Robinson(KQ)

DDT and Chlordane in the Hudson River Basin

by

Kelly Robinson

Submitted in partial fulfillment for the
degree of Masters of Science in the
Department of Earth and Environmental Sciences at
Rensselaer Polytechnic Institute

Approved:

Richard F. Bopp

Richard F. Bopp
Thesis Advisor

Rensselaer Polytechnic Institute
Troy, New York
May 2002

Newark Bay Study Area
NBSA-00088

Table of Contents

List of Figures iv

List of Tables vi

Acknowledgements ix

Abstract x

Chapter 1. Introduction 1

Production and Use 2

Properties 3

Sediment Core Dating 6

Chapter 2. DDT and Chlordane in Hudson River and New York/New Jersey Harbor Sediment 7

Introduction 7

Results and Discussion 8

Raritan Bay 10

Newtown Creek 14

Upper NY/NJ Harbor Near the Statue of Liberty 15

Harbor Transects 19

Kill Van Kull 23

Newark Bay 27

Arthur Kill 30

Tidal Hudson 35

Upper Hudson Basin 38

Central Park 39

Relative Concentrations of DDT and Chlordane Compounds in Hudson River and New York/New Jersey Harbor Sediment 43

Putting the Hudson River and New York/New Jersey Harbor Data in Perspective 48

Further Evidence of Fresh DDT Inputs Near the Arthur Kill 52

Chapter 3. Tracing Chlordane Residues in Fish and Crustaceans from the NY/NJ Harbor Complex 55

Introduction 55

Analysis 56

Results and Discussion 56

Chapter 4. Conclusions 70

References 73

Appendix I. Sales and Usage Statistics 77

Appendix II. Radionuclide Data 85

Appendix III. Sediment DDT and Chlordane Tracer Data 95

Appendix IV. DDT and Chlordane Sediment Data 102

Appendix V. DDT and Chlordane Fish Data 119

List of Figures

Figure 1-1. Structures of abundant technical chlordane components ... 4

Figure 1-2. Structures of DDT and related compounds ... 5

Figure 2-1. NY/NJ Harbor complex ... 11

Figure 2-2. pp'-DDD in Raritan Bay sediment ... 12

Figure 2-3. γ–chlordane in Raritan Bay sediment ... 13

Figure 2-4. pp'-DDD in upper harbor sediment ... 17

Figure 2-5. γ-chlordane in upper harbor sediment ... 18

Figure 2-6. pp'-DDD in harbor transects from 1982 to 1998 ... 20

Figure 2-7. γ-chlordane in harbor transects from 1982 to 1998 ... 21

Figure 2-8. pp'-DDD in Kill Van Kull sediment ... 25

Figure 2-9. γ-chlordane in Kill Van Kull sediment ... 26

Figure 2-10. pp'-DDD in Newark Bay sediment ... 28

Figure 2-11. γ-chlordane in Newark Bay sediment ... 29

Figure 2-12. ^{137}Cs activity in the Arthur Kill, cores KILI. 14 and KILI. 21 ... 32

Figure 2-13. pp'-DDD in Arthur Kill sediment ... 33

Figure 2-14. γ -chlordane in Arthur Kill sediment ... 34

Figure 2-15. pp'-DDD in tidal Hudson sediment ... 36

Figure 2-16. γ-chlordane in tidal Hudson sediment ... 37

Figure 2-17. pp'-DDD in sediment from Central Park Lake ... 41

Figure 2-18. γ-chlordane in sediment from Central Park Lake ... 42

Figure 2-19. pp'-DDD and pp'-DDE in RB17 from Raritan Bay ... 47

Figure 2-20. NOAA NST top 24 sites for DDT contamination ... 50

Figure 2-21. NOAA NST top 25 sites for α-chlordane contamination ... 51

Figure 2-22. Tributaries to the Arthur Kill 54

Figure 3-1. Relative concentrations of chlordane components from technical chlordane to American eels from the NY/NJ Harbor 60

Figure 3-2. Trans nonachlor vs. α-chlordane in eels 61

Figure 3-3. Trans nonachlor vs. α+γ-chlordane in eels. 62

Figure 3-4. Trans nonachlor vs. α+γ+oxychlordane in eels 63

Figure 3-5. Relative concentrations of chlordane components from technical chlordane to striped bass from the NY/NJ Harbor Complex 65

Figure 3-6. Trans nonachlor vs. α-chlordane in striped bass 66

Figure 3-7. Relative concentrations of chlordane components from technical chlordane to the blue crab and lobster hepatopancreas from the NY/NJ Harbor 68

Figure 3-8. Trans nonachlor vs. α-chlordane in blue crab and lobster hepatopancreas from the NY/NJ Harbor 69

