnal tides from Long Island Sound.

256. The mean tidal range is New Haven Harbor is 1.9 meters.

257. Riverine discharge controls the salinity structure of New Haven Harbor.

258. Outer New Haven Harbor has hydrographic characteristics similar to the Long Island Sound.

259. Salinity concentrations in the New Haven Harbor exhibit the greatest variability at Station 3, in the inner harbor, as depicted in Figure 4.1-2 in NAI (1981).

260. Patterns of species assemblages observed throughout the years 1973 to 1980 show substantial variability of the benthic fauna within the inner New Haven Harbor (NAI, 1981).

261. The fact that a species displays "opportunistic" traits such as rapid population growth or high mortalities in an area adjacent to environmental pollution does not always indicate that pollution is responsible for this behavior.

262. In New Haven Harbor, "opportunistic" species dominate areas less than 20 meters deep.

263. In Long Island Sound, "opportunistic" species dominate areas less than 20 meters deep.

264. In Long Island Sound, "non-opportunistic" species dominate areas greater than 20 meters deep.

265. The dominance of "opportunistic" species in less than 20 meters of water suggests that storm-generated

disturbance is a major factor in determining distribution.

266. Active processes in shallow estuarine environments may be responsible for the presence of "opportunistic" species.

267. Shallow water stations exhibit a minimum in species richness and density during the summer months.

268. Shallow water stations exhibit a minimum in species richness and density due to low dissolved oxygen and organic rich, silt-clay sediments.

269. Table 4.6-1 is an accurate representation of invertebrate fauna collected from epibenthic trawls in New Haven Harbor from 1971 through 1980 as part of the NAI (1981) summary report supplement.

270. Figure 3-1 in the summary report accurately shows the sampling locations for benthic invertebrates.

271. Studies in New Haven Harbor estuary have shown that dissolved oxygen has a pronounced annual cycle.

272. The lowest dissolved oxygen concentrations in New Haven Harbor occur in summer (July, August and September).

273. Attachment Q.VII.0016 is a true and accurate copy of "Ecologic Study of the Thames River Estuary (Connecticut)" authored by D.S. Tolderlund, U.S. Coast Guard Academy, New London, Connecticut, Report No. RDCGA 575, 1975.

274. Figure 3 in the Tolderlund (1975) report, is an accurate depiction of the bottom grab sample stations.

275. Benthic species were sampled between May 15-17, 1972, using a Peterson Bottom Grab Sampler and between June 23-26, 1972, using a biological dredge.

276. The most widespread polychaete species collected during the Tolderlund (1975) study was the cone worm Pectinaria gouldii which occurred at 16 of the 30 sampling stations based on the presence of tubes in the sediments.

277. The water column salinity at one location in the Thames River varied by as much as 24 parts per thousand during the summer.

278. The bottom salinity along the length of the Thames River estuary never varied by more than 3 percent on any given day and ranged from 27 parts per thousand to 30 parts per thousand.

279. Table 4 is a true and accurate representation of the benthic species data based on bottom grab sample counts.

280. Benthic species sampling in the Tolderlund (1975) study may have underestimated the abundance of smaller benthic invertebrates.

281. Predominant species encountered in bottom grab samples collected during the Tolderlund (1975) study included polychaetes, (Pectinaria gouldii, Nephtys caecea, Scoloplos robustus) and bivalves, Mercenaria mercenaria and Mulina lateralis).

282. Table 6 is an accurate representation of the species encountered in biological dredge samples during the Tolderlund (1975) study. Figure 9, in the Tolderlund (1975) study, is an accurate representation of the biological dredge sample stations for benthic invertebrates.

283. Attachment Q.VII.0017 is a true and accurate copy of the report entitled, "Trident Dredging, Thames River Channel, Draft Environmental Impact Statement," March 23, 1979, U.S. Navy.

284. Chloroform levels are high and dissolved oxygen levels are low in the upper reaches of the Thames River estuary (U.S. Navy, 1979).

285. In general, water quality of the Thames River estuary increases substantially as it flows toward Long Island Sound.

286. Evidence of nutrient enrichment and high coloform counts indicates a substantial pollution load applied to the upper reaches of the Thames River estuary.

287. The uppermost sampling station in the Thames River estuary (U.S. Navy, 1979) is dominated by the polychaete Streblospio benedicti and the bivalve mollusc Pellina agilis.

288. Benthic species diversity and abundance are lowest in the two uppermost sampling stations in the Thames River estuary (U.S. Navy, 1979).

289. Mid-channel sampling stations have high diversity and low species abundance in the Thames River estuary.

290. The benthic survey in the U.S. Navy (1979) report indicates that species complexes composing the Thames River bottom community are dominated by pioneer organisms.

291. Table D-1, in the U.S. Navy (1979) report, indicates that dominant polychaetes in the upper Thames River estuary include Streblospio benedicti, Capitella capitata, and Nephtys incisa. Benthic species distribution in the upper Thames River estuary are "patchy" in distribution.

292. Table D-1, in the U.S. Navy (1979) report, is a true and accurate representation of the benthic species present in the Thames River estuary.

293. Benthic species sampling Stations 8, 9, and 10, in the U.S. Navy (1979) report, contain faunal assemblages typical of nearshore benthic communities.

294. Benthic species composition at sampling Stations 8, 9, and 10 contain faunal assemblages typical of nearshore benthic communities and include Nucula proxima, Empelisca vadorum, and Nephtys incisa.

295. Mya arenaria were not abundant in the sampling stations included in the U.S. Navy (1979) report.

296. Attachment Q.VII.0018 is a true and accurate copy of the dissertation entitled, "Comparative Structure and Response to (Petroleum) Disturbance into Nearshore Infaunal Communities," authored by Jeffrey L. Hyland, Ph.D. Dissertation, University of Rhode Island, 1981.

297. In the Hyland (1981) study, one area within the Pettaquamscutt River in Rhode Island was sampled for benthic species.

298. The benthic sampling in the Pettaquamscutt River was performed in a shallow marshy area with extremely variable salinities.

299. The Pettaquamscutt River is located in the general vicinity of lower Narragansett Bay, Rhode Island as shown in the figure in Appendix I.

300. Benthic sampling consisted of 10 replicate samples collected on five separate occasions in 1977 and 1978.

301. The polychaete Streblospio benedicti was the dominant polychaete in the Pettaquamscutt River study area.

302. The polychaete Streblospio benedicti exhibited a sporadic peak in abundance in August 1977 samples.

303. The polychaete Streblospio benedicti and the oligochaete Tubificodies gabriellae were the two most abundant species encountered in the Pettaquamscutt River study area.

304. The Pettaquamscutt study area in the Hyland (1981) study contained a large proportion of species with sporadically variable densities including Streblospio benedicti, Scoloplos robustus, Ampelisca abdita, Gammarus mucronatus, Tubificodies gabriellae, Nereis succinea, and Heteromastus filiformis.

305. In the Pettaquamscutt River study area, species with persistent abundances were not encountered.

306. Appendix IV, in the Hyland (1981) dissertation, contains a list of benthic species found in natural bottom sediments of the Pettaquamscutt River study areas.

307. The most common bivalve encountered in the Pettaquamscutt River study area was Macoma balthica.

308. The polychaete Capitella capitata was rarely encountered at the Pettaquamscutt River study area except at test plots subjected to environmental disturbance.

309. The high level of dominance for Streblospio benedicti and Tubificodies garbriellae in the Pettaquamscutt River study area is characteristic of the benthos in upper reaches of estuaries.

310. Attachment Q.VII.0019 is a true and accurate copy of the paper entitled "Salinity and Faunal Distribution in the Pocasset River, Massachusetts," coauthored by H. L. Sanders, P. C. Mangelsdorf, Jr., and G. R. Hampson, of the Woods Hole Oceanographic Institution, Woods Hole, Massachusetts. The study was published in "Limnology and Oceanography," Volume 10 (Supplement), pgs. R216-R229, 1965).

311. The Pocasset River in Massachusetts has a small volume, moderate tidal amplitude, and moderate freshwater runoff.

312. The Pocasset River in Massachusetts is classified as a fluctuating estuary characterized by pronounced diurnal change in the salinity gradient throughout the estuary.

313. The Pocasset River in Massachusetts is a small estuary emptying into the eastern shore of Buzzards Bay.

314. Benthic faunal samples were collected in triplicate using a wide-diameter coreliner at seven sites located throughout the course of the estuary.

315. The seven locations sampled in the Pocasset River represent a wide range of salinity regimes.

316. The seven locations of benthic sampling are accurately represented in Figure 1.

317. Salinity fluctuations have the greatest magnitude at sampling stations 1 through 4.

318. In a gradient, the minimum number of species occurs in the middle reaches for the zone of maximum salinity variation.

319. The Pocasset River in Massachusetts is a fluctuating estuary with small volume and with low salinities or freshwater conditions in the upper reaches, and regions of pronounced diurnal or tidal salinity changes throughout most of its length.

320. Table 3 represents an accurate description of the numbers of species found at the seven Pocasset River benthic sampling stations.

321. Faunal impoverishment should be expected in areas of strong salinity fluctuations, as opposed to areas of lesser salinity fluctuations.

322. Figure 2, in Sanders, et. al., (1965), is an accurate representation of the salinity of sediment and bottom water at the seven Pocasset River sampling locations.

323. Rigid, periodic short-term fluctuations in water salinity stabilizes or buffers the salinity of the sediment.

324. Rigid, periodic short-term fluctuations in the water salinities greatly reduces the degree of physiological stress imposed on the infauna.

325. Many of the benthic species in the Sanders, et. al.,

(1965) study are widely distributed throughout the Pocasset River Estuary.

326. Dominant benthic species in the Sanders, et. al., (1965) study have a distribution confined to a specific portion of the Pocasset River.

327. Benthic invertebrate species collected from peripheral populations away from areas of the center of species distribution exist under suboptimal conditions.

328. Based upon Table 3 in the Sanders, et. al., 1965 paper, dominant polychaete species include Hypaniola grayi in the upper reaches of the Pocasset River estuary where highest salinity fluctuations occurred, and Streblospio benedicti and Polydora ligni in the middle reaches of the Pocasset River estuary.

329. Dominant molluscs in the Pocasset River include Gemma gemma and Hydrobia sp. which are found primarily in the middle to lower reaches of the estuary.

330. Changes in the benthic species composition of the Pocasset River took place between August, 1963 and May, 1965.

331. The second most abundant species in 1963, the polychaete Polydora ligni, was rare in 1965.

332. The most abundant polychaete species collected in 1963, Hypaniola grayi, was not encountered in 1965.

333. Infauna must contend with a changing salinity regime resulting in appreciable physiological stress.

334. Sediment salinities are stable and constant in marked contrast to the salinities in the immediately overlying water.

335. Benthic infauna live under much more stable salinity conditions than benthic epifauna and can escape the appreciable physiological stresses imposed on epifauna.

336. Benthic species populations in samples from the Pocasset River estuary averaged 107,000 individuals per square meter.

337. Benthic species populations in samples from the lower Pocasset River estuary averaged about 36,500 individuals per square meter.

338. The Pocasset River is a small estuary of 2.25 kilometers in length.

339. The distribution of marine and freshwater species in an estuary may be determined primarily by the rate and magnitude of salinity change.

340. Attachment Q.VII.0020 is a true and accurate copy of a paper entitled "Almyracuma proximoculi Gen. Et Sp. Nov. (Crustacea, Cumacea) From Brackish Water of Cape Cod, Massachusetts," authored by N.S. Jones and W.D. Burbanck, and published in the professional journal, Biological Bulletin, Volume 116, pgs. 115-124, 1959.

341. The substrate composition of the Pocasset River contains sand, gravel, and plant debris, but is indicative a disturbed environment with charcoal fragments and small pieces of iron slag.

342. Charcoal fragments and iron slag in the Pocasset River may be residue from a former iron foundry.

343. Table 2, entitled "Comparison of New Bedford Harbor Benthic Species With Species in Other Local Estuaries," is an accurate summary of benthic species community patterns in the New Bedford Harbor, New Haven Harbor, Thames River, Pocasset River, Pettaquamscutt River and Alewife Cove estuary.

344. Table 2 accurately summarizes the benthic species data derived presented in the sources referenced therein.

345. Table 2 is admissible in evidence as a summary of the benthic species data presented in the sources referenced therein.

346. The polychaete Streblospio benedicti has been described as abundant at each of the following New England estuarine systems: New Bedford Harbor, New Haven Harbor, Thames River, Pocasset River, Pettaquamscutt River and Alewife Cove estuary.

347. The polychaete Polydora ligni has been described as present, although not abundant, at the following five New England estuaries: New Bedford Harbor, New Haven Harbor, Thames River, Pocasset River, Pettaquamscutt River and Alewife Cove.

348. In general, species assemblages encountered in the following New England estuaries are similar: New Bedford Harbor, New Haven Harbor, Thames River,

Pocasset River, Pettaquamscutt River and Alewife Cove estuary.

349. In general, species assemblages in the New Haven Harbor and the Thames River estuary appear most comparable to the New Bedford Harbor Upper Estuary.

350. Dominant species in the five New England estuaries in Attachment Q.VII.0020 are species normally classified as "opportunistic."

351. The polychaete species common to the five New England estuaries include Streblospio benedicti, Capitella capitata, Polydora ligni, Pectinaria gouldii, and Eteone heteropoda.

352. The gastropod Nassarius obsoletus has been reported at most of these five New England estuaries.

353. The soft shell clam Mya arenaria is common to most of these five New England estuaries.

354. The chronic, widespread pollution of New Bedford Harbor Estuary from sewage, stormwater runoff and industrial wastes can easily account for the "stressed" character of benthic communities in the Upper Estuary.

355. There has been no information presented by the plaintiff that differentiates the reported or potential effects to aquatic organisms from PCBs from those effects that would occur from the other reported chronic anthropogenic pollution to New Bedford Harbor (i.e., sewage, heavy metals and other contaminants).

356. An examination of estuarine benthic communities in other regional urban estuaries reveals that the structure of the estuarine benthic community in New Bedford Harbor does not appear to be incrementally affected by the presence of PCBs more than what would have been expected as a result of the presence of other contaminants common to urban estuaries.

357. The following articles were written by authorities in the topic which the article addresses, and both the authors and the documents are relied upon generally by experts in the field.

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Brown, R. S., R. E. Wolke, S. B. Saila and C. W. Brown (1977). Prevalence of neoplasia in 10 New England Populations of the soft-shell clam (Mya arenaria). Ann. N.Y. Acad. Sci. 298: 522-534.

Crump-Wiesner, H. J., H. R. Feltz, and M. L. Yates (1974). A study of the distribution of polychlorinated biphenyls in the aquatic environment. Pesticide Monit. J. 8(3): 157-161.

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Gregor, D. J. and W. D. Gummer (1989). Evidence of atmospheric transport and deposition of organochlorine pesticides and polychlorinated biphenyls in Canadian Arctic snow. Environ. Sci. Technol. 23(5): 561-565.

Heit, M., C. Klusek, and J. Baron (1984). Evidence of deposition of anthropogenic pollutants in remote Rocky Mountain Lakes. Water, Air, Soil Poll. 22: 403:416.

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Jeffries, H. P. (1972). A stress syndrome in the hard clam, Mercenaria mercenaria. J. Invert. Path. 20: 242-251.

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Strachan, W. M. J. (1988). Toxic contaminants in rainfall in Canada: 1984. Env. Toxicol. Chem. 7: 871-877.

Tanabe, S. and R. Tatsukawa (1980). Chlorinated hydrocarbons in the North Pacific and Indian Oceans. J. Oceanogr. Soc. Japan 36: 217:226.

Tanabe, S., H. Hidaka, and R. Tatsukawa (1983). PCBs and chlorinated hydrocarbon pesticides in Antarctic atmosphere and hydrosphere. Chemoshere 12(2): 277-288.

Tolderlund, D. S. (1975). Ecological Study of the Thames River Estuary (Conn.). U. S. Coast Guard Academy, New London, Ct. Report No. RDCGA575, 135 pp.

U. S. Navy (1979), Trident Dredging, Thames River Channel, Draft Environmental Impact Statement.

Walker, H. A., E. Lorda, and S. B. Saila (1981). A comparison of the incidence of five pathological conditions in soft-shell clams, Mya arenaria, from environments with various pollution histories. Mar. Environ. Res. 5: 109-123.

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Zajac, R.N. and R.B. Whitlach (1982). Responses of estuarine infauna to disturbance. I. Spatial and temporal variation of recolonization. Mar. Ecol. Prog. Ser. 10:1-14.

POPULATION DYNAMICS

358. **The carrying capacity of a marine ecosystem is equal to the number of individual organisms that can be supported by the available resources.**

359. **The competition for one or many resources generally limits population growth in most marine ecosystems.**

360. **If necessary resources are available in unlimited supply, optimal population growth rates will occur and the population would increase exponentially.**

361. Within a stable ecosystem organisms allocate energy to maintenance, growth, and reproduction.

362. If population density surpasses the carrying capacity of the ecosystem based upon available space or resources, there will be fewer resources per individual and the allocation of energy to growth and reproduction will decrease.

363. A disturbed or stressed ecosystem that results in a decrease of population size will reduce competition, resulting in resources not being as limited; growth and reproduction will be maximized leading to a decrease in density-related mortality.

364. Responses of individual organisms and the community to a change in the population of a species are termed "compensatory mechanisms" when they act to compensate for population losses.

365. Compensatory mechanisms permit a population to persist in the face of mild disturbance, to recover from a population loss or impact, and to recolonize a disturbed site.

366. Compensatory mechanisms found in populations of estuarine invertebrates act to sustain a population even under continued stress.

367. Organisms found in the Upper Estuary of New Bedford Harbor have been recruited from other nearby populations outside of New Bedford Harbor.

368. A stress or disturbance in the ecosystem that eliminates or functionally disables part of the population puts the surviving members of the population at an advantage.

369. A high population density is more likely to invite predation, spread disease and parasitism, induce cannibalism in some species, and increase competition amongst all species.

370. When population density is decreased, the effect that predation, disease and parasitism, or similar factors has on growth, reproduction and survival is decreased.

371. Density-dependent mortality factors are generally responsible for determining the equilibrium density of a species population.

372. Density-dependent factors can include competition for food, competition for habitat, or the competition of predators or parasites.

373. Many environmental factors can lead to mortality in species population; however, generally only one or at the most very few are responsible for control of that population.

374. In order for species population to maintain an equilibrium it is only necessary that one reproductive adult be replaced by one reproductive adult in the next generation.

375. In species which reproduce tens of thousands to millions of eggs and sperm per reproductive event, over 99.999 percent of the eggs and larvae or juveniles may die before reaching reproductive age.

376. Reproductive strategies of species are important in determining population resiliency or elasticity and ability to recover from impact or stress.

377. Recovery of a population to its original state depends upon the degree or the magnitude of the effect or disturbance and the species affected.

378. When a community or population impact is eliminated or removed, the recovery of that population will depend to a large extent upon recruitment of juveniles from unaffected nearby populations.

379. Recruitment is a term used to describe the successful survival of juvenile to an adult reproductive stage, or the successful passage of individual organisms from one year class to the next.

380. R-selected reproductive strategies are exhibited by non-selective feeders who devote more energy to species survival through reproduction than to individual survival through growth and protection of young.

381. R-selected species have rapid development to the reproductive stage and have many reproductive efforts per year at the expense of evolving mechanisms and behaviors to avoid predation.

382. R-selected species have a large reproductive effort to insure quick recovery and overall success in a disturbed ecosystem.

383. Temperate estuaries are systems which constantly

experience stress and variability in environmental conditions.

384. R-selected species have evolved to be successful in the variable environment found in temperate estuaries.

385. Most estuarine benthic invertebrates have planktonic larvae and produce large numbers of them to insure dispersal and survival of the species.

386. Many estuarine benthic invertebrates in temperate estuaries are considered opportunists.

387. Many of the estuarine species which are opportunists are found in temperate estuaries like New Bedford Harbor.

388. Species currently found in the Upper Estuary in the Bedford Harbor or likely to be found after capping are typical of estuarine opportunists.

389. The opportunistic species found in the Upper Estuary of New Bedford Harbor or likely to be found after capping are successful at rapidly responding to population impacts.

390. R-selected species have selected for optimal reproductive effort and planktonic larvae; this has enabled their populations to respond to the variable environment impacts typical of temperate estuaries like New Bedford Harbor.

391. Coastal currents along the southeastern shore of Massachusetts distribute planktonic larvae from other locations in Buzzards Bay and Long Island Sound to New Bedford Harbor.

392. Even if all organisms in the Upper Estuary at New Bedford Harbor were eliminated, populations of those species currently found there would quickly reestablish themselves by recruitment from other nearby populations.

393. The survival of species populations in the Upper Estuary in New Bedford Harbor are more dependent on the relative success of species populations throughout Buzzard's Bay and Long Island Sound than upon the success of those individual organisms in New Bedford Harbor.

394. In general, species populations throughout Buzzard's Bay and Long Island Sound can be considered a source of

recruitment for species populations in New Bedford Harbor.

395. There is substantial transport of the planktonic larvae of marine species found within Buzzards Bay and Long Island Sound by the regional hydrodynamics.

396. Planktonic larvae of estuarine species generally stay in the plankton for a period of several days to several weeks.

397. Planktonic larvae can be transported within a period of several days to several weeks from several to hundreds of kilometers.

398. Most of the species found in the Sanford Ecological Services, (SES) 1987, survey of the benthos of New Bedford Harbor have planktonic larvae.

399. It is likely that those benthic species collected by SES, (1987) from in New Bedford Harbor are found in other areas of Buzzard's Bay and Long Island Sound.

400. Populations of reproductive adults can respond to their environment and its variability by exhibiting variability in population size.

401. Estuarine soft-bottom communities have a highly variable species composition.

402. Year-to-year fluctuations in species composition of estuarine benthic communities in New Bedford Harbor may reflect the variable adult mortality brought upon by hydrodynamic and climatic factors.

403. Samples of estuarine communities taken in close proximity are often found to be less alike in species composition than samples taken widely apart geographically.

404. Patchiness in the distribution of estuarine benthic species in New Bedford Harbor can be explained by the dispersal or concentration of planktonic larvae by currents.

405. Patchiness in the distribution of estuarine benthic species can be explained by small scale habitat heterogenety and can be explained by inter-and intra-specific competition as well as amensalistic interactions.

406. McCall (1977) stated that the rapidity with which

Long Island Sound species colonize a bottom empty of macrofauna suggests that these species are specially adapted to maintaining populations in a frequently disturbed environment.

407. According to McCall (1977) when one considers that Long Island benthic communities have been studied for over a century, little is known about species' life histories.

408. McCall (1977) indicated that species such as Capitella capitata and Streblospio benedicti are able to discover recently created empty habitats and quickly recolonize them in great abundance.

409. McCall (1977) considers these species; i.e., Capitella and Streblospio to be successful in colonizing disturbed habitats.

410. The effect of sub-lethal concentrations of contaminants upon the growth mortality and reproduction of estuarine species is not well known.

411. The effect of environmental contaminants on species population in the marine and estuarine environment is difficult to describe and poorly understood.

412. McFadden (1977) defines compensation as the tendency of populations of living organisms to experience: a) an increase in death rate or decrease in birth rate as they grow in density, establishing some ultimate upper limit, and b) a decrease in death rate or increase in birth rate as population density declines, thus leading to stabilization before extinction, or eventual return to higher numbers.

413. McFadden (1977) indicates that when compensation involves changes in birth and death rates in response to population density changes, the biological processes involved are often termed "density dependent."

414. If all the reproductive efforts of marine benthic, invertebrates and fish were successful in that they survived to reproductive age and spawned again, by the end of ten generations the mass of organisms in the ocean would be greater than the mass of water presently there.

415. There has been no direct evidence presented that the PCBs have either lethal or sub-lethal effects on individual organisms currently residing in the Upper Estuary of New Bedford Harbor.

416. Even if PCBs had a sub-lethal or lethal effect on individual organisms residing temporarily or permanently in the Upper Estuary of New Bedford Harbor, there is no data available to predict what the effect of these impacts to individual organisms would be on the entire species populations.

417. Estimation of population impact caused by PCBs in the Upper Estuary of New Bedford Harbor to species populations residing there would have to consider the size and area occupied by the parental stock of the species from which the Upper Estuary recruits its young.

418. It is often impossible to distinguish between relations that are causal or predictive compared to simply correlative because typically there is no a priori theoretical justification for the choice or selection of independent variables or for fluctuations or changes in the nature of these independent variables, or for the way in which the high dimensionality of the phenomenon being described has been accounted for.

419. The principles of population dynamics discussed above apply to avian populations in the New Bedford Harbor/Buzzard Bay area as well.

420. The following references are articles written by authorities on the topic which the article addresses, and both the authors and document are relied upon generally by experts in the field.

McCall, P. L. 1977. Community patterns and adaptive strategies of the infaunal benthos of Long Island Sound. J. Mar. Research 35(2): 221-263.

McFadden, J. T. 1977. An argument supporting the reality of compensation in fish populations and a plea to let them exercise it. In W. Van Winkle, ed., Proceedings of the Conference on Assessing the Effects of Power-Plant-Induced Mortality on Fish Populations, Perganon Press, New York.

BIOACCUMULATION

The Relationship Between Bioaccumulation of PCBs and Toxicity of PCBs to Marine Organisms

421. Bioaccumulation of PCBs by marine organisms is not an indication of toxicity to the organisms.

422. Bioaccumulation and toxicity are unlikely to represent concurrent aquatic hazards under stabilized environmental conditions -- i.e., high concentrations of toxic substances ultimately kill organisms, whereas only lesser levels of the substances (nonlethal levels) are associated with bioaccumulation.

423. This principle is incorporated into the experimental design of most laboratory bioaccumulation tests, in which test organisms are exposed to concentrations of PCBs that are low enough to preclude the toxicity (in particular, the mortality) that would render the tests useless.

424. EPA's water quality criteria for PCBs (EPA, 1980) are predicated upon residue considerations, as contrasted to toxicological considerations (EPA, 1990).

425. According to Pruell, et al., 1989, sediment-associated constituents can affect biota toxicologically <u>or</u> result in high concentrations of constituents in tissues of indigenous organisms.

426. According to Capuzzo and Farrington, undated, Attachment Q.VII.0021, a general question that remains unanswered was reported to be the extent to which body burdens of chemical constituents in marine bivalves relate to biological effects, particularly at the population level.

427. Coho salmon (a freshwater life stage) that contained body burdens of up to 57.00 ppm Aroclor 1254 after being exposed to the formulation for 260 days exhibited no observable toxicosis (Mayer et al., 1977).

428. Channel catfish (a freshwater species) characterized by body burdens of up to 32.0 ppm Aroclor 1260 during a 193-day exposure period exhibited no observable toxicosis (Mayer et al., 1977).

429. Twenty-eight (28-day) survival of juvenile sheepshead minnows containing body burdens of as much as 230 ppm (wet wt.) Aroclor 1016 was not significantly lower than survival of control fish, and up to 77 ppm Aroclor 1016 in eggs of adults did not affect survival of embryos or fry (Hansen et al., 1975).

430. American oysters containing as much as 101 ppm (wet wt) Aroclor 1254 were characterized by survival and growth that were comparable to control organisms during a 30-week monitoring period (Lowe et al., 1972).

431. Spot (a fish) with body burdens of as much as 27 ppm (wet wt.) Aroclor 1254 were unaffected toxicologically during a chronic (140-day) bioaccumulation study (Hansen et al., 1971).

432. Maximum acceptable toxicant concentrations (MATC, geometric mean of no-observed-effect concentration and lowest-observed-effect concentration) for several vital biological functions of adult minnows exposed to Clophen A50 for 40 days and monitored for sublethal effects for an additional 260 days were (adult body burden of Clophen A50; ppm, wet wt. ; Bengtsson, 1980) --

a. Swimming ability of adults: >170 - >180 ppm;

b. Hatching time for eggs: 5 ppm; and

c. Hatchability of eggs: 50 ppm.

433. Survival and several sublethal characteristics (fin rot and mouth erosion) of sheepshead minnows containing body burdens of Aroclor 1254 that ranged from 59.0 to 73.8 ppm, dry wt. (accumulated after 29 days of exposure to sediment from inner New Bedford Harbor [NBH]) were not significantly different from survival and sublethal characteristics of control fish (Hansen et al., 1986).

434. According to Capuzzo and Farrington, undated, Attachment Q.VII.0021, abundant populations of soft-shell clams and quahogs were reported in "heavily impacted" parts of inner NBH despite infaunal nature and high PCB burdens of the organisms.

435. According to Kolek and Ceurvels, 1981, overt effects of PCB uptake on marine organisms indigenous to the NBH area were not observed (during 1976 through 1980) <u>even though</u> some organisms contained PCB levels in excess of 500 ppm.

a. No sampled or observed organisms exhibited gross abnormalities or indications of disease.

b. Seasonal development of reproductive organs of finfishes appeared to be normal.

436. According to Bellmer, undated, "Despite very high levels of contaminants as well as evidence of bioaccumulation, these [NBH] wetlands are functioning as effective systems and have high resource values . . . these wetlands

continue to support and produce biota representative of New England estuaries ... plant biomass and vegetative structure, benthic and fish community composition and structure, and avian and mammal [sic.] do not demonstrate PCB and heavy metal contamination effects ... most data for PCBs found in the literature are from tissue level studies.

Potential For Depuration of PCBs By Marine Organisms

437. In general (with species-specific and other differences acknowledged), the more-water-soluble PCBs tend to be more available than the less-water-soluble PCBs to marine organisms, and, consequently, are more likely to be taken up by the organisms.

438. PCBs adsorbed to sediments have a low bioavailability to marine organisms (Fresenius et al., 1984).

439. Bioavailability of PCBs in sediment is directly related to water solubility of PCB congeners/isomers and sediment grain size, and inversely related to content of organic carbon in sediment and animal size (Fresenius et al., 1984).

440. If bioaccumulated, the more-water-soluble PCBs are more likely than the less-water-soluble PCBs to be depurated (eliminated) by the organisms.

441. American oysters were reported to have lost 100% of accumulated Aroclor 1016 (approximately 130 ppm, wet wt.) when placed in uncontaminated water for a period of 56 days (Pardsh et al., 1974).

442. Pinfish lost 61% of accumulated body burdens of Aroclor 1016 during a 56-day depuration period (Hansen et al., 1974).

443. Blue mussels with relatively low body burdens of Aroclor 1242 (0.070 ppm, wet wt.) were characterized by a biological half-life (BHL) for the material of 8 days during an 89-day depuration period in Puget Sound (Calambokidis et al., 1979).

444. American oysters exposed for 24-30 weeks to 1-5 ppb Aroclor 1254 accumulated body burdens of 101-425 ppm PCBS, wet wt. (BCFs = 85,000 x - 101,000 x), but depurated essentially 100% of material during 12-28 weeks (Lowe et al., 1972).

445. Blue mussels with low body burdens of Aroclor 1254 (0.34 ppm, wet wt.) were characterized by a BHL for the material of 23 days (Calambokidis et al., 1979).

446. Grass shrimp exposed for 3-5 weeks to comparatively low concentrations of Aroclor 1254 (0.04 - 0.62 ppb) lost about 50-98% of body burdens (0.2 - 10 ppm PCBs, wet wt.) during a 4-week depuration period (Nimmo et al., 1975).

447. Spot (a fish) lost 73% of accumulated Aroclor 1[illegible] [illegible]7 ppm, wet wt.) during an 84-day depuration per[illegible] [illegible]nsen et al., 1971).

448. Blue mussels exhibiting low body burdens of Aroclor 1260 (0.180 ppm, wet wt.) were characterized by a BHL for the material of 39 days (Calambokidis et al., 1979).

449. BHL for hexachlorobiphenyl in purple sea urchins ranged from 8.66 to 15.75 days (Tjeerdema and Jacobs, 1987).

450. Fiddler crabs rid their "bodies of up to 100% of unspecified PCBs during depuration periods of 14-21 days (Clark et al., 1986).

451. Contaminated cockles (body burdens of 6.83 ppm Aroclor 1242) eliminated 64% of PCBs (BHL = 7 - 14 days) during a 21-day period (Langston, 1978).

452. Elimination rates for cockles decreased with increased chlorination, and removal of isomers with more than 5-chlorine atoms was not observed (Langston, 1978).

453. In two depuration studies conducted with polychaetes (Courtney and Langston, 1978), body burdens of Aroclor 1254, which were relatively low (0.39 - 0.49 ppm, wet wt.), were reduced by up to 33% during a 3-week observation period.

454. BHL of four PCB congeners accumulated in blue mussels was (Pruell et al., 1986)

   a. 2,3,4', trichlorobiphenyl: 16.3 days;

   b. 2,2',4,5,5', pentachlorobiphenyl: 27.9 days;

   c. 2,2',3,3',4,4' hexachlorobiphenyl: 36.5 days; and

   d. 2,2',4,4',5,5,' hexachlorobiphenyl: 45.6 days.

455. Polychaete worms rid their bodies of about 50-88% of accumulated PCBs during approximately 2 months in uncontaminated media (Fowler et al., 1978; Elder et al., 1979).

456. Depuration of PCBs by polychaete worms was concentration-dependent, with higher initial loss rates evident in polychaetes containing higher body burdens of material. (Fowler et al., 1978)

457. Quahogs transplanted from New Bedford Harbor (NBH) to an "uncontaminated" depuration site lost 90% of accumulated Aroclor 1242 and 80% of Aroclor 1254 during an approximately 1-year period (Deubert et al., 1981).

458. Release of organic constituents by bivalve molluscs was reported to vary as a function of compound solubility, concentration, and partitioning between water and tissues (Capuzzo and Farrington, undated).

459. According to Capuzzo and Farmington, undated, in the case of blue mussels maintained in NBH -- a selective loss of lighter-chlorinated biphenyls was reported to be evident between pre- and post-spawning periods; heavier chlorinated biphenyls, however, were retained.

The Potential of PCBs To Biomagnify In Marine Food Chains

460. The importance of water, as compared to food (prey), as sources of PCBs in marine organisms has been extensively studied and debated without widespread agreement.

    a. Transfer of xenobiotic constituents from water to aquatic organisms is termed bioconcentration.

    b. Transfer of xenobiotic constituents from prey (lower trophic levels in food chains) to aquatic organisms in substantial amounts is termed biomagnification.

461. Scura and Theilacker (1977) evaluated the transfer of Aroclor 1254 in a three-component marine food chain established in the laboratory.

    a. The marine organisms constituting the food chain were -- primary producer: algal flagellate (*Dunaliella.* sp.); primary consumer (herbivore): rotifer (*Brachionus plicatilis*); and secondary consumer (low-level carnivore): larva of northern anchovy (*Engraulis mordax*).

    b. Water to which algae (and rotifers) were exposed contained from 0.0026 to 0.0136 ppb Aroclor 1254, which was representative of PCB levels in nearshore waters off of southern California.

c. Anchovies were maintained in water containing 0.002 ppb Aroclor 1254.

d. Concentrations of Aroclor 1254 in algae, which appeared to reach steady-state levels within 5 days after exposure of organisms to test material, ranged from 0.12 to 0.38 ppm, dry wt.

e. Concentrations of Aroclor 1254 in consumers, which also reached equilibrium within 5 days of the time that consumers were initially fed prey, ranged from 0.29 to 0.54 ppm for rotifers and from 1.11 to 2.67 ppm for fish.

f. Although the above-described body burdens of Aroclor 1254 in the three test organisms suggested amplification of PCBs in a step-wise fashion up the food chain, supplemental studies performed by Scura and Theilacker (1977) indicated that such was not the case.

g. When concentrations of PCBs in algae and rotifers were converted from a whole-body to lipid basis, differences between the two species were no longer evident -- i.e., what appeared to be biomagnification was simply a reflection of the greater lipid content of rotifers.

h. In the case of the last link in the evaluated food chain -- anchovy lipids contained a substantially higher concentration of PCBs (27.46 ppm) than rotifer lipids (2.80 ppm) but, in additional tests, PCB levels in lipids of unfed anchovies maintained in contaminated water (0.0025 - 0.0045 ppb PCBS) ranged from 37.33 to 62.67 ppm.

i. Consequently, the conclusion reached in this investigation was that PCB accumulation is not a food-chain phenomenon, but, rather, is the result of direct partitioning of the compounds between seawater and marine organisms.

462. Tanabe et al. (1984) identified physiochemical mechanisms operating at lower trophic levels and several factors not including biomagnification (i.e., metabolic capacity and life span) functioning at higher trophic levels as explaining PCB increases they observed at upper levels of a four-species food chain (zooplankton, myctophid fish, squid, and a mammal, the striped dolphin) in the western North Pacific Ocean.

463. Van den Broek (1979) emphasized lipid content of organisms as the basis of differences in PCB content of fishes and prey (brown shrimp) indigenous to the Medway Estuary, England.

464. Shaw and Connell (1980) implicated lipid content of organisms, rather than foodchain transfer, as influencing PCB levels in a multicomponent food web (a mollusk, several species of polychaete worms, three crustaceans, six fishes, and a bird) in the Brisbane River Estuary, Australia.

465. Osterberg and Keckes (1977) reported that PCB concentrations actually decrease at successive food chain levels in the Mediterranean Sea.

466. A panel of marine scientists addressing acceptable levels of PCBs in the New York Bight (NOAA, 1979) commented on the "generally held belief" that levels of pollutants in gilled marine animals are controlled mostly by concentrations of the pollutants in water.

467. The Office of Technology Assessment (1987) reported that bioaccumulation of organic chemicals depends primarily on the substances' ratio of lipid solubility to water solubility.

468. Macek et al. (1979) concluded that, with the exception of DDT, "the process of biomagnification, as classically defined, probably does not occur within communities of aquatic organisms."

469. Bellmer (undated), addressing wetlands/estuary of the Acushnet River in New Bedford Harbor concluded that these data showed no clear evidence for biomagnification ...

470. There is a scientific basis for concluding that PCBs do not biomagnify in marine food chains.

<u>Report/Source:</u> Predicting bioaccumulation of sediment-associated organic contaminants -- development of a regulatory tool for dredged material evaluation (Rubinstein et al., undated

471. **Laboratory Study B addressed the range and variability of the "accumulation factor" (AF) for polychaete worms and tellenid bivalves exposed in the laboratory for 42 days to a suite of PCB congeners and the PCB formulation Aroclor 1254 in sediment from New Bedford Harbor (NBH).**

472. The formula for deriving the AF was (all measurements expressed in dry wt.): AF (PCB conc. in tissue of organisms, ppb ÷ lipid content of organisms, %) ÷ (PCB conc. of sediment, ppb ÷ TOC content of sediment, %)

473. Although various parametric (i.e., "normal") statistical procedures were employed to evaluate significance of differences in calculated AFs, the validity of the procedures apparently was not evaluated -- i.e., the extent to which raw data conformed to the assumptions inherent in the use of parametric statistical procedures was not assessed and/or reported.

474. Mortality of organisms exposed to sedimentary levels of PCBs (levels as high as 41.3 ppm Aroclor 1254, dry wt.; NBH Sample 2) and other unmeasured constituents was not attributed to PCBS.

475. The cause of the above-referenced mortality was reported as "unknown."

476. The relative distribution of PCB congeners in organisms generally reflected the distribution of congeners in sediments.

477. Species exposed to the highest evaluated sedimentary concentration of PCBs (41.3 ppm Aroclor 1254, dry wt.; NBH Sample 2) exhibited the lowest mean AF (1.02 x).

478. Species exposed to the lowest evaluated sedimentary level of PCBs (0.03 ppm Aroclor 1254, dry wt.; Jamestown Island, Narragansett Bay) exhibited the highest mean AF (4.02 x).

Report/Source: a) Bioavailability and biological effects of PCBs and PAHs to marine bivalve molluscs: laboratory and field experiments with Mercenaria mercenaria (Capuzzo and Farrington, undated); b) The relationship between lipid composition and seasonal differences in the distribution of PCBs in Mytilus edulis L. (Capuzzo et al., undated); and c) Bioaccumulation and biological effects of PCBs on marine bivalve molluscs in New Bedford Harbor, Massachusetts (Capuzzo et al., undated).

479. Attachment Q.VII.0021 is a true and accurate copy of a document authored by J.M. Capuzzo and John W. Farrington entitled "Bioavailability and Biological Effects of PCBs and PAHs to Marine Bivalve Molluscs: Laboratory and Field Experiments with Mercenaria mercenaria."

480. Attachment 2.VII.0021 addresses bioavailability and biological effects of PCBs and PAHs to marine bivalve molluscs.

481. Uncontaminated blue mussels were transplanted from the Sandwich mussel beds to the Hurricane Barrier in New Bedford Harbor (NBH) and two distant offshore reference areas: Cleveland Ledge (in Buzzard's Bay) and Nantucket Sound.

482. The three groups of transplanted mussels were maintained in cages suspended 1 m above the ocean bottom for a year (November 1984 to November 1985).

483. The three groups of transplanted mussels were monitored biweekly for uptake of individual PCB congeners, lipid content, and condition index.

484. The three groups of transplanted mussels were not analyzed for metals or petroleum hydrocarbons although those constituents were recognized as important contaminants in NBH.

485. Neither water nor sediment at the three exposure sites was analyzed for PCBs (or other xenobiotic constituents).

486. Condition of mussels remaining at the Sandwich beds was not monitored during the course of the study.

487. Condition index of mussels ([dry wt. of soft tissues ÷ dry wt. of shell] x 1,000) transplanted in NBH was significantly lower than indices for reference mussels during just the pre-spawning period (approximately December 1984 through June 1985).

488. The experimental design of the study precludes the establishment of a causal relationship between body burden of PCBs in mussels and condition index of the organisms.

489. A causal relationship between body burdens of PCBs in mussels and condition index of the organisms is not claimed in the report.

490. The absence of condition measurements for Sandwich mussels during the course of the study confounds an understanding of the extent to which the condition of NBH mussels approximates the "natural" condition of Sandwich mussels, and the "better" condition of reference mussels reflects more advantageous environmental circumstances (e.g., greater current speed and/or food supply) at the reference sites.

491. A number of confidence intervals established around mean condition indices illustrated in Figure 1 are incorrectly portrayed as being "one-sided.

492. Approximately equal fractions of Aroclor 1016 or 1242 and Aroclor 1254 were contained in mussel tissues.

493. A general question that remains unanswered was reported to be the extent to which body burdens of chemical constituents in marine bivalves relate to biological effects, particularly at the population level.

494. Abundant populations of soft-shell clams and quahogs were reported to be present in "heavily impacted" parts of the harbor.

Report/Source: Preliminary data report: New Bedford Harbor Project (Hansen et al., 1986) supplemented by additional data (Hansen, 1987).

495. This study was designed to address toxicity and bioaccumulation potential of sediment collected from several sampling stations in the inner part of New Bedford Harbor (NBH) during January 21-22, 1986.

496. Sediment was analyzed for PCBs (Aroclor 1254 and "total PCB homologues), various metals, and total organic carbon (TOC).

   a. TOC content of sediment ranged from (dry wt.) 4.12% (lower part of inner harbor) to 11.3% (upper part of inner harbor).

   b. TOC levels in upper part of inner harbor were quite high and would be expected to limit the bioavailability of PCBs by complexing them in sediment (e.g., EPA, 1990; Rubinstein, undated).

497. Sediment was not analyzed for organic constituents other than PCBs and TOC.

498. Water established in testing vessels with sediment was not analyzed for PCBs or other xenobiotic constituents.

499. Laboratory toxicity tests were performed with sediment and amphipods and sheepshead minnows.

500. A laboratory bioaccumulation test was conducted with sheepshead minnows.

Laboratory Toxicity Tests with Amphipods

501. Amphipods, which are surface-deposit and suspension feeders, were evaluated in two sets of tests.

502. In the first set of tests (Test 1 and 2), amphipods were exposed for 10 days to sediment (six samples of treatment sediment and control material) washed with flowing filtered seawater (approximately 13 exchanges per day).

a. Treatment sediment was obtained from inner NBH at four sampling stations south of Interstate Route I-195 and at two stations north of I-195.

b. The sediment samples were reported to contain a range of metal concentrations and a gradient of PCB levels, which were reported as both Aroclor 1254 and the sum of measured PCB homologues (dry wt.) --

i. Station 5: 7.31 ppm Aroclor 1254 (10 ppm PCBs homologues);

ii. Station 7: 13.3 ppm Aroclor 1254 (17 ppm PCB homologues);

iii. Station 6: 19.3 ppm Aroclor 1254 (unreported amount of PCB homologues);

iv. Station 8: 30.9 ppm Aroclor 1254 (56 ppm PCB homologues);

v. Station 12: 231 ppm Aroclor 1254 (220 ppm PCB homologues); and

vi. Station 14: 1,100 ppm Aroclor 1254 (2,600 ppm PCB homologues).

c. Biological responses of amphipods monitored during this set of tests were survival at Days 4 and 10 of tests and daily emergence of organisms from sediment.

503. In the second set of amphipod tests (Tests 3 and 4) organisms were exposed for 10 days under dynamic (flow-through) conditions to treatment sediment (and

dilutions of this sediment and control material obtained from several of the above-identified sampling stations (Stations 5, 12, and 14).

a. This set of tests was designed, in part, to evaluate the toxicological effects of metal concentrations in sediment in that material obtained from Station 12 and a 21% dilution of material from Station 14 were characterized by the same levels of Aroclor 1254 (231 ppm), but different levels of metals (approximately an order-of-magnitude more metals at Station 12).

b. In addition, 14% of material from Station 12 and 3% of material from Station 14 were similarly paired (32-33 ppm Aroclor 1254 for both materials; about an order-of-magnitude more metals in the Station-12 dilution).

c. Daily survival of amphipods was monitored during these tests.

504. Results of the amphipod study indicated that:

a. Sediment from Station 5 (7.31 ppm Aroclor 1254; 10 ppm PCB homologues) was characterized by toxicity that was not significantly different from toxicity of control sediment (Tests 1 and 2); and

b. Sediment from Station 14 (the station with the highest reported levels of PCBS) had a "no-effect" concentration of 6% (i.e., 66 ppm) Aroclor 1254 and 156 ppm PCB homologues (Tests 3 and 4).