Figure A1-1. U.S. pesticide production 78

Figure A1-2. U.S DDT production and export 79

List of Tables

Table 1-1. Properties of abundant technical chlordane components ... 3

Table 1-2. Properties of DDT and relative abundances in technical DDT ... 5

Table 2-1. pp'-DDD and γ-chlordane in Newtown Creek sediment ... 15

Table 2-2. pp'-DDD and γ-chlordane in NY/NJ Harbor transect sediment ... 22

Table 2-3. pp'-DDD and γ-chlordane in the upper Hudson basin ... 38

Table 2-4. DDT compounds in American eels from Morses Creek ... 52

Table 2-5. DDT compounds in fish from the Sawmill River ... 53

Table 3-1. Relative chlordane concentrations in fish and crustaceans from the NY/NJ Harbor ... 59

Table 3-2. Average concentrations of chlordane components normalized to α-chlordane ... 59

Table A1-1. U.S. DDT production and use ... 80

Table A1-2. Total U.S. production of pesticides and related agricultural products ... 81

Table A1-3. Total U.S. production of fungicides ... 82

Table A1-4. Total U.S. production of herbicides ... 83

Table A1-5. Total U.S. production of insecticides ... 84

Table A2-1. Radionuclide data ... 86

Table A3-1. DDT and chlordane tracer data for the upper Hudson basin ... 96

Table A3-2. DDT and chlordane tracer data for the Central Park lake ... 96

Table A3-3. DDT and chlordane tracer data for the tidal Hudson River ... 97

Table A3-4. DDT and chlordane tracer data for Raritan Bay ... 98

Table A3-5. DDT and chlordane tracer data for the Arthur Kill ... 99

Table A3-6. DDT and chlordane tracer data for the Kill Van Kull ... 100

Table A3-7. DDT and chlordane tracer data for Newark Bay ... 100

Table A3-8. DDT and chlordane tracer data for Newtown Creek ... 100

Table A3-9. DDT and chlordane tracer data for the upper NY/NJ Harbor 101

Table A4-1. Comparison of Bopp and AXYS Analyses 103

Table A4-2. Chlordane in the upper Hudson basin 104

Table A4-3. DDT in the upper Hudson basin 104

Table A4-4. Chlordane in the tidal Hudson River 105

Table A4-5. DDT in the tidal Hudson River 106

Table A4-6. Chlordane in the upper NY/NJ Harbor 107

Table A4-7. DDT in the upper NY/NJ Harbor 108

Table A4-8 Chlordane in Newtown Creek 109

Table A4-9. DDT in the Newtown Creek 109

Table A4-10. Chlordane in the Kill Van Kull 110

Table A4-11. DDT in the Kill Van Kull 111

Table A4-12. Chlordane in the Arthur Kill 112

Table A4-13. DDT in the Arthur Kill 113

Table A4-14. Chlordane in Newark Bay 114

Table A4-15. DDT in Newark Bay 115

Table A4-16. Chlordane in Raritan Bay 116

Table A4-17. Chlordane in the Central Park lake 117

Table A4-18. DDT in the Central Park lake 118

Table A5-1. Chlordane in American eels from the NY/NJ Harbor 120

Table A5-2. DDT in American eels from the NY/NJ Harbor 121

Table A5-3. Chlordane in American lobster hepatopancreas from the NY/NJ Harbor 122

Table A5-4. Chlordane in blue crab hepatopancreas from the NY/NJ Harbor 122

Table A5-5. DDT in American lobster hepatopancreas from the NY/NJ Harbor 123

Table A5-6. DDT in blue crab hepatopancreas from the NY/NJ Harbor 123

Table A5-7. Chlordane in striped bass from the NY/NJ Harbor 124

Table A5-8. DDT in striped bass from the NY/NJ Harbor 127

Acknowledgements

I may have never made it to this day if it wasn't for the support of many people. I would like to thank Richard Bopp for allowing me this opportunity and for his support as my Undergraduate Advisor and Thesis Advisor. Richard's enthusiasm, patience, and insurmountable teaching ability made it difficult for me not to enjoy my work and gain so much valuable insight. I would also like to thank Damon Chaky for getting me settled into the "Bopp lab" and for his patience and help throughout my many computer tragedies.

The Department of Earth and Environmental Sciences at Rensselaer Polytechnic Institute has such a talented and diverse group of professors, including Ted Shuster, who all have so much to offer their students. I would like to thank them all for this.

I would also like to thank Margaret, Jeremiah, and Jeff for supporting me through the stressful times and for reminding me that there was life outside of school. I also have great appreciation for my parents' support in my decision to purse this degree. They gave me peace of mind in knowing that no matter how difficult things became, I would never have to survive off of Ramen noodles.

I would like to thank Ron Sloan, Michael Kane, and Dennis Keane, from the New York State Department of Environmental Conservation, for providing the fish data used in this project.

The support for this project came from the National Institute of Environmental Health Science through a Superfund Basic Research Program grant to Mount Sinai Medical Center (P42 ES07384) and the NYS Department of Environmental Conservation (Contract C003844).