505. **The effects of the presence of metals on toxicity of sediment cannot be determined.**

a. Although sediment from Station 12 and the 21% dilution of material from Station 14 contained the same amount of Aroclor 1254, sediment from Station 12, in addition to containing more metals than the diluted material, contained only approximately 40% of the PCB homologues measured in the diluted material.

b. As is apparent from the above-described circumstances, the comparable toxicity that was observed for the two sedimentary materials may have been a function of the higher metal levels of sediment from Station 12 being countered by the higher PCB-homologue level of the diluted material from Station 14.

c. Similarly, the 14% dilution of sediment from Station 12 contained both a higher metal level and a lower PCB-homologue level than the 3% sedimentary dilution from Station 14.

d. The results of this latter paired experiment were not fully reported by Hansen.

506. Based upon the above-presented 'no-observed-effect concentrations of sedimentary PCBS, the maximum acceptable toxicant concentration (MATC) for sedimentary PCBs in NBH sediment ranged from >10 ppm PCB homologues (Tests 1 and 2) to >156 ppm PCB homologues (Tests 3 and 4).

a. The MATC is the geometric mean of the no-observed-effect concentration and the lowest-observed-effect concentration.

b. The above-referenced MATC range is "open-ended" because multiple xenobiotic constituents other than PCBs (i.e., metals and, undoubtedly, numerous unmeasured constituents) were present in sediment that produced the lowest-observed-effect concentrations for amphipods.

507. The experimental design of the amphipod study precludes the establishment of a causal relationship between PCB levels in sediment and toxicological responses of amphipods.

Laboratory Toxicity Test with Sheepshead Minnows

508. Sheepshead minnows tested for sensitivity to sediment from inner NBH were adult fish that were exposed for 29 days under apparently static (possibly static eplacement) conditions to material obtained from --

a. Station 5: 7.31 ppm Aroclor 1254 (10 ppm PCB homologues);

b. Station 7: 13.3 ppm Aroclor 1254 (17 ppm PCB homologues);

c. Station 8: 30.9 ppm Aroclor 1254 (56 ppm PCB homologues);

d. Station 12: 231 ppm Aroclor 1254 (220 ppm PCB homologues); and

e. Station 14: 1,100 ppm Aroclor 1254 (2,600 ppm PCB homologues).

509. The fish were monitored for survival and several sublethal anomalies (fin rot and mouth erosion).

510. At the end of the 29-day exposure period, surviving fish were induced to spawn and fertilized eggs of fish were transferred to uncontaminated flowing water.

511. Developing embryos and fry were monitored in uncontaminated flowing water for an additional 28 days for survival and, in the case of fry, fin rot.

512. Results of the sheepshead minnow study caused the authors to conclude that:

a. Adult fish exposed to sediments collected from above I-195 died (actually, survival of adult fish was 72% for Station 12 [220 ppm PCB homologues] and 0% for Station 14 [2,600 ppm PCB homologues]; in addition, an unexplained reference was made to a seemingly untested 28% dilution of material from Station 12);

b. Survival of embryos and fry produced by adults exposed to sediments was reduced (actually, statistically significant reduced survival was only characteristic of young fish associated with sediment from Stations 12 and 14, the most contaminated stations); and

c. Fin rot was common in surviving adult fish and their progeny (statistically significant increases in fin rot only occurred in adult fish exposed to sediment from Stations 12 and 14).

513. In the sheepshead minnow study, concentrations of PCBs were reported just for sediment to which adult fish were intermittently exposed, not for associated water, with which fish had continuous contact.

514. Since water apparently was not exchanged during the 29-day exposure period (or perhaps was exchanged to only a limited degree), aqueous levels of PCBs to which adult fish were exposed may have been higher than would occur in inner NBH.

515. Results of the sheepshead minnow study indicate that the MATC for sedimentary PCBs in NBH was >56 ppm PCB homologues.

a. The MATC is the geometric mean of the no-observed-effect concentration and the lowest-observed-effect concentration.

b. The above-referenced MATC is open-ended because multiple xenobiotic constituents other than PCBs (i.e., metals and, undoubtedly, numerous unmeasured constituents) were present in sediment that produced the lowest-observed-effect concentrations for fish.

516. The experimental design of the sheepshead minnow study precludes the establishment of a causal relationship between PCB levels in sediment and toxicological responses of fish.

Laboratory Bioaccumulation Test with Sheepshead Minnows

517. Adult sheepshead minnows that survived the 29-day exposure (9-11 days exposure in the case of sediment from Station 14) to sediment from inner NBH in the above-described laboratory toxicity test were evaluated for body burdens of Aroclor 1254 and PCB homologues.

518. At the end of the exposure periods, fish had accumulated body burdens of Aroclor 1254 that generally approximated levels in sediment to which fish were exposed.

a. At the lowest test concentration (7.31 ppm Aroclor 1254 in sediment), body burdens of fish were reportedly an order-of-magnitude higher (15.6-21.0 ppm Aroclor 1254, dry wt.).

b. At the highest test concentration (1,100 ppm Aroclor 1254 in sediment), body burdens of organisms were reportedly an order-of-magnitude lower (100-107 ppm Aroclor 1254).

519. With regard to reported composition of PCB body burdens in sheepshead minnows:

a. The less chlorinated PCBs (i.e., 2-chlorine, 3-chlorine, and 4-chlorine biphenyls) were typically proportionally-represented (or over-represented) in fish relative to concentrations in sediment; and

b. The more-chlorinated PCBs (5-chlorine, 6-chlorine, and 7-chlorine biphenyls) were always underrepresented in fish relative to levels in sediment.

520. Results of the bioaccumulation study with sheepshead minnows caused the authors to conclude that:

a. PCB concentrations in adult fish were similar to levels in sediments;

b. Predominance of more-chlorinated PCB congeners in sediment relative to fish suggests that fish were not exposed to sediment for sufficient periods of time;

c. PCB concentrations in eggs produced by adult female fish were slightly lower than levels of PCBs in females; and

d. Metals (which were also evaluated during the study) were not accumulated from sediment by adult fish.

521. As previously discussed in this document, adult sheepshead minnows may have been exposed to environmentally unrealistic concentrations of water-borne PCBs during this study.

Report/Source: Pilot Study: summary of ambient water quality conditions; from New Bedford Harbor pilot study, pre-operational monitoring, progress report, 23 February 1988 (EPA and COE, 1988; only aquatic toxicity tests reviewed).

522. Ambient water collected from four sampling stations in inner New Bedford Harbor (NBH) during July 1987 was reported to be nontoxic as evidenced by the sea urchin sperm test.

523. Ambient water collected from four sampling stations in inner NBH on September 24, 27, and 28, 1987, was reported to be nontoxic as evidenced by the sea urchin sperm test.

524. Ambient water collected from four sampling stations in inner NBH on September 22, 1987, was reported to be nontoxic in comparison to site 'control' water as evidenced by the sea urchin test.

525. Ambient water collected from four sampling stations in inner NBH during July 1987 was reported to be nontoxic to sheepshead minnows.

526. Ambient water collected from four sampling stations in inner NBH during September 1987 was reported to be nontoxic to sheepshead minnows.

527. Ambient water collected from four sampling stations in inner NBH during July 1987 was reported to be nontoxic to mysid shrimp as measured by growth of shrimp

528. Ambient water collected from four sampling stations in inner NBH during July 1987 was reported to be nontoxic to mysid shrimp, in comparison to site "control" water, as measured by survival of shrimp.

529. Ambient water from inner NBH was not evaluated for toxicity to mysid shrimp during September 1987.

530. Results of toxicity tests performed during July 1987 with macroalgae and ambient water collected from four sampling stations in inner NBH were reported to be characterized by unacceptable or questionable scientific quality.

531. Results of toxicity tests performed during September 1987 with macroalgae and ambient water collected from four sampling stations in inner NBH were reported to be characterized by unacceptable scientific quality (test conducted with water collected on September 22); or

532. Toxicity of ambient water to macroalgae was reported to be attributable to "other than PCB concentrations."

533. Toxicity of ambient water to macroalgae was reported to be "quite possibly" attributable to copper.

534. Copper concentrations (total concentrations) in ambient water at the three most "up-estuary" sampling stations in inner NBH were reported to be "consistently" greater than EPA's acute marine water quality criterion of 2.9 ppb.

Report/Source: PCB concentrations in *Mytilus edulis* from the July and September mussel deployments; from New Bedford Harbor study, pre-operational monitoring, progress report (Pruell et al., 1988).

535. **Lower-molecular-weight PCB congeners were generally accumulated more rapidly and to higher levels. in blue mussels deployed in New Bedford Harbor (NBH) than higher-molecular-weight congeners.**

536. **The experimental design of the mussel study was characterized by several basic defects, which are inconsistent with appropriate scientific practices.**

   a. **The reference location was shifted from Cleveland Ledge in Buzzard's Bay (the reference station employed by Capuzzo et al. [undated] in another**

mussel bioaccumulation investigation) to near West Island mid-way during the study.

b. The number of mussel replicates employed in the study was changed from four to three half-way through the study.

c. During the first part of the mussel study (the June deployment), none of four critical reference samples were analyzed for PCBs after Day 3 of exposure (no explanation was provided for this dramatic omission).

537. Although parametric (i.e., normal) one-way analyses-of-variance (ANOVAS) were employed to evaluate statistical significance of location-related differences in body burdens of total PCBs in mussels, the validity of this statistical approach apparently was not evaluated -- i.e., the degree to which log-transformed data conformed to assumptions inherent in the use of parametric ANOVAs was not assessed and/or reported.

538. If log-transformed data did not conform to assumptions inherent in the use of parametric ANOVAS, purported "among-location" differences in PCB body burdens of mussels may be nonexistent from a statistical perspective.

Report/Source: Ambient water quality criteria for polychlorinated biphenyls (EPA, 980; mammalian toxicology and human-health effects excluded from review).

539. Attachment Q.VII.0022 is a full and accurate copy of the above-captioned document.

540. Attachment Q.VII.0022 is a public record setting forth the activities of the office or agency; or matters observed pursuant to duty imposed by law as to which matters there was a duty to report; or factual findings resulting from an investigation made pursuant to authority granted by law.

541. A PCB criterion to "protect salt-water aquatic life" was identified as 0.030 ppb PCBs applied as a 24-hr average.

a. The criterion was based upon bioconcentration factors (BCF = conc. of PCBs in tissue of organism ÷ conc. of PCBs in water [under steady-state conditions]) generated in laboratory tests with one freshwater species (brook trout) and two madne species (spot and sheepshead minnows).

b. The criterion was derived exclusively by estimating the highest concentration of PCBs in water that would not cause PCBs to bioconcentrate in edible fishes and shellfishes to a level higher than the FDA action level for PCBs (which, at that time, was 5.0 ppm, wet wt.).

c. The criterion was designed to protect human consumers of "salt-water aquatic life," as contrasted to being designed to protect the aquatic life themselves.

542. The 0.030 ppb "residue-based" PCB criterion for marine organisms is characterized by several scientific defects.

a. The criterion, although based primarily upon BCFs derived for Aroclor 1254, was (is) extrapolated to all types of PCBS.

b. The criterion was derived by employing a "lipid-correction" factor of 16%, as contrasted to the contemporary factor of 10%, which pertains to the edible part of the Atlantic herring, the most "fat-laden" of "important" consumed marine species (EPA, 1986). (A high lipid-correction factor generates a low value of the chtedon.)

543. In the case of marine (and freshwater) fishes, field studies were reported to apparently produce BCFs at least 10 x higher than reported laboratory studies.

a. This supposed differential in BCFs was the basis for speculating that field organisms obtain a substantial portion of PCB body burdens via biomagnification (i.e., uptake of PCBs from prey).

b. The above-referenced field and laboratory studies were performed with different species of marine fishes.

i. In the case of field studies, the species were speckled seatrout and several species that were only identified as "fishes" and which were not clearly identified in terms of BCFs in the cited literature (Nimmo et al., 1975).

ii. In the case of laboratory studies, the species were spot, sheepshead minnows, and pinfish.

c. The purported difference in BCFs between field- and laboratory-evaluated fishes could be an artifact associated with:

i. different species of fishes evaluated;

ii. inadequate (low) characterizations of PCB concentrations of ambient (field) water;

iii. high aqueous concentrations of PCBs generally evaluated in laboratory studies, as contrasted to low levels typically measured in field studies (levels of PCBs in water and BCFs for exposed organisms may be inversely related);

iv. derivation of laboratory-based BCFs by use of nominal, as compared to measured, concentrations of PCBs in test water (nominal levels are likely to be higher than actual levels because of adsorption of PCBs on surfaces of testing apparatus (e.g., test aquaria); and/or

v. the inability of relatively short-term laboratory studies to document equilibrium (maximum) body burdens of PCBs in test organisms.

544. Toxicity-based PCB criteria for marine organisms were not identified because of the absence of sufficient scientifically acceptable toxicological data (EPA, 1986).

a. Scientifically acceptable acute toxicological data pertained to just six tests with three invertebrate species (American oyster, brown shrimp, and grass shrimp).

b. Scientifically acceptable chronic toxicological data pertained to just two partial life-cycle tests with one fish species (sheepshead minnows).

545. Toxicity-based PCB criteria for marine organisms, if developed, will not be scientifically credible if criteria are not qualified in terms of exposure time of organisms to PCBS.

546. Attachment Q.VII.0023 is a true and accurate copy of portion of an EPA document entitled "Quality Criteria for Water -- 1986," May 1, 1986, published by the United State Environmental Protection Agency, 440/5-86-001, Office of Water Regulations and Standards, Washington, D.C. (1986 Water Quality Criteria Document)

547. Attachment Q.VII.0023 is a public record setting forth the activities of the office or agency; or matters observed pursuant to duty imposed by law as to which

matters there was a duty to report; or factual findings resulting from an investigation made pursuant to authority granted by law.

548. The 1986 Water Quality Criteria Document states that for an FDA action level for fish or shellfish, the appropriate BCF is the ... BCF for the edible portion (muscle for decapods, muscle with or without skin for fishes, adductor muscle for scallops, and total soft tissue for other bivalve molluscs) of a consumed species.

549. The lobster, Hamarus americanus, is a decapod.

550. The hepatopancreas (tomalley) of the lobster is not amedible muscle.

551. The FDA action level criteria of 2 ppm does not apply to the lobster tomalley.

Report/Source: Ratios of edible tissue to whole body PCB concentrations in flounder and lobster from New Bedford Harbor: final report (Hillman et al., 1987).

552. This study is based upon 30 winter flounder and 22 American lobsters collected in June 1985 from the three fishery closure areas (Areas 1-3) in the New Bedford Harbor (NBH) area and the unclosed Area 4.

553. A sampling plan was developed by Battelle to collect winter flounder (Pscudoleleuronectes americanus) and lobster (Homarus americanus) in order to provide an estimate of body burdens of PCBs in representative marine species in the New Bedford Harbor area.

554. The sampling plan provided for collection of different size classes, small, medium and large.

555. The sampling plan provided for collection of these pecies from each of the four closure areas.

556. The sampling plan thus provided 12 distinct classes of specimens of each species.

557. Three replicates of each species in each size class was taken from each closure area.

558. The specimens of lobster and winter flounder thus provided a reasonable representation of these species in the New Bedford Harbor area.

559. This sampling plan for collecting lobsters and flounders was much more systematic and statistically reliable than any previous; collection of marine organisms which were intended to provide a representation of body burden accumulations.

560. The sampling plan developed by Battelle was sufficiently robust to provide estimates of between and within sample variability in PCB body burden in each size class of each species from each closure area.

561. The results of the Battelle study of body burdens of PCBs in the edible tissue of the winter flounder and lobster from New Bedford Harbor are the most reliable data available to provide information of PCB body burdens in marine species in this area.

562. The results from the Battelle study on the winter flounder and lobster body burdens are more reliable than any past studies of body burden of PCB in marine species collected from New Bedford Harbor.

563. Any differences in estimates of PCB body burden in the edible tissue from the lobster and the winter flounder when compared to the Battelle study are due to biases introduced in the sampling plan or error, in the analysis of PCBs in the edible tissue in the other studies.

564. Any differences between the estimates of PCB body burden in the edible tissue of the winter flounder and lobster compared to the Battelle study are a result of depuration of PCB from the edible tissue of these species between the time they were collected and the time the Battelle study was conducted.

565. Edible muscle and whole-body tissues of flounder, as well as edible muscle, hepatopancreas, and whole-body tissues of lobsters, were selectively evaluated for total PCBs and 2-Cl through 9-Cl biphenyls on a wet-weight basis.

566. None of the numerous calculated ratios of PCB contamination in tissues of flounders and lobsters were evaluated for statistically significant differences.

567. Only 1 of 20 flounders evaluated for total PCBs in edible muscle contained levels greater than the 2 ppm FDA action level.

568. The above-referenced single flounder, which contained muscle with a 4.8 ppm PCB level, was a medium-sized fish, with an unknown history of movement, captured from Area 4.

569. The median total PCB level in muscle of the 20 evaluated flounders was --

a. Area 1: 0.88 ppm;

b. Area 2: 0.94 ppm;

c. Area 3: 0.32 ppm; and

d. Area 4: 0.24 ppm.

570. None of the 12 lobsters evaluated for total PCBs in edible muscle contained levels greater than the 2 ppm FDA action level.

571. The median total PCB level in edible muscle of the 12 lobsters was --

a. Area 1: 0.83 ppm;

b. Area 2: 0.46 ppm;

c. Area 3: 0.23 ppm; and

d. Area 4: 0.06 ppm

572. Despite the exclusive relevancy of the FDA action level (2 ppm PCBS) to edible muscle of fishes and decapods (EPA, 1986), the authors of this report frequently compare the action level to concentrations of PCBs in whole-body tissues of flounders and lobsters and, even, to concentrations of PCBs in the hepatopancreas of lobsters.

Report/Source: Polychlorinated biphenyl (PCB) analyses of marine organisms in the New Bedford Harbor area: 1976-1980 (Kolek and Ceurvels, 1981)

573. Attachment Q.VII.0024 is a true and accurate copy of the above captioned document.

574. Attachment Q.VII.0024 is a public record setting forth the activities of the office or agency; or matters observed pursuant to duty imposed by law as to which matters there was a duty to report; or factual findings resulting from an investigation made pursuant to authority granted by law.

575. Evaluation of trends in PCB body burdens of American lobsters (and other migratory species) was reported to be confounded by seasonal movements of lobsters in and out of the New Bedford Harbor (NBH) study area.

576. A possible source of PCB contamination for lobsters (and other organisms) in the study area was reported to be a spoil area located near West Island.

577. Overt effects of PCB uptake on indigenous marine organisms were not observed even though some organisms contained PCB levels in excess of 500 ppm.

578. No sampled or observed organisms exhibited gross abnormalities or indications of disease.

579. Seasonal development of reproductive organs of finfishes appeared to be normal.

Report/Source: Heavy metals in Merceneria merceneria and sediments from the New Bedford Harbor Region of Buzzard's Bay, Massachusetts (Genest and Hatch, 1981).

580. As illustrated below, much scientific research has demonstrated the presence of contaminants other than PCBs in New Bedford Harbor and Buzzards Bay.

581. The above-captioned article was written by authorities on the topic which the article addresses, and both the authors and the document are relied upon generally by experts in the field.

582. Quahogs and associated surficial sediment were collected monthly during April 1978 through March 1979 from three locations in Buzzard's Bay east of New Bedford Harbor (NBH).

583. Ouahogs and sediment were analyzed for five metals -- cadmium, copper, iron, lead, and zinc.

584. Annual mean bioaccumulation factors (BFs) for quahogs exposed to sediment were (conc. in tissue, dry wt. - conc. in sediment, dry wt.) --

a. iron: 0.03 x;

b. lead: 0.56 x;

c. cadmium: 5.04 x;

d. copper: 6.72 x; and

e. zinc: 6.92 x.

585. The pronounced relationships observed throughout the study between concentrations of metals in sediment and

quahogs were reported to indicate tha body burdens of metals in organisms were at least partially dependent on levels of the metals in sediment.

Report/Source: Geochemical study of sediment contamination in New Bedford Harbor, Massachusetts (Pruell et al., 1989).

586. This study is based upon a total of 13 sediment samples collected from New Bedford Harbor (NBH) on January 21-22, 1986, and January 6, 1987.

587. Sediment of NBH was reported to be contaminated with a complex mixture of potentially toxic constituents.

588. Sediment in some areas of NBH contained extremely high concentration of metals.

589. Concentrations of cadmium in sediment of the northern part of NBH were generally much higher than levels reported for other estuarine(ine environments.

590. Concentrations of copper in sediment of the northern part of NBH were generally much higher than levels reported for other estuarine environments.

591. Concentrations of chromium in sediment of the northern part of NBH were generally much higher than levels reported for other estuarine environments.

592. Concentrations of nickel in sediment of the northern part of NBH were generally much higher than levels reported for other estuarine environments.

593. Concentrations of lead in sediment of the northern part of NBH were generally much higher than levels reported for other estuarine environments.

594. Concentrations of zinc in sediment of the northern part of NBH were generally much higher than levels reported for other estuarine environments.

595. This report stated that the major source of sedimentary metals in NBH was probably an industrial outfall located approximately 2 km south of Station J (refer to attached Figure 1).

596. Sediment of NBH contained numerous polycyclic aromatic hydrocarbons (PAHs).

597. This reported stated that the major sources of sedimentary PAHs in NBH were probably combustion processes and/or Combined-Sewer-Overflows (CSOs).

598. Wetlands and Benthic Studies undertaken by EPA and its contractors in the upper estuary of New Bedford Harbor were undertaken to evaluate the effects of potential remediation, and not because of a perceived threat to those environments.

599. Many species of fish, shellfish, benthic invertebrates, migrating shorebirds, and waterfowl live either temporarily or permanently in the Upper Estuary of New Bedford Harbor.

600. New Bedford Harbor is a particularly favored wintering ground for several species of coastal waterfowl.

Report/Source: New Bedford Harbor Superfund Project wetland assessment: bioconcentration/bioaccumulation to PCBs and metals in Acushnet River biota (Sanford Ecological Services, 1989) only bioaccumulation of PCBs in aquatic food chains evaluated).

601. This study purports to address bioaccumulation and bioconcentration of xenobiotic constituents (PCBs and metals) in the Acushnet River biota.

   a. Bioaccumulation is conventionally defined as transfer of xenobiotic constituents from unspecified environmental sources (e.g., water, sediment, and food) to aquatic organisms.

   b. Bioconcentration is conventionally defined as transfer of xenobiotic constituents from water to aquatic organisms.

602. Much of the study actually addresses biomagnification of PCBs in three supposed estuarine food chains (two aquatic chains and one terrestrial chain).

   a. Biomagnification is conventionally defined as transfer of xenobiotic constituents from prey (lower trophic levels in food chains) to aquatic organisms in substantial amounts.

   b. In the study, the term "bioconcentration" is misused to mean storage of foreign constituents in particular "locations" of organisms.

603. In order to document the occurrence of biomagnification in a food chain it is necessary to quantify the temporal

and spatial characteristics for the interspecific prey-predator relationship.

604. The two supposed aquatic food chains evaluated in the study were: a) sea lettuce and ribbed mussels eaten by black ducks; and b)) ribbed mussels eaten by ring-billed gulls.

a. No attempt was made to document through site-specific food-habit studies that these supposed food chains were operative in the Acushnet River Estuary.

b. No attempt was made to document spatial or temporal variability of the supposed food chains.

c. No attempt was made to relate age, size, or lipid content of collected organisms to body burdens of PCBS.

d. No preliminary estimate was made to ascertain numbers of samples of each species by sex, age, weight, and lipid content that was necessary to demonstrate, with any statistical reliability, the presence or absence of biomagnification within the food chain.

605. The conclusion that biomagnification of Aroclor 1254 was "strongly suggested" in the sea lettuce/ribbed mussels and black-duck food chain represents a gross misuse of data in that PCB levels in black ducks were measured in only a single duck, which had an unknown history of movement.

606. Evaluation of the ribbed-mussel and ring-billed-gull food chain was reported to "suggest" that biomagnification of Aroclor 1254 "may" be occurring in the chain.

a. **The above-referenced assertion is not justified based upon evaluation of the raw data upon which the assertion is based.**

b. **The mean level of Aroclor 1254 in mussels was reported to be 10.60 ppm, wet wt. (if duplicate samples from each of five sampling stations are not preliminarily averaged), or 12.03 ppm (if the averaging technique consists of obtaining the mean of each set of duplicate samples for each of the five sampling stations and, then, employing each of the station means to obtain a "grand" mean).**

c. The mean level of Aroclor 1254 in muscle of ring-billed gulls (10 gulls) was reported to be 13.99 ppm wet wt.

d. A nonparametric statistical assessment (nonparametric unpaired "t" test) applied to the set of mussel data with the lower mean (mean body burden of Aroclor 1254 = 10.60 ppm) and the set of gull data (mean body burden of Aroclor 1254 = 13.99 ppm), after Cochran's test indicated variances of the two sets of data were heterogeneous, demonstrates that the two data sets are not significantly different at P = >0.50 (with the assumption of a twotailed alternative to the null hypothesis).

e. Therefore -- the differences reported between body burdens of Aroclor 1254 in mussels versus gulls have a greater than 50% probability of being random in nature.

607. Ribbed mussels were reported to contain body burdens of Aroclor 1242 as well as Aroclor 1254.

a. However, Aroclor 1242 was not reported to be detected in ring-billed gulls.

b. The absence of Aroclor 1242 in gulls further weakens the case for a trophic link between mussels and gulls, as well as the case for biomagnification between the two supposedly linked animals.

608. No visual evidence of OCB-related ecotoxicity was noted in the tidal wetland vegetation of the Acushnet River estuary.

609. The poor scientific quality of this report precludes it from contributing to an understanding of PCB dynamics in organisms indigenous to the New Bedford Harbor area.

Figure 1. Locations of sediment samples collected in New Bedford Harbor.

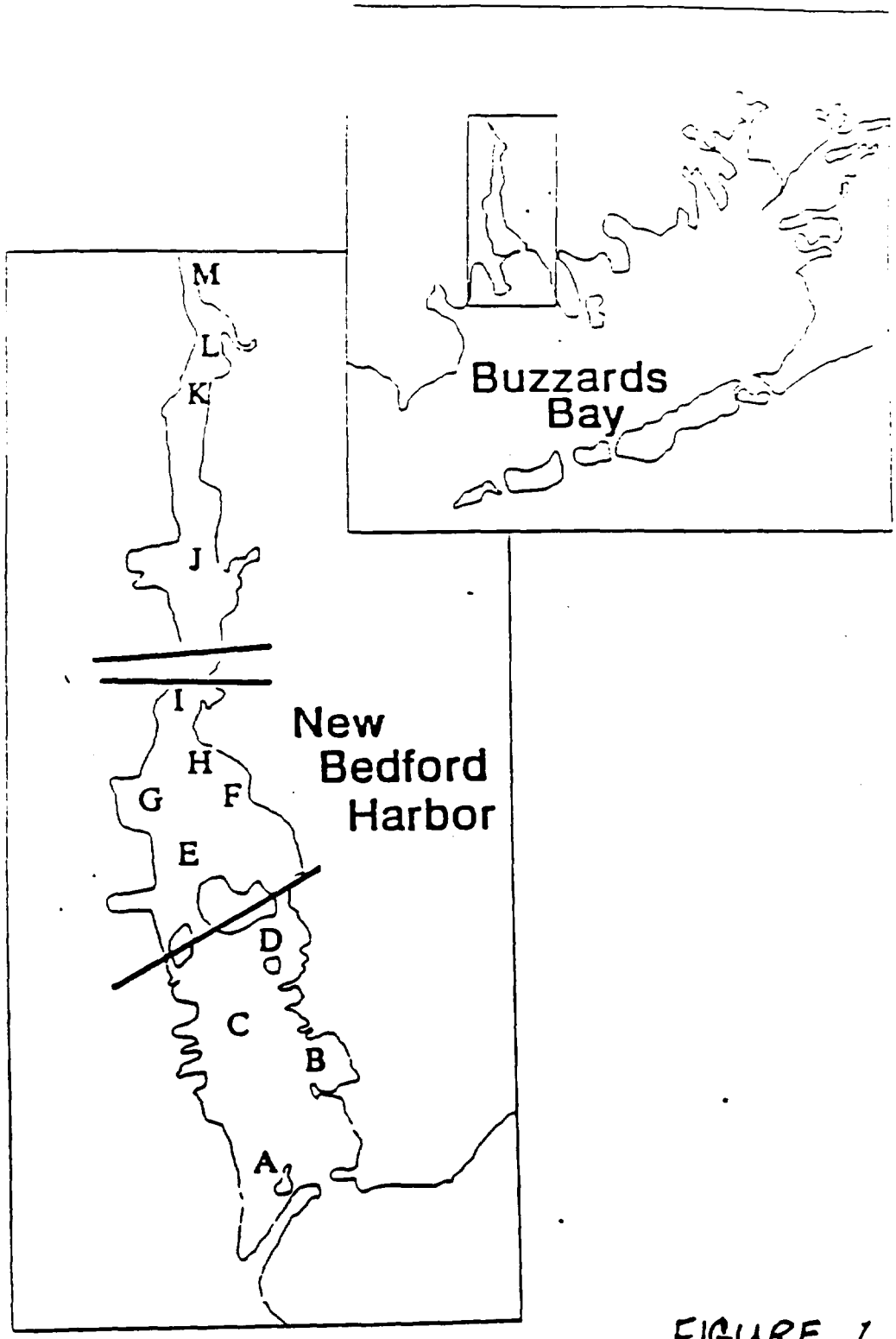

FIGURE 1

610. Sediment of NBH contained PCBs that appeared to be mixtures of Aroclors 1016 and/or 1242 (which were indistinguishable from each other) and Aroclor 1254.

611. Sediment-associated constituents can affect biota toxicologically or (emphasis added to distinguish between alternatives) result in high concentrations of constituents in tissues of indigenous organisms.

612. Organic carbon content of sediment is a major factor controlling bioavailability of nonpolar organic constituents such as PCBS.

613. Remediation of excessive concentrations of PCBs in sediment of NBH should reflect the environmental implications of constituents that do not covary distributionally with PCBs and the combined effects of all constituents associated with sediment of NBH. -

614. As inferred above, biological effects from constituents other than PCBs (e.g., metals) are to be expected in NBH.

Report/Source: A summary of data on tissue contamination from the first three years (1986-1988) of the mussel watch project (NOAA, 1989)

615. Body burdens of arsenic, chromium, silver, and low-molecular-weight polycyclic aromatic hydrocarbons (LMW PAHS) in blue mussels at selected stations in Buzzards Bay were reported to have significantly increased during the period of 1986 through 1988.

616. Body burdens of PCBs in mussels remained stable during the above-referenced period.

617. Molluscan body burdens of PCBs normalized for lipid content were more variable (coefficient of variation = 57%) than body burdens reported in terms of whole soft tissue (coefficient of variation = 50%).

618. Molluscan body burdens of PCBs were not correlated with lipid content of mollusks (correlation coefficient = -0.005).

619. The scientific usefulness of describing PCB body burdens of mollusks in terms of lipid content of the organisms is questionable according to results of this study.

620. Molluscan body-burden data were reported to incorporate species differences and not to be universally and strongly correlated with sediment contamination.

621. Sediment analyses, as contrasted to molluscan analyses, were reported to provide better measures of differences in contamination among sites.

622. In the SES (1988) wetland study, samples taken at the Popes Beach reference site wetland study area contained levels of PCBs and metals comparable to the wetland study site in the New Bedford Harbor Estuary.

623. In the SES (1988) wetland study, levels of chromium were found in the sediment at the Popes Beach reference site ranging from 3 to 180 parts per million.

624. In the SES (1988) wetland study, levels of copper were found in the sediment at the Popes Beach reference site ranging from 8 to 1400 parts per million.

625. In the SES (1988) wetland study, levels of lead were found in the sediment at the Popes Beach reference site ranging from <5 to 430 parts per million.

626. In the SES (1988) wetland study, levels of zinc were found in the sediment at Popes Beach reference site ranging from 26 to 800 parts per million.

627. The SES (1988) wetland study reported that growth of sea lettuce (Ulva lactuca) growth was lush and green, an indication that inner New Bedford Harbor waters have enriched levels of nitrogen and phosphorus.

628. Reinisch, et al. (1986) is a report reasonably relied upon by experts in the field of environmental toxicology.

629. In the SES (1988) wetland study the reference study area at Popes Beach was near Hacker Street Flat which has been reported (Reinisch et al., 1986) to have very high levels of metals, PCBs and other contaminants (1988).

630. In order for sampling results from environmental studies to be statistically reliable it is necessary to have estimates of within - and between sample variability.

631. In the SES (1988) wetland study, there was no effort to collect statistically reliable data on wetlands flora, benthic invertebrates and estuarine fishes, saltmarsh insects, birds, terrestrial mammals, or endangered, threatened, rare, and unique species.

632. All results reported in SES (1988) is of an observational and qualitative nature, much of it relying on secondary sources of information.

633. The SES (1988) wetland study reported that there were bird censuses conducted on eight days. On only one of those days were any species of tern documented to have been present.

634. The SES (1988) wetland study reported that the bird census was conducted on eight dates. On only one of those dates was a peregrine falcon sighted.

635. In the SES (1988) wetland study the application of non-parametric statistical tests or community structure analyses to the data resulting from bird censuses results in extremely limited information with which determine avian community structure and usage of these habitats

636. The SES (1988) wetland study states that there are no visual signs of stress that may be the result of heavy metal or PCB toxicity in the vegetational community.

637. There are no visual signs of stress that may be the result of heavy metal or PCB toxicity in the vegetational community.

638. The SES (1988) wetland study states that the contaminated saltmarshes did not have a lower productivity than the control marshes.

639. The contaminated saltmarshes did not have a lower productivity than the control marshes.

640. The SES (1988) wetland study states that it is not known what factor(s) are regulating the distribution of [benthic] organisms within the Acushnet River Estuary; it may be a natural biological phenomenon or a combination of stresses including possible exposure to low salinity water, nutrient enrichment, and sublethal toxic effects of heavy metals, as well as PCBs.

641. It is not known what factor(s) are regulating the distribution of [benthic] organisms within the Acushnet River Estuary; it may be a natural biological phenomenon or a combination of stresses including possible exposure to low salinity water, nutrient enrichment, and sublethal toxic effects of heavy metals, as well as PCBs.

642. The SES (1988) wetland study states that it is unlikely that "small mammals inhabiting wetlands/uplands adjacent to the Acushnet River Estuary are being negatively impacted by the presence of the high contaminant levels."

643. It is unlikely that small mammals inhabiting wetlands/uplands adjacent to the Acushnet River Estuary are being negatively impacted by the presence of the high contaminant levels.

644. The SES (1988) wetland study states that "toxic effects from PCBs to nonaquatic wildlife species located in the lower trophic level (e.g. herbivores) would not be anticipated based on available literature and the data from this study.

645. Toxic effects from PCBs to nonaquatic wildlife species located in the lower trophic level (e.g. herbivores) would not be anticipated based on available literature and the data from this study.

646. In the SES (1988) study, the statement that "biomagnification of the PCB contamination levels appear to be occurring within the wetlands of the Acushnet River Estuary based on the results of this study" is without any statistical foundation.

647. The SES 1988 wetland study states that the presence of high levels of PCBs and heavy metals in the New Bedford Harbor System and especially within the Inner Harbor and Upper Acushnet Estuary is generally viewed as the major environmental issue within New Bedford Harbor. (ES)

648. The presence of high levels of PCBs and heavy metals in the New Bedford Harbor System and especially within the Inner Harbor and Upper Acushnet Estuary is generally viewed as the major environmental issue within New Bedford Harbor. (ES)

649. The presence of high levels of heavy metals in addition to PCBs is generally viewed as the major environmental issue within New Bedford Harbor. (ES)

650. The SES 1988 wetland study states that a comparison of the Pope Beach and Acushnet River Estuary wetland suggests that the structural characteristics of the estuary wetlands have not been altered by the PCB contaminant levels. (ES)

651. A comparison of the Pope Beach and Acushnet River Estuary wetland suggests that the structural characteristics of the estuary wetlands have not been altered by the PCB contaminant levels.

652. The SES 1988 wetland study states that the wetlands within the Acushnet River Estuary appear to represent a diverse and productive system. (ES)

653. The wetlands within the Acushnet River Estuary appear to represent a diverse and productive system.

654. The SES 1988 wetland report states that heavy metals (Cr, Cu, Pb and Zn) are bioaccumulating within the tissues of selected organisms. (ES)

655. Heavy metals (Cr, Cu, Pb and Zn) are bioaccumulating within the tissues of selected organisms.

656. The SES 1988 wetland study states that toxic effects from PCBs to terrestrial species located in the lower trophic levels are not anticipated. (ES)

657. Toxic effects from PCBs to terrestrial species located in the lower trophic levels are not anticipated.

658. The SES 1988 wetland report states that although the waters of the Acushnet River Estuary are classified as SB by the Massachusetts Division of Water Pollution Control, they do not meet the SB criteria because of the problems with dissolved oxygen, coliform bacteria, heavy metals, as well as PCBs. (3-14)

659. Although the waters of the Acushnet River Estuary are classified as SB by the Massachusetts Division of Water Pollution Control, they do not meet the SB criteria because of the problems with dissolved oxygen, coliform bacteria, heavy metals, as well as PCBs.

660. The SES 1988 wetland study states that total concentrations for copper and lead were 10 to 1000 times higher than the US EPA Marine Water Quality Criteria of 2.9 parts per billion and 140 parts per billion, respectively. (3-17)

661. Total concentrations for copper and lead were 10 to 1000 times higher than the US EPA Marine Water Quality Criteria of 2.9 parts per billion and 140 parts per billion, respectively.

662. At no point in the SES study is there any mention of .79 parts per trillion PCB as an ambient water quality criteria for PCBs.

663. The SES 1988 wetland study states that elevated levels of selected metals (Cr, Cu, Pb, and Zn) were detected in surface sediments (0-30 cm deep) throughout the wetland. (3-26)

664. The SES 1988 wetland study states that the occurrence of relatively high concentrations of selected metals at locations within the Popes Beach and Acushnet River Estuary Wetlands suggests that metal contamination in this area is a geographically widespread phenomenon. (3-26)

665. The occurrence of relatively high concentrations of selected metals at locations within the Pope Beach and Acushnet River Estuary Wetlands suggests that metal

contamination in this area is a geographically widespread phenomenon.

666. The SES 1988 wetland study states that most infaunal species live in the upper (0-10 cm) layer of the sediment. (3-60)

667. Most infaunal species live in the upper (0-10 cm) layer of the sediment.

668. The SES (1988) wetland study states that among the avian species recorded during the censuses there were a comparatively high density of water birds for the New England region at these dates. (3-67)

669. The SES (1988) wetland study states that the avian census conducted in September 1986 at the Pope Beach site recorded far fewer species and numbers of individuals than the Acushnet Estuary September survey. (3-67)

670. The avian census conducted in September 1986 at the Pope Beach site recorded far fewer species and numbers of individuals than the Acushnet Estuary September survey.

671. The SES (1988) wetland study states that its comparisons of the study site, the Upper Acushnet River Estuary, with the Popes Beach site showed no significant reduction of bird species or density in the study site saltmarsh and uplands edge habitats.

672. The SES (1988) wetland report states that the Massachusetts Natural Heritage Program was unaware of any rare plant or animal special population or ecologically significant natural communities in the study area. (3-81)

673. The Massachusetts Natural Heritage Program did not consider the Roseatetern colony on Bird Island in Buzzards Bay to be relevant to the SES study.

674. The SES (1988) wetland study states that elevated levels of metal were detected in the saltmarsh vegetation. (5-2)

675. The SES (1988) wetland study states that the potential adverse affects of metals released from marsh sediments is the metal enrichment in the saltmarsh grass litter, an integral part of the detrital food web within saltmarshes. (5-2)

676. The SES (1988) wetland study states that the avian census did not reveal any decrease in bird diversity or abundance at the Acushnet River Estuary when compared to the control site. (5-3)

677. The SES (1988) wetland study states that there is little scientific literature available which detailed the effects of consuming quantitative amounts of PCBs on various wildlife species.

678. There is little scientific literature which detailed the effects of consuming quantitative amounts of PCBs on various wildlife species. (5-3)

679. The SES (1988) wetland study states that heavy metals appear to be bioaccumulating within the biota of the Acushnet River Estuary.

680. The SES (1988) wetland study states that metal contaminants are of concern in the Acushnet River Estuary and its associated wetlands. (6-4)

681. The SES (1988) wetlands report states that since the construction of the hurricane barrier, sediment accretion rates in the Upper Acushnet River Estuary have ranged from 1.7 to 4.0 cm per year. (7-1)

682. Sediment accretion rates in the Upper Acushnet River Estuary range from 1.7 to 4.0 cm per year.

683. The SES (1988) wetland report, states that based on these rates of accretion, 17 to 40 cm (0.6 to 1.3 feet) of sediment would accumulate on the bottom of the estuary within 10 years, covering existing contaminants. (7-1)

684. The SES (1988) wetland report, states that the zone of bioturbation is primarily within the top 9 cm (3.5 inches). (7-1)

685. The zone of bioturbation is primarily within the top 9 cm (3.5 inches).

Report/Source: Wetland study report for the New Bedford Superfund Site: final report, IEP, June 1988.

686. In part, this study purports to address bioaccumulation, particularly biomagnification, of xenobiotic constituents (including PCBs and various metals) in Acushnet River biota.

a. Bioaccumulation is conventionally defined as transfer of xenobiotic constituents from unspecified environmental sources (e.g., water, sediment and food) to aquatic organisms.

b. Biomagnification is conventionally defined as transfer of xenobiotic constituents from prey (lower trophic levels in food chains) to aquatic organisms in substantial amounts.

c. Statements appearing throughout this report indicate that the author(s) may not understand the difference between bioaccumulation and biomagnification.

d. Such statements (or phrases) typically employ the terms "food chain" or "trophic" to refer to "bioaccumulation," leaving the reader unsure as to whether "general" bioaccumulation of constituents in aquatic species occupying different food-chain or trophic levels is being alleged or, conversely, if biomagnification between trophic levels is being suggested.

687. In the IEP (1988) wetland study, it was suggested that differences in the benthic community structure between the wetland study areas could be attributed to environmental variables other than concentration of various contaminants, e.g., such as sediment textural characteristics and sediment chemistry.

688. The study primarily focuses upon a food chain (web) that purportedly consisted of grass shrimp being eaten by mummichogs and winter flounder.

a. No attempt was made to document through site-specific food-habits studies that this purported food chain is operative in the Acushnet River wetlands.

b. No attempt was made to document temporal variability of the purported food chain.

c. No attempt was made to relate age, size, or lipid content of collected organisms to body burdens of PCBS.

d. No preliminary estimate was made of the number of organisms required to establish the presence or absence of biomagnification at an acceptable level of statistical precision.

689. The PCB data base for the main focus of the study was limited as follows --

a. Grass shrimp: three replicates for each of six wetland areas (Areas 1,2 [a reference area in another bioaccumulation study; Sanford Ecol. Serv., 1988] 3, 4, 5, and 9);

b. Mummichogs: three replicates for each of three wetland areas (Areas 2, 5, and 9); and

c. Winter flounder: two replicates for one wetland area (Area 2).

690. Confusion exists as to the sampling locations for fishes in that the report identifies these sampling locations to be "Wetlands 2, 5, and 9" [p. 176 of report] and "Wetland Sites 2, 5, and 9" [p. 175 of report]. The report then states [p. 169] that "Site 1 = Wetlands 1, 3, and 5; Site 2 = Wetlands 4 and 9; and Site 3 = Wetland 2."

691. The previously-referenced replicates for grass shrimp, mummichogs, and winter flounder appear to have been analytical replicates of the same biological samples, (as contrasted to replicates pertaining to different groups of animals), thereby precluding a determination of natural variation in body burdens of PCBs in these three types of aquatic organisms.

692. The report is characterized by the critical omission of not identifying whether PCB levels reported in organisms pertain to wet or dry weight of organisms.

693. Evaluation of the purported grass shrimp and mummichog/winter flounder food chain was reported to indicate that:

a. "movement of PCBs through food chains is occurring...";

b. "PCB ... ingestion by mummichogs ... is probably related more to its predation on consumer organisms, such as shdmp ...";

c. "the mummichog, in turn, serves as a food source for several species of larger finfish as well as predatory wading birds ... PCB transfer to these trophic levels is therefore likely ..."; and

d. "the winter flounder is also omnivorous, feeding on isopods, copepods, amphipods, shrimp, crabs, worms, mollusks, and some seaweed .... PCB ingestion through any of these species is possible .... bioaccumulation of PCBs through these food chains is indicated by the data."

e. It was also reported that data "were geared" to an evaluation of "bioaccumulation/bioconcentration" patterns between "lower trophic levels" and winter flounder "<u>or</u> <u>other</u> <u>sport</u> <u>finfish</u>" [emphasis added].

694. The above-referenced conclusions are highly speculative and have no basis in fact with the limited data that were collected.

a. Sport finfish other than winter flounder were not sampled or evaluated.

b. Winter flounder (an unspecified number of fish) were collected from just a single wetland area (Area 2), which was supposedly a reference area.

c. It was reported that "flounder was only taken off of Wetland 2, making comparisons with this species impossible."

d. Concerning PCB biomagnification in the purported grass shrimp - mummichog trophic link, it was reported that "detailed statistical analyses cannot be done on these data due to the insufficient number of samples and subsamples" and that "the data lack the power to discriminate statistically significant differences between species ... [or] trophic levels..."

695. With regard to statistical interpretation of PCB body burdens in grass shrimp versus mummichogs:

a. the mean PCB level in grass shrimp collected from all wetland areas except the reference area (Area 2) was 8.13 ppm (PCB values for individual wetland areas were: 7.63, 25.33, 2.40, 3.60, and 1.67 ppm);

b. the mean PCB level in mummichogs (also excluding the reference area) was 26.05 ppm (PCB values for individual wetland areas were: 44.00 and 8.1 0 ppm);

c. a parametric statistical evaluation (parametric unpaired "t" test) applied to the two data sets (after Cochran's test indicated homogeneity of variances of the two data sets) demonstrates the absence of a significant difference at $P = > 0.10$ (with the assumption of a two-tailed alternative to the null hypothesis);

d. consequently, the observed difference in PCB body burdens of grass shrimp and mummichogs is statistically nonsignificant.

696. The statement in the IEP (1988) wetland study that the data presented in the SES (1988) bioaccumulation study "clearly indicate a PCB bioaccumulation/biomagnification

trend in the Acushnet Estuary is not supported by data presented in the SES (1988) study.

697. In particular, there is inadequate data to show any statistically significant trend in bioaccumulation either within a species group or among species reported to be part of the same food chain.

698. All statements in the IEP (1988) or SES (1987) suggesting that trends in the data of PCB body burden exists are without foundation because they failed to take adequate samples so that appropriate statistics could be applied to evaluate whether or not differences in sample results were due to chance or to significant differences.

699. In order to collect an adequate number of samples with which to draw conclusions regarding differences between sampling results, it is necessary to document within - and between sample variability.

700. All conclusions reached in the SES (1987) or the IEP (1988) bioaccumulation study are without foundation because analysis of body burdens of PCBs in the species sampled was conducted without regard to the individual organism's age, size, sex, weight, or percent lipid content.

701. The statement in the IEP (1988) wetland study that "biomagnification of PCBs is apparent in several of the food chains investigated and suggest a widespread condition throughout the Acushnet River Estuary and Buzzards Bay," is without basis.

702. No neoplasms or tumors were reported on livers of examined winter flounder (13 fish).

703. The overall effect of PCB contamination and bioaccumulation on the biological systems in the estuary was reported as not being readily apparent.

704. A large part of this report (approximately 50%) was devoted to bioaccumulation and biomagnification investigations other than the IEP study (in particular, the biomagnification investigation performed for the Acushnet River estuary by Sanford Ecological Services [1988]) as well as general and/or unsubstantiated comments pertaining to the issues of bioaccumulation and biomagnification.

705. Unreferenced independent investigations were cited as having "... demonstrated the dethmental impacts of PCBs on ... biological attributes in other fish species."

706. The poor scientific quality of this report precludes it from contributing to an understanding of PCB dynamics in aquatic organisms indigenous to the New Bedford Harbor area.

Wetland Study Report for the New Bedford Superfund Site by IEP, Inc. (1988)

707. In the IEP (1988) wetland study wetland two, located approximately 3,000 feet to the east of the Acushnet River Estuary, was selected as a comparative or reference site to which wetlands in the New Bedford Harbor Estuary would be compared.

708. In the section of the IEP (1988) wetland study describing sampling methodology for sediment collections, the word "random" as used in the discussion does not apply in a statistical sense.

709. In the IEP (1988) wetland study, samples of saltmarsh sediments from the five wetland area studies indicated that chromium, copper, lead, zinc, and PCBs were found at all locations at similar ranges of concentrations.,

710. The IEP (1988) wetland study states that metal contamination is widespread throughout the New Bedford Harbor Estuary.

711. Metal contamination is widespread throughout the New Bedford Harbor Estuary.

712. The IEP (1988) wetland study states that metal contaminants may have been released from industrial activities into the estuary over a longer period of time, and in higher concentrations, than the PCBs.

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714. The IEP (1988) wetland study states that "the data from both the SES [1987] and IEP [1988] [studies] have limitations for extensive quantitative analysis; only qualitative statements can be made regarding the comparison of the two data sets."

715. The data from both the SES [1987] and IEP [1988] [studies] have limitations for extensive quantitative analysis; only qualitative statements can be made regarding the comparison of the two data sets.

716. The IEP (1988) wetland study states that the qualitative statements are backed by recognizable trends in the concentrations of chemicals in the wetland systems.

717. Although the implication of the previous two statements is that any differences in data collected between respective wetland areas can indicate a trend, the statistical foundation for concluding that trends exist in these data has not been established.

718. In the IEP (1988) wetland study, analysis of variance using different level taxa by lumping genera with family or orders results in information that has little, if any, usefulness in defining or describing the structure of benthic or intertidal communities since within taxa higher than species there are likely to be a variety of niches occupied by various species.

719. In the IEP (1988) wetland study, the use of diversity and evenness indices to define a community structure is not presented in sufficient detail to ascertain whether or not different taxonomic groups were included as part of the analysis.

720. In the IEP (1988) wetland study, if such community structure indices as species diversity and evenness included different level taxa, then usefulness of the community structure analyses is limited and conclusions drawn from the analyses, misleading.

721. In the IEP (1988) wetland study, the fact that diversity index varied between sampling periods and wetlands is no foundation for quantifying the structure, function or health of the benthic wetland communities.

722. In the IEP (1988) wetland study, it was suggested that differences in the benthic community structure between the wetland study areas could be attributed to environmental variables other than concentration of various contaminants, e.g., such as sediment textural characteristics and sediment chemistry.

723. Differences in the benthic community structure between the wetland study areas could be attributed to environmental variables other than concentration of various contaminants, e.g., such as sediment textural characteristics and sediment chemistry.

724. The IEP (1988) wetland study states that: "diversity in wetland one, the wetland study area in the upper estuary] was low, indicative of the stress, as estuaries generally are (Rhoads, et. al., 1978)."

725. The diversity in the wetland study area in the Upper Estuary was low, indicative of the stress, as estuaries generally are (Rhoads, et. al., 1978).

726. The finfish population study conducted by IEP in their 1988 wetland study has little usefulness in defining the population structure and usage of the New Bedford Harbor Estuary by endemic or migratory finfish species because of the sampling methodology employed and the sampling frequency used.

727. The finfish study conducted by IEP (1988) in their wetland study failed to quantitatively estimate with any reliability, either demersal or pelagic finfish species because of the sampling methodology employed and the sampling frequency used.

728. Any conclusions reached in the IEP finfish study (1988) conducted during the wetland study are speculative because the [foundation of] data used in making these conclusions is inadequate.

729. In the study of avifauna conducted during the IEP (1988) wetland study, there was no data collected that would indicate frequency or fidelity of usage of the Upper New Bedford Estuary as a feeding habitat for any of the tern species.

730. During the IEP (1988) wetland study no species listed as threatened or endangered were observed in the New Bedford Harbor Estuary during the study period.

731. In the IEP (1988) wetland study, there were no neoplasms or tumors of the livers observed in the winter flounder Pseudopleuronectes americanus, that were examined.

A Wetland Analyses in a Highly Polluted Harbor - New Bedford, Massachusetts, USA by the Army Corps of Engineers USACE-NED (1989)

732. **The USACE-NED (1989) wetland analysis report states that the least tern nests primarily on mainland beaches in variable size colonies and forages on the silverside, Menidia menidia.**

733. **The least tern nests primarily on mainland beaches in variable size colonies and forages on the silverside, Menidia menidia.**

734. **In the USACE-NED (1989) wetland analysis report, any conclusions related to differences in community structure**

in the wetlands studied is confounded by grouping and comparison of different level taxa in the same analyses

735. Conclusions reached based upon community structure analyses which group and compare different level taxa are not valid.

736. Both the IEP (1988) and the USACE-NED (1989) reports that cell extracts from the soft shell clam (Mya arenaria) tumors were related to presence of PCB congeners, citing a paper by Reinisch et al., (1984).

737. The conclusion by IEP (1988) and USACE-NED (1989) does not correctly portray the conclusions or the basis for the conclusions reached in the Reinisch et al., (1984) report.

738. In the discussion of bioaccumulation findings in the USACE-NED (1989) wetland analysis report, all statements indicating that biomagnification may be taking place with any of the food chains studied are without statistical foundation. Differences seen may have been attributable to chance.

739. Statements in the USACE (1989) wetland analysis report relating to the capability of certain speed currents resuspend certain size sediment particles do not take into consideration the other physical factors in the sediment bed that retard the resuspension of sediment particles. (28)

740. The statement in the USACE-NED (1989) wetland analysis report relating current speed to resuspension of sediment particles is therefore inaccurate.

741. Statements in the USACE-NED (1989) wetland analysis report relating to differences in the community structure in the wetlands studied are not supported by the data since the analysis was confounded by taking into consideration different level taxa within the comparison period.

742. Utilizing taxa above species level in statistical comparisons or in community structure indices does not adequately account for the fact that generally subtaxa within families or within orders may have substantially different ecological niches.

743. In the USACE-NED (1989) wetland analysis report, community structure indices and other analyses compared the results of samples using taxa, some of which were the generic or family level.

744. In the USACE-NED (1989) wetland analysis report, the discussion relating to fish species composition and its relationship to the Upper Estuary is based upon an inadequate sampling plan.

745. Studies of the finfish community in the Upper Estuary of New Bedford Harbor upon which the USACE-NED (1989) wetland analysis report relies were flawed by having inadequate sampling both in terms of replication of samples and frequency of samples.

746. Conclusions reached in the USACE-NED (1989) wetland analysis report relating to the finfish community and Upper New Bedford Harbor are based upon inadequate numbers of samples.

747. The USACE-NED (1989) wetland analysis report states (page 36) that the concentration of Aroclor 1254 in the ring-billed gull, the muscle, the snail, and the mouse indicates that biomagnification may be taking place within this food chain.

748. The reports upon which the USACE-NED (1989) wetland analysis report relies have not developed a statistically reliable foundation with which to make this conclusion relating to biomagnification.

749. The conclusion in the USACE-NED (1989) wetland analysis report that the data for Peromyscus leucopus "suggest that biomagnification of PCBs may be taking place within this food chain as well" is not supported by the data.

750. There is inadequate data from the study of Peromyscus leucopus in the USACE-NED (1989) wetland analysis report to base any conclusion on biomagnification within a food chain participated in by Peromyscus leucopus.

751. In the USACE-NED (1989) wetland analysis report, the statement that "in general the data show a gradual increase in the order of magnitude of the PCB concentration from vegetative matter to herbivore/filter feeder levels is not supported by the data.

752. The statement in the USACE-NED (1989) wetland analysis report relating to the relative concentration of PCB from vegetative matter to herbivore/filter feeder level is inaccurate.

753. The USACE-NED (1989) wetland analysis report states that "to ascertain whether animal populations are in decline due to the presence of contaminants or other biotic factors within the estuary, transplant experiments and experiments which expose organisms to known quantities of existing contaminants need to be performed." (39)

754. To ascertain whether animal populations are in decline due to the presence of contaminants or other biotic factors within the estuary, transplant experiments and experiments which expose organisms to known quantities of existing contaminants need to be performed.

755. The USACE-NED (1989) wetland analysis report states that plant biomass vegetative structure, benthic and fish community composition structure and avian bird [illegible] and mammal do not demonstrate PCB and heavy me[illegible] contamination effects.

756. Composition and structure of the avian [illegible] in the wetlands in New Bedford Harbor do not [illegible] PCB contamination effects. (39)

757. With regard to the IEP study, Bellm[illegible] that no neoplasms were observed on livers of winter flounder (13 fish) collected by IEP.

758. With regard to both the IEP and Sanford studies (and possibly other studies), Bellmer stated that "despite very high levels of contaminants as well as evidence of bioaccumulation, these [NBH] wetlands are functioning as effective systems and they have high resource values. These wetlands continue to support and produce biota representative of New England estuaries. Plant biomass and vegetative structure, benthic and fish community composition and structure, and avian and mammal [sic] do not demonstrate PCB and heavy metal contamination effects. Most data for PCBs found in the literature are from tissue level studies."

759. With regard to the IEP and Sanford studies (and possibly other studies), Bellmer concluded that "... these data showed no clear evidence for biomagnification..."

BENTHIC STUDIES, New Bedford Superfund Project Benthic Sampling, Prepared by Sanford Ecological Services, Inc. January 1987

760. Sanford Ecological Services, Inc. (SES, 1987) conducted a sampling of the benthic community in New Bedford Harbor "for the purpose of determining the existing benthic community within the area."

761. The SES (1987) study states that 22 randomly selected stations were sampled at each of which 3 samples were collected using a Smith-McIntyre grab (0.1 meter 2 in area).

762. Figure 2-1 in the SES (1987) benthic study indicates 14 stations.

763. There is no indication in the SES (1987) benthic study that stations sampled were chosen randomly, in a statistical sense, or that replicate samples taken at each station were chosen in a random fashion, in a statistical sense.

764. It is unclear how many sampling stations were used in the SES (1987) study.

765. SES (1987) benthic study indicated that a total of 66 benthic samples were collected.

766. There is no indication that in the laboratory identification of species in the SES (1987) benthic study the quality control procedure for resorting samples was effective and accurate in determining the identification of species or species abundances within a sample.

767. There is no documentation as to why some species were categorized as infaunal versus epifaunal species.

768. In the SES (1987) benthic study, it is not clear whether station 16 had 3 replicates sampled or only 2.

769. In the SES (1987) benthic study, there is no justification other than conjecture that sample 17-A was actually a sample taken from station 16.

770. In the SES (1987) benthic study the listing under polychaetes of the species Hydroides dianthus may be the same species as individuals classified as Serpulidae sp.

The Infaunal Community of a Polychlorinated Biphenyls Polluted Harbor, New Bedford, Massachusetts, USA (Bellmer, 1988)

771. Bellmer (1988) states that "The analyses presented in this text are based on limited data (one sampling period). This analyses [SIC] should be viewed as preliminary in nature."

772. The Bellmer (1988) report states that "physiological studies indicate no clear relationship between pollutant concentrations and the survival of benthic organisms."

773. The Bellmer (1988) report states that "the use of a community structure indices[a] with these data is effective for revealing the ecological effects of PCB and heavy metals."

774. There is no scientific justification for concluding the statement referenced above.

775. In the Bellmer (1988) benthic report the reference to Sokal and Rohlf (1980) discussing the design of the benthic field sampling program is misleading. Sokal and Rohlf (1980) had no part in designing this field sampling program.

776. The Bellmer (1988) study states that 22 stations were sampled using a 0.1 m2 Smith-McIntyre grab.

777. The Bellmer (1988) study states that 4 stations in the upper estuary were sampled using a Van Veen grab which sampled the surface area of 0.04 m2.

778. The 0.04 m2 Van Veen grab sampled area approximately 2.5 times less than the 0.1 m2 Smith-McIntyre grab.

779. In any benthic study the number of species and individuals sampled should be determined based on the surface area and volume of the sediments sampled and is dependent upon the characteristics of the distribution of each species.

780. There is no evidence that the characteristics of the distribution of the species sampled was taken into consideration in designing the sampling plan in Bellmer (1989).

781. There is no indication in the Bellmer (1988) benthic study that the results from sampling with the 0.04 m2 Van Veen grab and the 0.1 m2 Smith-McIntyre grab were normalized to account for the use of different size sampling gear.

782. There was no intercomparability study conducted between the 0.04 Van Veen grab and the 0.1 m2 Smith-McIntyre grab to assure that the basis for comparing the results of these samples was valid.

783. Such an intercomparability study should have been conducted to validate the comparison of results from the two different-sized grabs.

784. In Table 1 of the Bellmer (1988) benthic report, the numbers of species and numbers of individuals collected at each station is substantially different from the numbers of species and individuals collected from each station as reported in the SES (1987) study.

785. The [number of] species reported in the SES (1987) benthic study includes taxa that are at a higher level of species, i.e. genera and family.

786. In the analysis conducted in the Bellmer (1988) benthic study report there is no adjustment for the fact that some of the taxa reported as genera or family may have included more than one species.

787. Even if species reported as epifaunal species by SES (1987) are eliminated from the SES (1987) data tables, the number of species and individuals are not the same as reported in Table 1 of Bellmer (1988).

788. There are many environmental variabilities including sediment characteristics as well as salinity, temperature, and dissolved oxygen, that can affect the distribution and abundance of species.

789. Only a limited number of environmental parameters associated with these other characteristics were documented in the SES (1987) benthic study.

790. It is probable that the distribution of species in the New Bedford Harbor Estuary is limited by the sediment oxygen demand.

791. It is likely that the species distribution and abundance in New Bedford Harbor is limited by interspecific dynamics of the endemic species.

792. It is probable that the distribution and abundance of benthic species in New Bedford Harbor could be limited by food supply.

793. It is probable that the distribution and abundance of benthic species in New Bedford Harbor could be limited by habitat availability.

794. It is probable that the distribution and abundance of benthic species in New Bedford Harbor could be limited in New Bedford Harbor by predation.

795. The statement in Bellmer (1988) that "several studies have shown a strong relationship between grain size and organic content of the substrate (Mayer, et. al. 1985)" has no relevance to this analysis of the benthos in New Bedford Harbor.

796. In the Bellmer (1988) study the statement that "the density of individuals per sample[s] ranged from 1,450 to 20,875" is of limited usefulness since no units were presented.

797. The various regression analyses presented in the Bellmer (1988) benthic report are of no usefulness since it has not been demonstrated in any way that numbers of species

varies linearly or logarithmically with levels of contaminants.

798. In the Bellmer (1988) benthic report the regression of diversity or evenness indices against concentration of PCBs is of no usefulness since it has not been demonstrated that diversity and evenness indices vary linearly or logarithmically with concentration of PCBs.

799. In the Bellmer (1988) benthic study Figure 7d is meaningless since the abscissa units are meaningless.

800. In the Bellmer (1988) benthic report Figure 7e is of limited usefulness since it has not been demonstrated that the density of species varies either linearly or logarithmically with concentration of PCB.

801. In the Bellmer (1988) benthic report Figure 7f is of no usefulness because the units on the abscissa have not been specified and there has been no demonstration that numbers of species vary in any way linearly or logarithmically with concentration of mercury.

802. In the Bellmer (1988) benthic report Figure 7f is of no usefulness because the units on the abscissa have not been specified and there has been no demonstration that numbers of species vary in any way linearly or logarithmically with concentration of arsenic.

803. In the Bellmer (1988) benthic report Figure 7h is of no usefulness since the abscissa has no units and there has been no demonstration that arsenic levels vary linearly or logarithmically with Shannon diversity indices.

804. In the Bellmer (1988) benthic report Figure 7h is of no usefulness since the abscissa has no units and there has been no demonstration that arsenic levels vary linearly or logarithmically with Pielou evenness indices.

805. In the Bellmer (1988) benthic report the statement that the study results show that the infaunal data (i.e. number of species, community index, community evenness) do correlate[d] with the levels of pollution has not been demonstrated in any way.

806. In the Bellmer (1988) benthic report the statement that "as these [contaminant] levels increased in the samples the number of species decreased" is of limited usefulness since no cause and effect relationship has been demonstrated.

807. In the Bellmer (1988) benthic report the statement that "infauna are more sensitive to pollution than epifaunal

species because they interact with the sediments to a higher extent" is not supported by the study.

808. The statement in Bellmer (1988) benthic report that "organisms which are constantly exposed to the sediments accumulate higher concentrations of pollutants than epifaunal species" has not been documented for New Bedford Harbor.

809. The statement in the Bellmer (1988) study that "the infaunal benthic community in the study is responding to the high levels of PCBs in the sediment" has not been demonstrated by the data or the analysis resulting from this report.

810. In fact, any changes in the benthic community documented by Bellmer (1988) could just as well have been a result of other environmental variables measured or not measured in this study, i.e., sediment oxygen demand, organic content of sediments, salinity or temperature regime, and interspecific species dynamics.

811. It is stated in Bellmer (1988) that "the response record here may be due to some degree by other factors (e.g., other pollutants, etc.) not measured during this sampling effort."

812. The statement in the Bellmer (1988) benthic report that both the evenness (J') and diversity indices (H') decreased with an increase in the PCB concentrations should not be taken to imply a cause and effect relationship based on the evidence presented in this report.

813. The statement in Bellmer (1988) benthic report that "in this study the species community indices (H' and J') and regression analysis have detected infaunal community changes due to pollution" has not established any cause and effect relationship.

814. **Within the context of this report it is a misuse of community analysis indices.**

815. The following are additional references utilized in this section:

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PCB BACKGROUND CONCENTRATIONS
(CONCENTRATIONS BASED ON TOTAL PCBs)

STUDY LOCATION	REFERENCE	CONCENTRATION RANGES (ppt)
Surface Water:		
USGS national survey of surface water bodies	Crump, Weisner, et al., 1974	100 - 4,000
Lake Nurume, Antarctica	Tanabe et al., 1983	0.048
Ocean Water:		
North Pacific	Tanabe & Tatsukawa, 1980	0.27 - 1.11
Antarctica	Tanabe et al., 1985	0.052 - 0.072
Rainfall:		
Lake Superior area	Strachan, 1988	1.7 - 23
Cree Lake, northern Saskatchewan	Strachan, 1988	3.1
Kouchibouguac, New Brunswick	Strachan, 1988	1.1
Snowpack:		
Northwest Territories	Gregor & Gummer, 1989	0.02 - 1.74
Antarctica	Tanabe et al., 1985	0.16 - 1.0

NOTES:

1. Reported ranges are presented as parts per trillion (ppt) for purposes of comparison.

April 18, 1990
Halcom Project 6002-3588A

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COMPARISON OF NEW BEDFORD HARBOR BENTHIC SPECIES
WITH SPECIES IN OTHER LOCAL ESTUARIES

BENTHIC SPECIES	NEW BEDFORD HARBOR (Upper estuary)	NEW HAVEN HARBOR	THAMES RIVER	POCASSET RIVER	PETTAQUAMSCUTT RIVER
Polychaeta:					
Boccardiella hamata	R	-	-	-	-
Branla clavata	-	-	-	-	R
Capitella capitata	C	A	-	LC	LC
Eteone heteropoda	C	r	-	R	LC
Eumida sanguinea	LC	r	-	-	-
Glycera americana	LC	C	-	-	-
Heteromastus filiformis	LC	r	-	-	LC
Hypania invalida grayi	-	-	-	A	LC
Lumbrineris tenuis	R	r	-	-	-
Maldanopsis elongata	-	r	R	-	-
Mediomastus ambiseta	LC	r	-	-	-
Nephtys caecoides	-	-	C	-	-
Nephtys incisa	R	LC	-	-	-
Nereis acuminata	LC	-	-	-	-
Nereis succinea	LC	A	-	C	C
Nereis virens	R	r	LC	-	-
Ninoe nigripes	-	-	LC	-	-
Pectinaria gouldii	LC	r	A	R	-
Podarke obscura	LC	r	-	-	-
Polydora ligni	LC	LC	LC	C	LC
Polydora socialis	LC	r	-	-	-
Pygospio elegans	-	-	-	C	-
Scoloscoloplides viridis	-	r	-	LC	LC
Scolopios fragilis	-	r	-	LC	-
Scolopios robustus	-	-	LC	-	C
Sthenelais boa	R	r	-	-	-
Streblospio benedicti	A	A	-	A	A
Tharyx acutus	A	r	-	-	-
Tharyx sp.	-	-	-	LC	-
TOTAL POLYCHAETE SPECIES:	19	20	7	11	10

NOTES:

A = Abundant
C = Common
LC = Less common
R = Rare
r = Rare (inferred from literature)
- = Not reported

Benthic species data derived from the following sources: New Bedford Harbor (Sanford Ecological Services, 1987), New Haven Harbor (Normandeau Associates, Inc., 1979), Thames River (Tolderlund, 1975), Pocasset River (Sanders et al., 1965), and Pettaquamscutt River (Nyland, 1981). Species totals are for purposes of comparison and, generally, do not include species collected from less than five percent of the samples.

SECTION VII
TABLE I
(RFA NO. 54)

COMPARISON OF NEW BEDFORD HARBOR BENTHIC SPECIES
WITH SPECIES IN OTHER LOCAL ESTUARIES

BENTHIC SPECIES	NEW BEDFORD HARBOR (Upper estuary)	NEW HAVEN HARBOR	THAMES RIVER	POCASSET RIVER	PETTAQUAMSCUTT RIVER
Oligochaeta:					
Tubificoides gabriella	-	-	-	(not identified)	A
Tubificoides spp.	C	-	-	(not identified)	-
TOTAL OLIGOCHAETE SPECIES:	1	0	0	4	1
Crustacea:					
Ampelisca abdita	-	-	-	-	C
Ampelisca vadorum	R	LC	-	-	-
Crangon septemspinosa	R	LC	-	R	-
Gammarus mucronatus	-	-	-	-	LC
Gammarus oceanus	-	-	C	-	-
Gammarus tigrinis	-	-	-	A	-
Microdeutopus gryllotalpa	LC	-	-	-	-
Neomysis americana	-	LC	-	-	-
Neopanope sayi	LC	-	-	-	-
Rhithropanoeus harrisii	-	-	-	-	LC
TOTAL CRUSTACEAN SPECIES:	4	3	1	2	3
Bivalvia:					
Gemma gemma	LC	A	-	A	-
Macoma balthica	-	r	-	LC	LC
Macoma sp.	-	-	-	-	R
Mercenaria mercenaria	LC	r	C	R	-
Mulinia lateralis	LC	LC	-	-	-
Mya arenaria	LC	r	LC	LC	-
Tellina agilis	LC	LC	-	-	-
TOTAL BIVALVE SPECIES:	5	6	2	4	2
Gastropoda:					
Crepidula fornicata	LC	r	-	-	-
Hydrobia sp.	-	-	-	A	-
Nassarius obsoletus	C	A	C	R	-
Nassarius trivittatus	R	r	-	-	-
Tergipes despectus	-	-	-	-	R
Teldia limatula	-	r	R	-	-
TOTAL GASTROPOD SPECIES:	3	4	2	2	1
TOTAL SPECIES NUMBER:	32	33	12	23	16

NOTES:

A = Abundant
C = Common
LC = Less common
R = Rare
r = Rare (inferred from literature)
- = Not reported

Benthic species data derived from the following sources: New Bedford Harbor (Sanford Ecological Services, 1987), New Haven Harbor (Normandeau Associates, Inc., 1979), Thames River (Tolderlund, 1975), Pocasset River (Sanders et al., 1965), and Pettaquamscutt River (Hyland, 1981).
Species totals are for purposes of comparison and, generally, do not include species collected from less than five percent of the samples.

816. To the extent that PCB congeners may have differential toxicological effects to aquatic organisms, it has not been verified that methodologies utilizing rat hematoma cells to predict suggested toxic can predict absolute toxicological effect of these congeners on aquatic organisms in bioassays or in the environment.

817. There have been very few aquatic exposure biassays utilizing different PCB congeners with aquatic toxicity species.

818. A relative paucity of information resulting from exposure of aquatic organisms to various PCB congeners in acute chronic bioassays prevents reliable predictions of the absolute effect or PCB congeners in the environment.

Assessment of Quincy Bay Contamination, Summary Report prepared for U.S. Environmental Protection Agency Region I, Boston, Massachusetts. June 1988.

819. A study was conducted to investigate the types and concentrations of pollutants in sediment deposits in Quincy Bay, Massachusetts, the incident of abnormalities and patterns of various contaminants, including PCB, PCB distribution in marine life and the potential public health implications of consumption of seafood exposed to contaminated Quincy Bay sediments for USEPA Region I by Metcalf & Eddy.

820. Quincy Bay sediment and aquatic organisms living in Quincy Bay are associated with various contaminants including lead, chromium, copper, PCB and PAHs.

821. Studies prepared for U.S. EPA report that in both Quincy Bay and New Bedford Harbor, hepatopancreas tissue ("tomalley") levels of polychlorinated biphenyls ("PCBs") exceeded the US FDA Tolerance Level.

822. In June 1988, EPA released a study of lobster taken from Quincy Bay, entitled "Assessment of Quincy Bay Contamination, Summary Report," June 1988 ("EPA Quincy Bay Study").

823. Results of the EPA Quincy Bay Study as set forth in Attachment Q.VII.0025 indicated that the edible tissue of both winter flounder and the lobster had PCB concentrations lower than the U.S. FDA tolerance level.

824. The results of the EPA Quincy Bay Study found that the tomalley exceeded the U.S. FDA tolerance level with concentrations being found up to approximately 61 parts per million wet weight.

825. The EPA Quincy Bay Study data reported that composited lobster meat, excluding the tomalley, contained 0.203 to 0.272 parts per million ("ppm") PCBs.

826. Based on reported levels, the EPA Quincy Bay Study data on PCB levels in Quincy Bay lobster tomalley measured a mean of 43 ppm net weight.

827. 1987 EPA data on PCB contamination in tomalley tissue in New Bedford Harbor lobster were reported at concentrations of 22.136 ppm for Closure Area 2; 14.414 ppm for Closure Area 3; and 3.691 ppm for Closure Area 4.

828. The EPA Quincy Bay Study reported measurements of mean PCB level in Quincy Bay lobster tomalley tissue exceeded the maximum reported levels of PCB contamination in tomalley tissue in three of the four closure areas of New Bedford Harbor.

829. While a maximum measurement of 80.308 ppm was reportedly found in lobster hepatopancreas tissue from Closure Area 1 in New Bedford Harbor, this measurement was based on samples taken from a single lobster.

830. Reported levels of PCBs found in lobster from Quincy Bay are similar to the median PCB levels reported for lobsters from the outer area of New Bedford Harbor, which is closed to lobstering.

831. One of the recommendations that followed from the study was that the Massachusetts Department of Public Health (DPH) should immediately issue a human health advisory regarding a risk from consumption of lobster tomalley.

832. In connection with the issuance of the EPA Quincy Bay Study, Paul Keogh, Deputy Director of Region 1, EPA, stated, "We fully expect they [Massachusetts DPH] will be issuing an advisory, warning the public not to eat lobsters not just from Quincy Bay but from any urban bay in Massachusetts." (Patriot Ledger, June 20, 1988.)

833. After the completion of the EPA Quincy Bay Study, EPA did not recommend the closure of Quincy Bay to lobster fishing.

834. After the completion of the EPA Quincy Bay Study, the DPH did not close Quincy Bay to lobster fishing.

835. After the completion of the EPA Quincy Bay Study, on or about June 20, 1988, the Massachusetts Department of Public Health ("DPH") issued a public health advisory stating that persons eating lobster should not eat the

tomalley. DPH did not state that consumers should not eat lobster from Quincy Bay or other urban bays in Massachusetts.

836. Referring to the EPA Quincy Bay study, the FDA District Director stated, "In my belief, the concern over the risks of consuming lobsters was overstated. It was overstated by people who put out reports that the sky is falling." (Boston Globe, April 9, 1989, South Weekly at 1.)

837. In August 1988, the federal Food and Drug Administration ("FDA") completed a study of lobster from Quincy Bay and other areas ("FDA 1988 Lobster Study").

838. The lobster meat from Quincy Bay that was analyzed in the FDA 1988 Lobster Study included the lobster tomalley.

839. The findings of the FDA 1988 Lobster Study as to analyses for PCBs in lobster meat, including the tomalley, were trace levels of PCBs in most lobster, PCB levels no higher than 1.2 ppm in composite samples of lobster from Quincy Bay, and PCB levels of 6.3 to 9.7 ppm in tomalley of lobster from Quincy Bay.

840. The FDA 1988 Lobster Study stated, "FDA scientists and expert advisors have concluded that the amount of tomalley consumed by an individual eating a lobster meal would have no toxicological significance because the tomalley represents an insignificant portion of a consumer's average total diet. Consequently, there are no toxicological reasons for consumers to refrain from eating tomalley as part of a lobster dinner."

841. After the issuance of the 1988 FDA Lobster Study, the FDA District Director, Edward McDonnell, stated, "Looking at these most recent samples [of samples from February 1988 through August 1988], there is no reason to question or to suggest a curtailment of commercial lobstering." (The Patriot Ledger, Tues., October 4, 1988 at 42.)

842. In June of 1989, FDA again tested lobster from Quincy Bay and Boston Harbor for PCB levels ("FDA 1989 Lobster Study"). The findings of the FDA 1989 Lobster Study were that levels of PCBs in composited samples of lobster meat, including the tomalley, ranged from 0.19 to 0.64 ppm.

843. The FDA 1989 Lobster Study results, like the FDA 1988 Lobster Study results showed levels under the FDA limit of 2.0 ppm PCBs in the samples of lobster meat.

844. Referring to the results of the FDA 1989 Lobster Study, Dr. Robert Scheuplein, Acting Director of the Office of Toxicological Sciences, of the FDA Center for Food Safety and Applied Nutrition, stated, "Are they safe? Yes, I eat them. But is there a small risk? Yes, but it wouldn't dissuade me from eating them or giving them to my children. In the absence of better information, we think that the risk is so small you can ignore it. It is much smaller than you get in a normal diet." (Boston Globe, July 6, 1989 at 19.)

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Alleged Injury to Birds

Birds In General

A. Roseate Terns

845. Prior to approximately 1920, herring gulls and black-backed gulls were not known to nest in or around Cape Cod, New Bedford Harbor, or the surrounding area.

846. Monomoy Island, Massachusetts, is the home of the largest colony of herring gulls and black-backed gulls in the northeastern United States, and one of the largest in the world.

847. Since at least 1930, the population of herring and black-backed gulls in or around Cape Cod, New Bedford Harbor, and the surrounding area, has increased significantly, due primarily to the increased availability of food from landfills or garbage dumps.

848. Between approximately 1930 and the mid-1970's, the population of roseate terns in or around Cape Cod, New Bedford Harbor, and the surrounding area, decreased due to the increasing population of black-backed gulls.

849. The primary threat to the present population of roseate terns in or around Cape Cod, New Bedford Harbor, and the surrounding area is the large populations of herring and black-backed gulls.

850. Herring and black-backed gulls prey on the eggs and chicks of roseate terns, thereby effectively limiting or diminishing the population of such terns.

851. Roseate terns are fishers, not scavengers, and feed exclusively on prey which they capture, and do not feed on refuse from landfills or garbage dumps.

852. Black-backed gulls are scavengers and will feed on refuse from landfills or garbage dumps.

853. While the availability of food for roseate terns has remained substantially unchanged, the availability of food for black-backed gulls has increased dramatically due to the increased number of landfills and garbage dumps in or around Cape Cod, New Bedford Harbor, and the surrounding area, which has led to a significant increase in the population of black-backed gulls.

854. Herring and black-backed gulls are physically larger than roseate terns.

855. Herring and black-backed gulls are more agressive than roseate terns.

856. Herring and black-backed gulls begin nesting earlier than roseate terns.

857. Herring and black-backed gulls are highly aggressive in defending their nesting territories from other species, including roseate terns.

858. Since the late 1970's, herring and black-backed gulls have displaced large numbers of roseate terns from various colonies in and around Cape Cod, including Monomoy Island, Massachusetts.

859. Prior to the late 1970's, Monomoy Island was the largest and most important nesting area for roseate terns in the northeastern United States.

860. The reduction of nesting sites of roseate terns in the northeastern United States is largely attributed to the increased populations of herring and black-backed gulls.

861. There is no published information regarding what pollutants or contaminants exist in or around the migration paths or the wintering grounds of roseate terns that nest in the northeastern United States.

862. In 1989, the U.S. Fish and Wildlife Service released a report entitled "Roseate Tern Recovery Plan Northeastern Population" ("Roseate Tern Recovery Plan").

863. The Roseate Tern Recovery Plan was prepared by Ralph Andrews, Gerry Atwell, Bradford G. Blodget, Ian C.T. Nisbet,and Michael Scheibel at the request of the U.S. Fish and Wildlife Service.

864. The Roseate Tern Recovery Plan is a business record, which was prepared or received and kept in the ordinary course of business; it was the ordinary course of business for the U.S. Fish and Wildlife Service to prepare, keep and maintain such records; and the record was made or prepared at or near the time of a regularly conducted business activity of U.S. Fish and Wildlife Service by or from information transmitted by a person with knowledge of such activity.

865. The Roseate Tern Recovery Plan is a record, report statement or data compilation of a public office or agency which sets forths the activities of the office or agency, or matters observed pursuant to duty imposed by law at which matters there was a duty to report, or factual findings resulting from an

investigation made pursuant to authority granted by law.

866. Statements and conclusions in the Roseate Tern Recovery Plan are admissions of the United States.

867. Statements and conclusions in the Roseate Tern Recovery Plan are admissible in evidence.

868. According to the Roseate Tern Recovery the population of roseate terns in the northeastern United States "has been relatively stable since 1977."

869. The population of roseate terns in the northeastern United States has been relatively stable since 1977.

870. According to the Roseate Tern Recovery Plan, most of the roseate terns which nest in the northeastern United States migrate to and winter along the coast of South America.

871. Most of the roseate terns which nest in the northeastern United States migrate to and winter along the coast of South America.

872. According to the Roseate Tern Recovery Plan, roseate terns nesting in the northeastern United States spend a total of approximately 8 months of each year in transit during migration or at their wintering grounds.

873. Roseate terns nesting in the northeastern United States spend a total of approximately 8 months of each year in transit during migration or at their wintering grounds.

874. According to the Roseate Tern Recovery Plan, roseate terns breeding in the northeastern United States spend a total of approximately 4 months of each year in their breeding areas.

875. Roseate terns breeding in the northeastern United States spend a total of approximately 4 months of each year in their breeding areas.

876. According to the Roseate Tern Recovery Plan, in the northeastern United States, there is no evidence of substantial mortality of adult roseate terns during the breeding season.

877. For the northeastern United States, there is no evidence of substantial mortality of adult roseate terns during the breeding season.

878. According to the Roseate Tern Recovery Plan, roseate tern nesting pair populations at Bird Island, Massachusetts ("Bird Island") have increased since 1977.

879. Roseate tern nesting pair populations at Bird Island, Massachusetts ("Bird Island") have increased since 1977.

880. According to the Roseate Tern Recovery Plan, roseate terns nesting in the northeastern United States generally breed with high success.

881. Roseate terns nesting in the northeastern United States generally breed with high success.

882. According to the Roseate Tern Recovery Plan, in the absence of predation, the main cause of roseate tern hatching failure is desertion.

883. In the absence of predation, the main cause of roseate tern hatching failure is desertion.

884. Roseate tern nesting pair populations at Bird Island fluctuate from year to year due to such factors as migration to other colonies and predation.

885. According to the Roseate Tern Recovery Plan, if chemical pollution had adverse effects on the roseate tern population in the northeastern United States, such effects were probably limited to the period before the mid-1970's.

886. If chemical pollution had adverse effects on the roseate tern population in the northeastern United States, such effects were probably limited to the period before the mid-1970's.

887. According to the Roseate Tern Recovery Plan, the chief threat to the roseate tern population in the northeastern United States is the large populations of black-backed and herring gulls.

888. The chief threat to the roseate tern population in the northeastern United States is the large populations of black-backed and herring gulls.

889. According to the Roseate Tern Recovery Plan, in the northeastern United States, roseate terns, chicks and eggs are subject to predation by great horned owls, black-crowned night-herons, herring and great black-backed gulls, peregrine falcons and ants.

890. In the northeastern United States, roseate terns, chicks and eggs are subject to predation by great horned owls, black-crowned night-herons, herring and great black-backed gulls, peregrine falcons and ants.

891. PCBs have been detected in the eggs of roseate terns collected at Falkner's Island, CT; Monomoy, MA; and Great Gull Island, NY.

892. The plaintiffs have no evidence to present that demonstrates that any roseate tern has ever died as a result of

PCBs.

893. The plaintiffs have no evidence to present that demonstrates that any roseate tern has ever been injured as a result of PCBs.

894. New Bedford Harbor is not a frequent feeding area for a majority of the population of roseate terns nesting in the northeastern United States.

895. According to the Roseate Tern Recovery Plan, "the impact of an oil spill or disease outbreak could be particularly devastating" to the population of roseate terns nesting in the northeastern United States.

896. Other than predators, the single greatest threat to the population of roseate terns nesting at Bird Island is the possibility of an oil spill in Buzzards Bay or the surrounding area.

897. The oil spilled by the passenger vessel Bermuda Star in Buzzards Bay in June, 1990, represents a threat to the population of roseate terns nesting at Bird Island which is more serious than any threat posed by the presence of alleged PCB contamination in New Bedford Harbor.

898. The continuing threat of oil spills in Buzzards Bay represents a threat to the population of roseate terns nesting at Bird Island which is more serious than any threat posed by the presence of alleged PCB contamination in New Bedford Harbor.

899. According to the Roseate Tern Recovery Plan, outbreaks of shellfish poisoning caused by blooms of the marine dinoflagellate represent a threat to the population of roseate terns nesting at Bird Island.

900. Outbreaks of shellfish poisoning caused by blooms of the marine dinoflagellate represent a threat to the population of roseate terns nesting at Bird Island which is more serious than the presence of PCBs in New Bedford Harbor.

901. In an article, Organochlorine Residues in Common Terns and Associated Estuarine Organisms, Massachusetts, USA, 1971-81, Marine Environmental Research, 11:33-66 (1984), authored by Dr. Nisbet, it was stated that "In Buzzards Bay levels of PCBs declined significantly between 1971 and 1981."

902. In Buzzards Bay, levels of PCBs declined significantly between 1971 and 1981.

903. In an article, Organochlorine Residues in Common Terns and Associated Estuarine Organisms, Massachusetts, USA, 1971-81, Marine Environmental Research, 11:33-66 (1984), authored by Dr. Nisbet, it was stated that "PCBs are widespread in fish caught at

sea north of New England and Eastern Canada."

904. PCBs are widespread in fish caught at sea north of New England and Eastern Canada.

905. In an article, Organochlorine Residues in Common Terns and Associated Estuarine Organisms, Massachusetts, USA, 1971-81, Marine Environmental Research, 11:33-66 (1984), authored by Dr. Nisbet, it was stated that "Mean residue concentrations of PCBs appear to have decreased after 1976" and that "[T]he foregoing is true, at least at station H."

906. Roseate terns tend to forage over open water.

907. Because roseate terns capture prey by diving into the water and seizing prey in their bills, roseate terns do not forage over areas of excessively shallow water.

908. In a paper authored by Dr. Ian Nisbet, it was stated that roseate terns were observed feeding in two distinct areas of Buzzards Bay, and avoided the allegedly polluted parts of New Bedford Harbor.

909. In a paper authored by Dr. Ian Nisbet, it was stated that tern populations in the northeastern United States are experiencing intense pressure from human activities. Such pressures include loss of nesting habitat, disturbance from recreational use, and increased mortality due to hunting in the winter ranges.

B. Common Terns

910. Common terns are fishers, not scavengers, and feed exclusively on prey which they capture, and do not feed on refuse from landfills or garbage dumps.

911. The population of common terns in Massachusetts has steadily increased since at least 1976.

912. The common tern is not an endangered species.

913. The common tern is not a threatened species.

914. Common terns have a tendency to establish feeding territories which they use and defend.

915. Common terns tend to establish feeding territories along stretches of coastline in close proximity to their nesting sites.

916. Common terns use feeding territories to forage more effectively and efficiently.

917. Common terns prefer to establish feeding territories in close proximity to nesting areas.

918. Common terns with established feeding territories do not tend to forage outside of such territories.

919. Common terns nesting on Bird Island tend to establish feeding territories along the shores of Bird Island, which provide sufficient area to support the common tern population of Bird Island.

920. The population of common terns nesting on Bird Island is not limited by an insufficient feeding area.

921. In comparison to Monomoy Island, the abundancy of prey around Bird Island is better.

922. The plaintiffs have no specific knowledge of common terns feeding in the upper estuary of New Bedford Harbor.

923. Other than predators, the single greatest threat to the population of common terns nesting in and around Buzzards Bay is the possibility of an oil spill in Buzzards Bay or the surrounding area.

924. The oil spilled by the passenger vessel Bermuda Star in Buzzards Bay in June, 1990, represents a threat to the population of common terns nesting in and around Buzzards Bay which is more serious than any threat posed by the presence of alleged PCB contamination in New Bedford Harbor.

925. The continuing threat of oil spills in Buzzards Bay represents a threat to the population of common terns nesting in and around Buzzards Bay which is more serious than any threat posed by the presence of alleged PCB contamination in New Bedford Harbor.

926. Least terns are not comparable to either roseate or common terns in terms of nesting, feeding or other behaviors.

C. Ecology in and around New Bedford Harbor

927. EPA has expended approximately $30 million over a period of 8 years in connection with its remedial investigation and feasibility study at the New Bedford Harbor Superfund site.

928. For several years prior to EPA's remedial investigation and feasibility study, state investigations or monitoring of New Bedford Harbor were conducted.

929. In the course of the remedial investigation and feasibility

study, neither the EPA nor any other federal or state agency has previously identified any adverse effects upon avian species related to the alleged PCB contamination of New Bedford Harbor.

930. None of the reports generated by the EPA or other federal or state agencies identifies any adverse effects upon avian species related to the alleged PCB contamination of New Bedford Harbor.

931. The EPA report entitled "Baseline Ecological Risk Assessment, New Bedford Harbor Site, Feasibility Study, April, 1990" does not identify nor make any reference to any adverse effects upon avian species related to the alleged PCB contamination of New Bedford Harbor.

932. The EPA report entitled "Executive Summary of the Baseline Risk Assessment for the New Bedford Harbor Site, June 1988" does not identify nor make any reference to any adverse effects upon avian species related to the alleged PCB contamination of New Bedford Harbor.

933. The populations of common terns and roseate terns nesting in and around Buzzards Bay have been the subjects of numerous short and long term scientific studies for at least 20 years.

934. In a report prepared by IEP, Inc. in connection with EPA's remedial investigation and feasibility study at the New Bedford Harbor Superfund site, which reported the results of a study of wildlife in and around the upper estuary of New Bedford Harbor, there were no reported sightings of either roseate terns or common terns in the upper estuary.

935. In the report prepared by IEP, Inc. it was reported that terns sighted in the vicinity of New Bedford Harbor preferred to feed, nest and rest at the Lloyd Demarest Wildlife Center located at Dartmouth, Massachusetts.

936. The Lloyd Demarest Wildlife Center is located several miles from New Bedford Harbor.

937. Historically, New Bedford Harbor has never served as a nesting area for either common terns or roseate terns.

938. Historically, New Bedford Harbor has never served as a nesting area for significant populations of either common terns or roseate terns.

939. Roseate and common terns frequently nest in the same general areas and prefer remote islands or beaches.

940. The tern populations in an around Buzzards Bay are among the most thoroughly studied and closely monitored in the world.

941. There are numerous scientific publications which document

the various studies made of the tern populations in an around Buzzards Bay.

942. Each summer for more than 20 years, the tern colonies located on Bird Island have been closely observed and studied.

943. Each summer for more than 20 years, one or more individuals has made personal observations of the tern colonies located on Bird Island.

944. The studies conducted at Bird Island include numerous population censuses, observations of the courtship, nesting and breeding of terns, the feeding habits of terns, and many other aspects of behavior.

945. No previously published study regarding the tern colonies located on Bird Island has ever established a correlation bewteen the alleged PCB contamination in New Bedford Harbor and any adverse effects on such tern colonies.

946. Previous studies which have sought to establish a correlation between the alleged PCB contamination in New Bedford Harbor and adverse effects on the populations of terns in and around Buzzards Bay have found no such correlation.

947. No previously published study regarding the tern colonies located on Bird Island has ever reported the occurrence of any birth defects or embryo-toxicity within such colonies.

948. Because the tern colonies of Bird Island are so closely monitored, it is highly unlikely that significant tern mortality would go undetected.

949. Because the tern colonies of Bird Island are so closely monitored, it is highly unlikely that no one would observe significant tern mortality, if it existed.

950. Because the tern colonies of Bird Island are so closely monitored, it is highly unlikely that no one would observe birth defects or other effects on reproduction, if they existed.

951. Because the tern colonies of Bird Island are so closely monitored, it is highly unlikely that no one would observe or recover deceased adult terns, if they existed.

952. Because the tern colonies of Bird Island are so closely monitored, it is highly unlikely that no one would observe a tern exhibiting tremors, if it existed.

953. Because the tern colonies of Bird Island are so closely monitored, it is highly unlikely that no one would observe a tern which was unable to fly, if it existed.

954. Because of the proximity of Bird Island to populated areas

such as Marion, Wareham, and other towns, it is highly unlikely that no one living in such towns would observe significant tern mortality, if it existed.

955. Tern census information collected by federal and state wildlife agencies indicates that the common and roseate tern populations in and around Buzzards Bay have been stable or increasing for several years.

956. With the passage of time, the alleged PCB contamination in New Bedford Harbor becomes less threatening.

957. At present, the alleged PCB contamination in New Bedford Harbor is less threatening than it was ten years ago.

958. It is highly unlikely that the common and roseate tern populations in and around Buzzards Bay would have been stable or increasing for over ten years, if the alleged PCB contamination in New Bedford Harbor posed a significant threat to such populations.

959. When female roseate and common terns lay eggs, they experience a negative fat balance, which means that their bodies transfer more fat into the eggs than the terns are ingesting.

960. In order to lay eggs, female roseate and common terns must mobilize considerable amounts of body fat.

961. If female roseate and common terns have accumulated PCBs in their fatty tissues, such PCBs would be mobilized during periods of egg-laying.

962. If female roseate and common terns mobilized significant quantities of PCBs during periods of egg-laying, it is highly unlikely that no behavioral effects would be observed.

963. There are no published studies which correlate behavioral effects in female roseate and common terns during periods of egg-laying with the presence of mobilized PCBs in such terns.

964. If female roseate and common terns mobilized significant quantities of PCBs during periods of egg-laying, it is highly unlikely that no evidence of stress would be observed.

965. There are no published studies which correlate evidence of stress in female roseate and common terns during periods of egg-laying with the presence of mobilized PCBs in such terns.

966. Bird Island lies off of the coast of Marion, Massachusetts and is more than 10 miles from the upper estuary of New Bedford Harbor, measured on a straight line basis.

967. If a bird flew along a straight path from Bird Island to New Bedford Harbor to forage, the round trip distance would

exceed 20 miles, exclusive of any distance travelled in attempting to capture prey.

968. If a bird flew along a straight path from Bird Island to New Bedford Harbor to forage, most of that path would lie over land, not water, and the bird would be effectively ignoring miles of inlets and shoals which provide shallow water and good foraging opportunities.

969. If a bird flew along from Bird Island to New Bedford Harbor to forage and followed the coastline, the round trip distance would exceed 30 miles, exclusive of any distance travelled in attempting to capture prey.

970. New Bedford Harbor is located at the outer edge of the typical foraging range for terns nesting on Bird Island.

971. New Bedford Harbor is not a frequent feeding area for any significant percentage of the tern populations nesting on Bird Island.

972. The shoreline along all of New Bedfor Harbor represents only 12 percent of the coastline within 12 miles of Bird Island.

973. The only reason the plaintiffs have raised any issue related to common or roseate terns is for purposes of this lawsuit.

974. The nesting populations of common and roseate terns have been stable since the late 1970's.

975. The nesting populations of common and roseate terns have not declined during 1989 and 1990.

976. The primary feeding areas for common and roseate terns nesting on Bird Island are within 12 km of the nesting island.

977. Although some individual common or roseate terns which nest on Bird Island may travel as far as 20 km to feed, the majority of birds nesting on Bird Island obtain their food from within 5-8 km of the nesting island.

978. The areas of New Bedford Harbor which contain the highest levels of PCB contamination are approcimately 10.3 miles (16.6km) from the nesting colony in a straight-line destance, most of which is overland.

979. The areas of New Bedford Harbor which contain the highest levels of PCB contamination are approximately 13.6 miles (22km) from the nesting colony using the shortest overwater distance.

980. The areas of New Bedford Harbor which contain the highest levels of PCB contamination are outside the normal feeding range of nesting common and roseate terns.

981. A very small proportion of the population of nesting common or roseate terns nesting on Bird Island would travel to New Bedford Harbor to feed.

982. There are adequate feeding areas within Buzzards Bay for the entire nesting population of common terns on Bird Island.

983. There are adequate feeding areas within Buzzards Bay for the entire nesting population of roseate terns on Bird Island.

984. In late June and July, schooling fish are plentiful near the nesting colony on Bird Island, and nesting terns do not travel as far to forage.

985. After young roseate terns have fledged, family groups disperse throughout the breeding range, and tend to concentratge on outer beaches.

986. The major premigratory staging areas for roseate terns nesting in Massachusetts are barrier island located between Long Island and Cape Cod, where the birds tend to feed offshore.

987. The nesting colony of common and roseate terns on Bird Island has been studied extensively for the past 20 years.

988. Plaintiffs have evidence that PCBs have had no adverse effect on adult terns nesting on Bird Island since 1970.

989. Plaintiffs have evidence that PCBs have had no adverse effect on reproductive success of common or roseate terns nesting on Bird Island since 1970.

990. Plaintiffs have no evidence that PCBs have caused abnormalities in tern chicks on Bird Island.

991. Plaintiffs have evidence that levels of PCBs in eggs of common and roseate terns declinede significantly since 1971.

992. The primary threat to nesting populations of common and roseate terns has been, and continues to be, from herring and/or great black-backed gulls and predation by other species.

993. Despite intensive study involving daily visits to Bird Island to study nesting terns for a period of over 15 years, tghere are no published reports of tern mortality or abnormal behavior of terns that was attributed to contamination with PCBs.

994. Plaintiffs have evidence that mortality of adult terns on Bird Island during the nesting season is very low.

995. Plaintiffs have evidence that the primary mortality of adult terns occurs during migration and on the wintering grounds.

996. During the egg-laying period, female terns mobilize stored fat reserves into the production of eggs.

997. During the egg-laying period, female terns utilize more fat in the production of eggs than they consume on a daily basis, and thus are in a negative energy balance.

998. Despite intensive study of nesting common and roseate terns on Bird Island over a number of years, there are no published reports of nesting female terns exhibiting any of the symptoms observed in Terns 1 and 2 which died in 1989, in spite of the fact that each egg-laying female tern would have been utilizing fat reserve in the production of eggs.

999. Terns 1 and 2 were found in early August, at which time the terns would be expected to be storing fat reserves in anticipation of migration in late August or early September.

1000. Terns 1 and 2 were found approximately 10 and 15 miles, respectively, from New Bedford Harbor.

1001. Terns 1 and 2 were not reported to be emaciated, but had deposits of visceral fat.

1002. Plaintiffs have no evidence that Terns 1 and 2 were utilizing fat reserves at a time when the terns would be expected to be in a positive energy balance and storing fat for migration.

1003. The tremors and outstretched wings exhibited in Terns 1 and 2 prior to death is symptomatic of several types of contamination or diseases.

1004. Terns 1 and 2 were not examined for bacterial or viral disease or evidence of toxins other than PCBs.

1005. Plaintiffs have evidence that terns are susceptible to avian cholera, botulism, and shellfish poisoning.

1006. PCBs are odorless.

1007. PCBs obtained through the food chain would be odorless.

1008. PCBs Obtained through the food chain would not smell sweet.

1009. A sweet and flowery odor during necropsy of a bird would be very unusual.

1010. Plaintiffs have evidence that average PCB levels in Atlantic silversides and sand lance collected around Bird Island between 1974 and 1976 were less than 0.5 and 1.5 ppm, respectively.

1011. Plaintiffs have evidence that PCB levels in terns on Bird Island declined significantly between 1971 and 1981.

1012. During the period in which organochlorine levels in common and roseate terns were under study, average PCB levels in roseate terns was considerably lower than that in common terns.

1013. Plaintiffs have evidence that one reason for this is roseate terns usually feed in deeper onshore waters or further offshore than common terns in less polluted waters.

1014. Plaintiffs have evidence that roseate terns in Buzzards Bay avoided feeding in the areas most heavily polluted with PCBs in New Bedford Harbor.

1015. Avian census data from a 1987 study of New Bedford Harbor indicated that no roseate terns or common terns were reported from a study site in the upper estuary, although common terns were observed at a study site near Pope Beach on Buzzards Bay.

1016. Although least terns were observed in the upper estuary site, this species has different nesting and feeding requirements than the common and roseate terns.

II. The Terns

A. General

1017. The plaintiffs allege that on August 7, 1989, Dr. Robert Tremblay of the Marion Animal Hospital, Inc. ("Dr. Tremblay") received a live common tern from the Animal Control Officer of Marion, Massachusetts (the "first tern"), which subsequently died.

1018. The plaintiffs allege that on August 14, 1989, Dr. Tremblay received a live common tern from an unidentified individual (the "second tern"), which subsequently died.

1019. Neither the plaintiffs nor anyone else conducted a comprehensive investigation to determine the cause of death of either the first tern or the second tern.

1020. The plaintiffs have no evidence to present that demonstrates that a comprehensive investigation was conducted to determine the cause of death of either the first tern or the second tern.

1021. Neither the plaintiffs nor anyone else ever identified the contents of the stomach of either the first tern or the second tern.

1022. The plaintiffs have no evidence to present that demonstrates what was contained in the stomach of either the first tern or the second tern.

1023. Neither the plaintiffs nor anyone else ever identified what type of food or other substance was present in the stomach of either the first tern or the second tern.

1024. The plaintiffs have no evidence to present that demonstrates what type of food or other substance was present in the stomach of either the first tern or the second tern.

1025. Neither the plaintiffs nor anyone else ever identified what type of food or other substance was consumed by either the first tern or the second tern prior to its being recovered

1026. The plaintiffs have no evidence to present that demonstrates what type of food was consumed by either the first tern or the second tern prior to its being recovered

1027. Neither the plaintiffs nor anyone else ever identified where either the first tern or the second tern fed immediately prior to being recovered.

1028. The plaintiffs have no evidence to present that demonstrates where either the first tern of the second tern fed immediately prior to being recovered.

1029. Neither the plaintiffs nor anyone else ever analyzed any tissue sample taken from either the first tern or the second tern for organophosphate compounds.

1030. The plaintiffs have no evidence to present that demonstrates whether any of the tissues of the first tern or the second tern contained any organophosphate compound.

1031. Neither the plaintiffs nor anyone else ever analyzed any tissue sample taken from either the first tern or the second tern for metals.

1032. The plaintiffs have no evidence to present that demonstrates whether any of the tissues of the first tern or the second tern contained any metals.

1033. Neither the plaintiffs nor anyone else ever analyzed any tissue sample taken from either the first tern or the secbnd tern for PAHs.

1034. The plaintiffs have no evidence to present that demonstrates whether any of the tissues of the first tern or the second tern contained any PAHs.

1035. Neither the plaintiffs nor anyone else ever performed any chemical analysis of any sample of liver tissue from either the first tern or the second tern.

1036. The plaintiffs have no evidence to present that

demonstrates that any chemical analysis was performed on any sample of liver tissue from either the first tern or the second tern.

1037. A scientifically conducted investigation to determine the cause of death of a common tern would include chemical analysis of the liver tissue.

1038. Liver tissue is chemically analyzed to determine the presence or absence, or the concentrations, of certain enzymes, which may provide evidence of the cause of death.

1039. In a scientifically conducted investigation to determine the cause of death of a common tern, the liver tissue is chemically analyzed to measure to presence or absence, or the concentrations of vitamin A and retinene.

1040. The presence or absence, or the concentrations of vitamin A and retinene may provide evidence of the cause of death.

1041. Neither the plaintiffs nor anyone else ever chemically analyzed any sample of liver tissue from either the first tern or the second tern in order to determine the concentrations of vitamin A and retinene.

1042. The plaintiffs have no evidence to present that demonstrates the concentrations of vitamin A or retinene in any sample of liver tissue from either the first tern or the second tern.

1043. Neither the plaintiffs nor anyone else ever conducted a controlled laboratory experiment to determine what is a "normal" level of vitamin A for the liver tissue of a common tern.

1044. The plaintiffs have no evidence to present that demonstrates that a controlled laboratory experiment was conducted to determine what is a "normal" level of retinene for the liver tissue of a common tern.

1045. Neither the plaintiffs nor anyone else knows what is a "normal" level of vitamin A for the liver tissue of a common tern.

1046. The plaintiffs have no evidence to present that demonstrates what is a "normal" level of retinene for the liver tissue of a common tern.

1047. Neither the plaintiffs nor anyone else has ever conducted a controlled laboratory experiment to determine what is a "normal" level of acetylcholinesterase for the brain tissue of a common tern.

1048. The plaintiffs have no evidence to present that demonstrates that a controlled laboratory experiment was

conducted to determine what is a "normal" level of acetylcholinesterase for the brain tissue of a common tern.

1049. Neither the plaintiffs nor anyone else knows what is a "normal" level of acetylcholinesterase for the brain tissue of a common tern.

1050. The plaintiffs have no evidence to present that demonstrates what is a "normal" level of acetylcholinesterase for the brain tissue of a common tern.

1051. None of the tissue samples removed from either the first tern or the second tern was ever chemically analyzed for substances other than acetylcholinesterase or organochlorines.

1052. PCBs are odorless.

1053. PCBs do not produce a sweet odor.

1054. PCBs do not produce a flowery odor.

1055. The carcasses of the first and second terns were observed to have a "sweet" or "flowery" odor.

1056. Various petroleum and other substances have a "sweet" or "flowery" odor.

1057. The "sweet" or "flowery" emitted by the carcasses of the first and second terns indicates that the first and second terns were contaminated with a substance other than PCBs.

1058. The first and second terns were exposed to a substance, other than PCBs, with a "sweet" of "flowery" odor, which the terns ingested.

1059. The first and second terns were exposed to a substance, other than PCBs, with a "sweet" of "flowery" odor, which contacted the terns' feathers and which the terns ingested by preening their feathers.

1060. If the first and second terns were exposed to PCBs, such PCBs were combined with another substance with a "sweet" or "flowery" odor.

1061. The plaintiffs have no evidence to demonstrate that the first and second terns were not exposed to a petroleum product which emitted a "sweet" or "flowery" odor.

1062. The plaintiffs have no evidence to demonstrate that the first and second terns did not die as a result of being contaminated with a substance other than PCBs which emitted a "sweet" or "flowery" odor.

1063. The first and second terns were exposed to a petroleum

product with a "sweet" of "flowery" odor, which contacted the terns' feathers and which the terns ingested by preening their feathers.

1064. The plaintiffs have no evidence to demonstrate that the first and second terns were not exposed to a petroleum product which emitted a "sweet" or "flowery" odor.

1065. The plaintiffs have no evidence to demonstrate that the first and second terns did not die as a result of being contaminated with a substance other than PCBs which emitted a "sweet" or "flowery" odor.

1066. It is highly unusual to note a "sweet" and "flowery" odor at a necropsy.

1067. The deaths of the first and second terns do not establish that the alleged PCB contamination in New Bedford Harbor is a risk to avian species.

1068. The deaths of the first and second terns do not establish that the alleged PCB contamination in New Bedford Harbor is a significant risk to avian species.

1069. The deaths of the first and second terns do not establish that the alleged PCB contamination in New Bedford Harbor is a material risk to avian species.

1070. Even if PCBs contributed to the deaths of the first and second terns, the deaths of the first and second terns do not establish that the alleged PCB contamination in New Bedford Harbor is a risk to avian species.

1071. Even if PCBs contributed to the deaths of the first and second terns, the deaths of the first and second terns do not establish that the alleged PCB contamination in New Bedford Harbor is a significant risk to avian species.

1072. Even if PCBs contributed to the deaths of the first and second terns, the deaths of the first and second terns do not establish that the alleged PCB contamination in New Bedford Harbor is a material risk to avian species.

1073. Even if PCBs contributed to the deaths of the first and second terns, the deaths of the first and second terns do not establish that the alleged PCB contamination in New Bedford Harbor is a risk to common terns and roseate terns.

1074. Even if PCBs contributed to the deaths of the first and second terns, the deaths of the first and second terns do not establish that the alleged PCB contamination in New Bedford Harbor is a significant risk to common terns and roseate terns.

1075. Even if PCBs contributed to the deaths of the first and

second terns, the deaths of the first and second terns do not establish that the alleged PCB contamination in New Bedford Harbor is a material risk to common terns and roseate terns.

1076. Even if PCBs contributed to the deaths of the first and second terns, the alleged concentrations of such PCBs in the tissues of the terns indicate a recent exposure to a highly concentrated source of PCBs.

1077. Even if PCBs contributed to the deaths of the first and second terns, the alleged concentrations of such PCBs in the tissues of the terns indicate a recent exposure to a source of PCBs having a concentration at least one order of magnitude larger than any concentration ever measured in any biota sampled from New Bedford Harbor or Buzzards Bay.

1078. Even if PCBs contributed to the deaths of the first and second terns, the alleged concentrations of such PCBs in the tissues of the terns indicate a recent exposure to a source of PCBs having a concentration at least one order of magnitude larger than any concentration ever measured in any fish sampled from New Bedford Harbor or Buzzards Bay.

1079. Even if PCBs contributed to the deaths of the first and second terns, the alleged concentrations of such PCBs in the tissues of the terns indicate a recent exposure to a source of PCBs having a concentration at least one order of magnitude larger than any concentration ever measured in any crustacean sampled from New Bedford Harbor or Buzzards Bay.

1080. Even if PCBs contributed to the deaths of the first and second terns, the alleged concentrations of such PCBs in the tissues of the terns indicate a recent exposure to a source of PCBs having a concentration at least one order of magnitude larger than any concentration ever measured in any shellfish sampled from New Bedford Harbor or Buzzards Bay.

1081. Even if PCBs contributed to the deaths of the first and second terns, the alleged concentrations of such PCBs in the tissues of the terns indicate a recent exposure to a source of PCBs having a concentration not known to exist in any biota found in New Bedford Harbor or Buzzards Bay.

1082. Even if PCBs contributed to the deaths of the first and second terns, the alleged concentrations of such PCBs in the tissues of the terns indicate a recent exposure to a highly contaminated source of PCBs which was not part of the terns' food chain.

1083. Even if PCBs contributed to the deaths of the first and second terns, the presence of a "sweet" or "flowery" odor emanating from the carcasses indicates exposure to either a highly concentrated source of PCBs not related to New Bedford Harbor, or exposure to another odiferous substance.

1084. Even if PCBs contributed to the deaths of the first and second terns, that does not suggest the presence of a large scale or long term threat to the population of common terns or roseate terns in view of the facts that such populations have been at least stable, if not increasing, for more than 10 years.

B. Dr. Tremblay

1085. Dr. Tremblay does not know what caused the death of either the first tern or the second tern.

1086. Dr. Tremblay is not qualified to determine the cause of death of a common tern.

1087. Dr. Tremblay is not qualified to determine the cause of death of either the first tern or the second tern.

1088. Dr. Tremblay did not determine the cause of death of either the first tern or the second tern.

1089. Dr. Tremblay does not know what caused the death of either the first tern or the second tern.

1090. Dr. Tremblay did not perform a comprehensive investigation in an attempt to determine the cause of death of either the first tern or the second tern.

1091. Dr. Tremblay is not an avian toxicologist or an avian pathologist.

1092. Dr. Tremblay has no formal training in either avian toxicology or avian pathology.

1093. Dr. Tremblay performed a necropsy or partial necropsy on both the first and second terns and removed certain tissues from each, which tissues were sent to the New England Wildlife Center ("NEWC") along with the carcasses of the first and second terns.

1094. A necropsy is a post mortem procedure in which one or more organs or tissue samples are removed from an animal carcass.

1095. Dr. Tremblay did not perform a chemical analysis of any of the tissues he removed from either tern.

1096. Dr. Tremblay did not record any visual observations he made during the necropsies or partial necropsies of the first and second terns.

1097. Dr. Tremblay did not examine the contents of the stomach of

either the first tern or the second tern.

1098. Dr. Tremblay did not visually or chemically identify the contents of the stomach of either the first tern or the second tern.

1099. Dr. Tremblay does not know what material was present in the stomach of either the first tern or the second tern.

1100. Dr. Tremblay does not know where either the first tern or the second tern fed prior to being recovered and brought to him.

1101. Dr. Tremblay did not analyze the liver tissue of either the first tern or the second tern in any way.

1102. Dr. Tremblay did not chemically analyze the liver tissue of either the first tern or the second tern in any way.

1103. After examining the first and second terns, Dr. Tremblay believed that those terns had been poisoned by an organic phosphate such as the kind used in pesticides.

C. New England Wildlife Center (NEWC)

1104. On or about August 11, 1989, NEWC received from Dr. Tremblay the carcass of the first tern and the tissues previously removed therefrom by Dr. Tremblay, and NEWC assigned an accession number of A890811063 to the carcass and tissues of the first tern.

1105. On or about August 21, 1989, NEWC received from Dr. Tremblay the carcass of the second tern and the tissues previously removed therefrom by Dr. Tremblay, and NEWC assigned an accession number of A890821105 to the carcass and tissues of the second tern.

1106. No one working for or on behalf of NEWC knows what caused the death of either the first tern or the second tern.

1107. No one working for or on behalf of NEWC is qualified to determine the cause of death of a common tern.

1108. No one working for or on behalf of NEWC is qualified to determine the cause of death of either the first tern or the second tern.

1109. No one working for or on behalf of NEWC determined the cause of death of either the first tern or the second tern.

1110. No one working for or on behalf of NEWC knows what caused the death of either the first tern or the second tern.

1111. No one working for or on behalf of NEWC performed a comprehensive investigation in an attempt to determine the cause of death of either the first tern or the second tern.

1112. No one working for or on behalf of NEWC is an avian toxicologist or an avian pathologist.

1113. No one working for or on behalf of NEWC has any formal training in either avian toxicology or avian pathology.

1114. No one working for or on behalf of NEWC performed a chemical analysis of any of the tissues he removed from either the first tern or the second tern.

1115. No one working for or on behalf of NEWC examined the contents of the stomach of either the first tern or the second tern.

1116. No one working for or on behalf of NEWC visually or chemically identified the contents of the stomach of either the first tern or the second tern.

1117. No one working for or on behalf of NEWC knows what material was present in the stomach of either the first tern or the second tern.

1118. A volunteer named Lori Harvey, was working at NEWC in August, 1989.

1119. Lori Harvey performed a necropsy or partial necropsy on the first and second terns and removed certain tissues from each.

1120. Lori Harvey has no formal training in the proper procedure for performing a necropsy or partial necropsy on a common tern.

1121. Lori Harvey was not supervised while performing the necropsies or partial necropsies on the carcasses of the first and second terns.

1122. Lori Harvey is not qualified to determine the cause of death of a common tern.

1123. Lori Harvey is not qualified to determine the cause of death of either the first tern or the second tern.

1124. Lori Harvey is not an avian toxicologist or avian pathologist.

1125. Lori Harvey did not determine the cause of death of either the first tern or the second tern.

1126. Lori Harvey does not know the cause of death of either the first tern or the second tern.

1127. Some of the tissue samples removed by Lori Harvey were sent to Hazleton Laboratories America, Inc. ("HLA") for analysis. The tissue samples sent to HLA for analysis consisted only of brain tissue and "stomach contents" for each of the first and second terns.

1128. No liver tissue samples from either the first or second tern were sent by NEWC to HLA for analysis.

1129. The tissue samples removed by Dr. Tremblay and received by NEWC were sent to Dr. Norval King ("Dr. King").

1130. The tissue samples analyzed by HLA and the tissue samples examined by Dr. King were removed from the first and second terns at different times by different people.

1131. The "stomach contents" tissues removed by Lori Harvey from the first and second terns was observed by Ms. Harvey to include some surrounding fat.

D. Dr. Norval King

1132. On or about November 15, 1989, Dr. King or a consulting firm, Pathobiology, Inc., with which Dr. King is affiliated, received from NEWC the tissue samples which had been removed by Dr. Tremblay from the first and second terns.

1133. Either Dr. King or his assistant assigned an identification number of PB-1251-89 to the tissues from the first tern, and an identification number of PB-1253-89 to the tissues from the second tern.

1134. Dr. King did not perform a comprehensive investigation to determine the cause of death of either the first tern or the second tern.

1135. Dr. King did not determine the cause of death of either the first tern or the second tern.

1136. Dr. King does not know the cause of death of either the first tern or the second tern.

1137. Dr. King is not an avian toxicologist or avian pathologist.

1138. Dr. King is not qualified to determine the cause of death of a common tern.

1139. Dr. King is not qualified to determine the cause of death of either the first tern or the second tern.

1140. Dr. King performed only a microscopic examination of the tissues from the first and second terns and did not perform any other examination or analysis of those tissues.

1141. Dr. King did not examine the contents of the stomach of either the first tern or the second tern.

1142. Dr. King did not visually or chemically identify the contents of the stomach of either the first tern or the second tern.

1143. Dr. King did not perform a chemical analysis upon any of the tissues from either the first or second tern.

1144. The information listed under the heading "Relevant History" on Dr. King's "pathologic diagnosis" reports, which are set forth on the document bearing plaintiffs' Bates number 77-0018, was provided by NEWC and does not represent any observation which Dr. King made.

1145. Dr. King did not perform a necropsy of either the first tern or the second tern and did not make any observations of either tern carcass.

1146. Dr. King's examination was inconclusive as to the cause of death of either the first tern or the second tern.

1147. The results of the analyses performed by Dr. King do not preclude the possibility that the first and second terns died as a result of organophosphate contamination.

1148. The results of the analyses performed by Dr. King do not preclude the possibility that the first and second terns died as a result of chemicals or pollutants other than PCBs.

E. Hazleton Laboratories (HLA) and Lisa Novesky

1149. HLA received from NEWC a sample of brain tissue from the first tern and assigned a LIMS or identification number of 91104045 to that sample. HLA received from NEWC a sample of "stomach contents" from the first tern and assigned a LIMS or identification number of 91104046 to that sample.

1150. HLA received from NEWC a sample of brain tissue from the second tern and assigned a LIMS or identification number of 91104047 to that sample. HLA received from NEWC a sample of "stomach contents" from the second tern and assigned a LIMS or identification number of 91104048 to that sample.

1151. HLA analyzed the brain tissues of the first and second terns for acetylcholinesterase.

1152. HLA analyzed the brain tissues of the first and second terns for PCBs and chlorinated hydrocarbons.

1153. HLA analyzed the "stomach contents" of the first and second

terns only for PCBs and chlorinated hydrocarbons.

1154. HLA did not analyze any of the tissues from the first or second tern for any substance other than cholinesterase, PCBs or chlorinated hydrocarbons.

1155. No one working for or on behalf of HLA performed a comprehensive investigation to determine the cause of death of either the first tern or the second tern.

1156. No one working for or on behalf of HLA knows what caused the death of either the first tern or the second tern.

1157. No one working for or on behalf of HLA is qualified to determine the cause of death of a common tern.

1158. No one working for or on behalf of HLA is qualified to determine the cause of death of either the first tern or the second tern.

1159. No one working for or on behalf of HLA determined the cause of death of either the first tern or the second tern.

1160. No one working for or on behalf of HLA knows what caused the death of either the first tern or the second tern.

1161. No one working for or on behalf of HLA performed a comprehensive investigation in an attempt to determine the cause of death of either the first tern or the second tern.

1162. No one working for or on behalf of HLA is an avian toxicologist or an avian pathologist.

1163. No one working for or on behalf of HLA has any formal training in either avian toxicology or avian pathology.

1164. No one working for or on behalf of HLA examined the contents of the stomach of either the first tern or the second tern.

1165. No one working for or on behalf of HLA visually or chemically identified the contents of the stomach of either the first tern or the second tern.

1166. No one working for or on behalf of HLA knows what material was present in the stomach of either the first tern or the second tern.

1167. No one working for or on behalf of HLA performed any examination or analysis of any liver tissue from either the first tern or the second tern.

1168. The results of the cholinesterase analyses performed by HLA were inconclusive as to the cause of the death of the first tern

or second tern, in the absence of any controls or baseline information for cholinesterase levels for "healthy" common terns.

1169. In the absence of information regarding the "normal" level of acetylcholinesterase for the brain tissue of a common tern, it is not possible to meaningfully interpret the results of the cholinesterase analyses performed by HLA.

1170. The results of the cholineseterase analyses performed by HLA do not preclude the possibility that the first and second terns died as a result of organophosphate contamination.

1171. The results of the cholinesterase analyses performed by HLA do not preclude the possibility that the first and second terns died as a result of exposure to some substance other than PCBs.

1172. The results of the PCB analyses performed by HLA were inconclusive as to the cause of the death of the first tern or second tern, in the absence of any controls or baseline information for PCB levels for "healthy" common terns.

1173. The results of the PCB analyses performed by HLA do not preclude the possibility that the first and second terns died as a result of organophosphate contamination.

1174. The results of the PCB analyses performed by HLA do not preclude the possibility that the first and second terns died as a result of exposure to some substance other than PCBs.

F. Dr. Ian Nisbet

1175. Dr. Nisbet did not perform a comprehensive investigation to determine the cause of death of either tern.

1176. Dr. Nisbet did not determine the cause of death of either tern.

1177. Dr. Nisbet did not perform a necropsy on either tern.

1178. Dr. Nisbet is not an avian toxicologist or pathologist.

1179. Dr. Nisbet did not observe either of the microscope slides which were viewed by Dr. King.

1180. Dr. Nisbet did not review the unabridged chromatograms produced by HLA.

1181. Dr. Nisbet did not observe either of the tern carcasses or any of the tissue samples removed from them.

1182. Dr. Nisbet has personally observed and studied colonies of roseate and common terns in and around Cape Cod and the surrounding area for approximately 20 years and has never observed a roseate or common tern that exhibited tremors.

1183. Dr. Nisbet has personally observed and studied colonies of roseate and common terns in and around Cape Cod and the surrounding area for approximately 20 years and has never recovered a roseate or common tern whose death was caused by PCBs.

1184. Dr. Nisbet has published a number of articles relating to common and roseate terns.

1185. Statements and conclusions in articles published by Dr. Nisbet are admissions of the plaintiffs.

1186. Statements and conclusions in articles p[illegible]ed by Dr. Nisbet are admissible in evidence.

1187. Dr. Nisbet has published several articles on the subject of the effects of organochlorines, including PCBs, on the reproductive success of common and roseate terns in the Massachusetts colonies, and has consistently concluded that there were no adverse effects caused by such compounds.

1188. In an article, Organochlorine Residues and Shell Characteristics of Roseate Tern Eggs, 1981, J. Field Orinthol, 54(4):394-400 (1985), co-authored by Dr. Nisbet, levels of PCBs found in the eggs of roseate terns were found to be lower than those in eggs of common terns, which was attributed to the tendency of roseate terns to feed in cleaner waters.

1189. In an article, Organochlorine Residues and Shell Characteristics of Roseate Tern Eggs, 1981, J. Field Orinthol, 54(4):394-400 (1985), co-authored by Dr. Nisbet, it was stated that "there was no evidence of eggshell changes in Roseate Terns associated with organochlorine contamination."

1190. In an article Organochlorine Residues and Shell Characteristics of Roseate Tern Eggs, 1981, J. Field Orinthol, 54(4):394-400 (1985), co-authored by Dr. Nisbet, it was stated that "In conclusion, our results suggest that levels of organochlorine compounds in Roseate Terns in 1981 were not high enough to have measurable effects on eggshell characteristics."

1191. In an article Population Models for Common Terns in Massachusetts, Bird-Banding, 49:50-58 (1978), authored by Dr. Nisbet, it was stated that "Adult [common tern] mortality during the breeding season appears to be very low" and "most mortality probably takes place during migration or on the winter quarters."

1192. In an article, Organochlorine Residues and Shell Characteristics of Roseate Tern Eggs, 1981, J. Field Orinthol, 54(4):394-400 (1985), authored by Dr. Nisbet, it was stated that "No other organochlorine residue was associated with adverse effects on common terns in this study, despite high exposure to PCBs."

1193. From Nisbet and Reynolds, 1984, Organochlorine residues in Common Terns and Associated Estuarine Organisms, Massachusetts, USA. Marine Environmental Research 11 (1984) 33-66.

(a) Average PCB concentrations in a sample of 132 Atlantic silversides collected around Bird Island in 1974 were 0.49 ppm wet weight. Average PCB concentrations in 95 Atlantic silversides collected around Ram Island in 1974 were 1.77 ppm (wet weight).

(b) Average PCB concentrations in 20 sand lance collected from around Bird Island in 1976 were 1.25 ppm (wet weight). Average concentrations in sand lance from upper Buzzards Bay were 0.26 ppm (wet weight).

(c) The authors state that there were "significant downward trends in concentrations of PCBs" from tern eggs collected at Bird Island between 1971-1981.

(d) Levels of PCBs in breast muscle of common terns were comparable to levels in eggs (18.2 ppm and 15.4 ppm, respectively).

(e) Concentrations of PCBs in eggs that failed to hatch were not significantly different than PCB levels in eggs collected at random in the colony.

(f) The study concludes that tern eggs that failed to hatch had elevated levels of DDE.

(g) Hatching success of common terns at Bird Island was usually in the range of 93-97%, and productivity in the range of 1.8-2.1 fledged young per pair.

(h) Other than DDE, no other organochlorine residue was associated with adverse effects on common terns, despite high exposure to PCBs.

1194. From Roseate Tern Recovery Plan; Northeastern Population, U. S. Fish and Wildlife Service, January 1989.

(a) Family groups disperse throughout the breeding range in late summer, tending to concentrate on outer beaches (i.e. away from areas with higher levels of contamination in inshore areas.)

(b) Major premigratory staging areas are between Long Island and Cape Cod; there the birds appear to feed offshore.

(c) Terns arrive in late April/early May; they leave by September 18. The terns are present for a maximum of 5 months.

(d) The northeastern population of roseate terns has been fairly stable since 1977.

(e) Citing Nisbet (1980), the productivity of roseate tern chicks has been generally high in recent years, and this trend has been maintained at least in Massachusetts for several decades.

(f) There is no evidence of substantial mortality of adults during the breeding season (citing Nisbet 1980).

(g) Mortality factors on the wintering ground or on migration are most likely significant.

(h) If organochlorine residues had an adverse effect on tern such effects were probably limited to the period before the mid-1970's.

(i) The most consistent factor responsible for reduction in nesting colonies was the occupation of the colonies by herring and/or great black-backed gulls.

(j) Factors responsible for the species being threatened or endangered include human activity, competition from expanding numbers of large gulls and predation on the nesting grounds, and mortality on the wintering grounds.

(k) Available information shows that nesting roseates feed almost entirely on small fish, primarily young of the American sand lance.

(l) At Monomy, some terns died after consuming sand lance that had accumulated toxin (from the marine dinoflagellate Gonyaulax excavata; red tide), possibly by feeding on cape pods or mysids during a bloom of this algae.

(m) Disease has not been a significant problem, but terns and other species have succumbed to avian cholera and botulism.

1195. From Nisbet, Massachusetts, p 94-95 in Kress et al. 1983, The status of tern populations in northeastern United Sates and adjacent Canada, Colonial Waterbirds 6:84-106.

(a) Predation is now the most important factor limiting the breeding success of all four species (of terns, including common, roseate, arctic and least). Populations of common, roseate, and least terns were stable or increasing from 1970 to 1982.

1196. From Nisbet, 1983, Territorial feeding by common terns, Colonial Waterbirds 6:64-70.

(a) Common tern feeding territories were established all around the shoreline within 5-6 km of the colony at Bird Island. One territory was 8.5 km away, and he has seen birds were observed defending territories up to 11 km away.

(b) Territories are used less often in late June and July when schooling fish are plentiful near the colony.

(c) Nisbet has not studied feeding territories in Massachusetts in the post-fledging period.

(d) Feeding territories are used by the same individuals for periods of at least several weeks, and probably throughout the season.

(e) Buzzards Bay has enough shoreline of varied topography to provide territories for most or all of the pairs of common terns at Bird Island.

(f) The rate of fishing success and the size of fish caught by terns at Bird Island were higher than those at Monomoy, indicating that the habitats were better quality.

1197. From Custer et al. 1983, Organochlorine residues and shell characteristics of roseate tern eggs, 198', J. Field Ornithology 54(4): 394-400.

(a) Concentrations of organochlorine compounds in roseate tern were considerably lower than those in common terns.

(b) One reason for this is that roseate terns usually feed in less polluted waters than common terns; they feed either in deeper waters onshore, or farther offshore. "For example, in Buzzards Bay, Massachusetts, Roseate Terns fed primarily in 2 discrete areas and avoided the parts of the bay most heavily polluted with PCBs from point sources at New Bedford (Nisbet 1981, Nisbet and Reynolds, in press)."

(c) "In conclusion, our results suggest that levels of organochlorine compounds in Roseate Terns in 1981 were not high enough to have measurable effects on eggshell characteristics." (continues to say "however, our results do not rule out the possibility that levels in 1971 or earlier might have been high enough to have caused adverse effects [Hays and Risebrough 1972]).

1198. From Nisbet, 1973, Terns in Massachusetts;: Present numbers and historical changes, Bird-Banding 44(1):27-55.

(a) Colonies at Ram and Bird islands were overrun by gulls between 1964-1966; subsequently gull control programs permitted partial resettlement.

(b) Common terns on Bird island: 1970-250, 1971-350, 1972-310, Roseate terns on Bird Island: 1970-600, 1971-1300; 1972-1100.

1199. From Safina et al., 1988, Evidence for prey limitation of common and roseate tern reproduction, The condor 90:852-859.

(a) Although productivity studied for only two years, data suggests that prey population fluctuations may limit reproductive success in the terns they studied. (Cedar Beach Long Island).

1200. The following are articles of a type relied upon by experts in the field.

Andrews, R., Atwell, G., Blodget, B.G., Nisbet, I.C.T., Scheibel, M. (Northeast Roseate Tern Recovery Team), Roseate Tern Recovery Plan, Published by Region 5 U.S. Fish and Wildlife Service, (1989)

Custer, T.W., Nisbet, I.C.T., and Krynitsky, A.J., Organochlorine Residues and Shell Characteristics of Roseate Tern Eggs, 1981, J. Field Orinthol, 54(4):394-400 (1985)

Lincer, J.L., and Peakall, D.B., PCB Pharmacodynamics in the Ring Dove and Early Gas Chromatographic Peak Diminution, Environ. Pollut., 4:59-69 (1973)

McLaughlin, J., Counting the Gulls of Monomoy, The Boston Globe, (May 20, 1990)

Nisbet, I.C.T., Population Models for Common Terns in Massachusetts, Bird-Banding, 49:50-58 (1978)

Nisbet, I.C.T., Reynolds, L. M., Organochlorine Residues in Common Terns and Associated Estuarine Organisms, Massachusetts, USA, 1971-81, Marine Environmental Research, 11:33-66 (1984)

III. Chemistry

1201. The only authority cited for Dr. Nisbet's opinion that the "fingerprint" of the PCBs allegedly present in the tissues of the first and second terns--that is, the presence of substantial quantities of less chlorinated PCB congeners--is Dr. Nisbet's own study, Nisbet and Reynold.

1202. Nisbet and Reynold suggest that New Bedford Harbor samples contain substantial quantities of tri- and tetrachlorobiphenyls similar to those found in 1016.

1203. In Dr. Nisbet's opinion, he does not define what he means by less chlorinated PCB congeners.

1204. The basis for Dr. Nisbet's opinion is stated to be an examination of the chromatograms prepared by Hazelton Laboratories.

1205. The chromatograms from Hazelton laboratories were prepared

on packed column chromatograph.

1206. Quantitation by level of chlorination of PCBs was not done by HLA.

1207. Quantitation by level of chlorination cannot be done based on the HLA chromatograms because chlorobiphenyl quantitation cannot be performed with packed column chromatography.

1208. If the term "fingerprint," as used by Dr. Nisbet, refers to the presence of specific congeners, he could not make such a deduction based on the HLA chromatograms.

1209. The predominant chlorobiphenyl groups in New Bedford Harbor samples are tri-, tetra- and pentachlorobiphenyl.

1210. The chlorobiphenyls of interest to Battelle and Hydroqual for preparation of their food chain model were tris, tetras, pentas and hexas.

G. Ward Stone

1211. Ward B. Stone (Mr. Stone) does know what caused the death of either the first or second tern.

1212. Mr. Stone is not qualified to determine the cause of death of a common tern.

1213. Mr. Stone is not qualified to render an opinion as to the cause of death of a common tern.

1214. Mr. Stone is not qualified to determine the cause of death of either the first tern or the second tern.

1215. Mr. Stone is not qualified to render an opinion as to the cause of death of either the first tern or the second tern.

1216. Mr. Stone does not know what caused the death of either the first tern or the second tern.

1217. Mr. Stone did not perform a comprehensive investigation to determine the cause of death of either tern.

1218. Mr. Stone did not determine the cause of death of either the first tern or the second tern.

1219. Mr. Stone did not perform a necropsy on either the first tern or the second tern.

1220. Mr. Stone is not an avian toxicologist or pathologist.

1221. Mr. Stone did not observe either of the microscope slides

which were viewed by Dr. King.

1222. Mr. Stone did not review the unabridged chromatograms produced by HLA.

1223. Mr. Stone did not observe either of the tern carcasses or any of the tissue samples removed from them.

1224. Mr. Stone did not perform a chemical analysis of any of the tissues which were removed from either the first tern or the second tern.

1225. Mr. Stone did not examine the contents of the stomach of either the first tern or the second tern.

1226. Mr. Stone did not visually or chemically identify the contents of the stomach of either the first tern or the second tern.

1227. Mr. Stone does not know what material was present in the stomach of either the first tern or the second tern.

1228. Mr. Stone does not know where either the first tern or the second tern fed prior to being recovered and brought to him.

1229. Mr. Stone did not analyze the liver tissue of either the first tern or the second tern in any way.

1230. Mr. Stone did not chemically analyze the liver tissue of either the first tern or the second tern in any way.

IV. Toxicology

1231. Given the assumption of equal PCB doses, there is no evidence to indicate that terns bioaccumulate PCBs to any greater extent than do the chicken, quail, dove or mallard.

1232. Ring doves fed 10 ppm Aroclor 1254 for 200 days developed brain PCB concentration of 5.5 ppm (wet weight). (Lincer and Peakall, 1973)

1233. White crested cormorants ingesting prey with a PCB concentration of 1.6 ppm had brain PCB concentrations of 2.9 ppm PCB (expressed on a wet weight basis). (Peakall review)

1234. There is no evidence to indicate that the common terns autopsied at the New England Wildlife Center had mobilized their fat stores.

1235. Nisbet and Reynolds (1984) indicate that the ratio of tern egg PCB concentration (wet weight) to fish PCB concentration (wet weight) is 30.

1236. Based on Nisbet's bioaccummulation factor, during the portion of the year when terns are present in the New Bedford Harbor area, consumption of prey containing an average of 10 ppm PCB or less would not produce PCB concentrations in the brains of terns in excess of 300 ppm.

1237. Based on Nisbet and Reynolds' bioaccumulation factor, during the portion of the year when terns are present in the New Bedford Harbor area, consumption of prey containing an average of 5 ppm PCB or less would not produce PCB concentrations in the brains of terns in excess of 300 ppm.

1238. Based on Nisbet and Reynolds' bioaccumulation factor, during the portion of the year when terns are present in the New Bedford Harbor area, consumption of prey containing an average of 2 ppm PCB or less would not produce PCB concentrations in the brains of terns in excess of 300 ppm.

1239. The plaintiffs know of no laboratory study which has examined the accumulation of PCBs in the tissues, organs, or eggs of terns.

1240. Terns feeding in New Bedford Harbor do not have a steady diet of prey containing an average of 10 ppm PCB or more.

1241. Terns feeding in New Bedford Harbor do not have a steady diet of prey containing an average of 5 ppm PCB or more.

1242. Terns feeding in New Bedford Harbor do not have a steady diet of prey containing an average of 2 ppm PCB or more.

1243. There is no evidence of a food source in the New Bedford Harbor area containing PCBs at a concentration equivalent to that reportedly found in the stomach contents of the terns.

1244. The plaintiffs know of no dose-response study examining the toxicity of PCBs in any species of terns.

1245. The plaintiffs know of no scientific study which has examined the time course of PCB accumulation in terns.

1246. In the Lincer and Peakall study, PCB Pharmacodynamics in the Ring Dove and Early Gas Chromatographic Peak Diminution, Environ. Pollut., 4:59-69 (1973), ring doves fed 10 ppm Aroclor 1254 for 200 days had PCB concentrations in the muscle, liver, and fat which were higher than the brain PCB concentration.

1247. PCB concentrations in brain tissue of PCB-treated ring doves were approximately equal to or less than PCB concentrations in their eggs (Lincer and Peakall, 1973).

1248. Concentrations of PCBs in tern eggs are approximately equal to or less than PCB concentrations in the brain of the egg-laying

tern.

1249. Using the reported bioaccumulation factor of 30 calculated by Nisbet and Reynolds (1984), average concentrations of PCBs in biota eaten by terns would have to be 10 ppm and higher to produce brain PCB concentrations of 300 ppm and greater.

1250. The average concentration of PCBs in the prey of terns in Buzzards Bay is lower than 10 ppm.

1251. The average concentration of PCBs in the prey of terns in Buzzards Bay is lower than 5 ppm.

1252. The average concentration of PCBs in [illegible] of terns in Buzzards Bay is lower than 2 ppm.

1253. Lincer and Peakall (1973) observed no difference in mortality between PCB-treated and untreated ring doves which were subjected to starvation stress.

1254. Mobilization of PCBs from fat stores was not responsible for the death of the terns found in Wareham and Marion.

1255. The cause of death of two terns is uncertain.

1256. Causation of the deaths of the terns has not been adequately investigated or established.