Abstract

Dated sediment cores help us track particle associated transport and monitor degradation. Cores that were collected throughout the NY/NJ Harbor have provided us with chronologies for particle associated contaminants including DDT and chlordane within the harbor. Analysis of these samples indicates that input from a former manufacturing facility is the major source of DDT to the harbor. This is seen in the western harbor where the Passaic, the Arthur Kill, and the Kill Van Kull have the highest levels of pp'-DDD. Wastewater inputs from Newtown Creek and transport down the mainstem of the Hudson River also contribute to the DDT contamination within the harbor, but these sources are not as significant as the industrial inputs. Levels have decreased since the mid sixties at most sites throughout the harbor complex. The exceptions are the Arthur Kill and Newtown Creek. Analysis of recent samples from the Arthur Kill suggests that there may be a continuous source of fresh DDT, possibly from improper disposal. A sample from the early 1970s has detected concentrations of pp'-DDD and pp'-DDT of 100 and 46 ppb, respectively. In about 1985, pp'-DDD had increased to 280 ppb, and pp'-DDT had increased to 650 ppb. Sediment deposited in about 1996 had the same level of pp'-DDT, 650 ppb, and higher levels of pp'-DDD, 520 ppb. The increase of the metabolite is most likely due to the breakdown of the fresh source of pp'-DDT.

Cores collected from Newtown Creek show pp'-DDD doubling between 1990 and 1996. Between 1996 and 1998, levels have remained the same. The pp'-DDT/pp'-DDD ratio decreased from 0.21 to 0.12, indicating that there is not a new DDT source.

A core collected from a lake in Central Park, Manhattan, has higher levels of DDT than any of the harbor samples. pp'-DDD peaked in the late 1960s at 3100 ppb. The high historical levels in the lake suggest direct application of DDT to the lake surface, probably for mosquito control or to the trees for gypsy moth control. More recent samples had lower but still elevated

levels. Concentrations of 1600 ppb pp'-DDD in sediment from the early 1980s and 2300 ppb in sediment deposited in the 1990s indicates continued input from the drainage basin or redistribution within the lake sediments.

The sources of chlordane contamination to the harbor are through wastewater discharge and a more significant unidentified source in the western harbor. Levels have decreased at all of the sites with the exception of Newtown Creek, a wastewater indicator site. All analyzed components of chlordane increased by 50 percent or more between 1990 and 1998 in Newtown Creek sediments. Increases in both DDT derived and chlordane components decades after the ban on domestic use suggests changes in the treatment processes at Newtown Creek as a possible source.

An extensive database provided by the NYSDEC has allowed for the observation of relative behaviors of components of technical chlordane in American eels, striped bass and the hepatopancreas of blue crabs and lobsters. It was possible to trace the typical relative concentrations from sediment to fish and crustaceans. The parent to metabolite ratios in fish and crustaceans were much lower than those detected in sediment. This is to be expected due to metabolism once ingested. In the striped bass and eels, the combined effects of metabolism and accumulation are very similar for trans nonachlor and α-chlordane. This was not seen in the hepatopancreas samples. Accumulation of oxychlordane, the primary metabolite, was observed in all species, but this was seen to a greater extent in the hepatopancreas samples of blue crabs and lobsters.

Chapter 1. Introduction

DDT and chlordane are chlorinated hydrocarbon pesticides that were widely used throughout the United States. Although DDT has been banned in the U.S. for three decades and chlordane for over one, they remain widespread throughout the environment in sediment, wildlife, and even humans. They are highly persistent in the environment and bioaccumulate throughout the food chain. Despite their banning decades ago, it is still important to monitor concentrations in sediment and biological systems due to this persistence.

Often when samples are analyzed for DDT and chlordane, only the total concentrations are considered and reported. While this is important with respect to regulatory actions, it is also important to look at the individual compounds in order to build an understanding of behavior of the pesticide in the environment. Relative concentrations of individual compounds can give evidence of biodegradation, transport, and bioaccumulation or indicate fresh sources of contamination.

The Hudson River is a sink for numerous contaminants. It flows from the Adirondack Mountains in upstate New York to the Atlantic Ocean at the NY/NJ Harbor, a distance of some 315 miles. In the harbor, Hudson River sediment and water mix with inputs from contiguous water systems, including the Passaic, Hackensack and Raritan Rivers, and Newark, Raritan and Jamaica Bays. The Hudson River, its tributaries, and the other water bodies around the harbor have all contributed to the contamination found in the harbor sediment. Using dated sediment cores has made it possible to develop contaminant chronologies and monitor the fate of these pollutants within the sediment column. In some cases, primary sources of pollutants to the harbor have been characterized. This method has provided valuable information pertaining to sediment contamination in numerous studies (*Bopp et al., 1982, Bopp et al., 1993, Bopp et al., 1998*).

Production and Use

In many cases, complete and useful production records are not easy to find. The most complete records for DDT were reported by the U.S. Tariff Commission in Synthetic Organic Chemicals, Pesticides and Related Products (1947-1970). No such records exist for chlordane. Chlordane is included in the reports, however the figures are combined with other organic chemicals. Domestic production figures can be found in Appendix I.

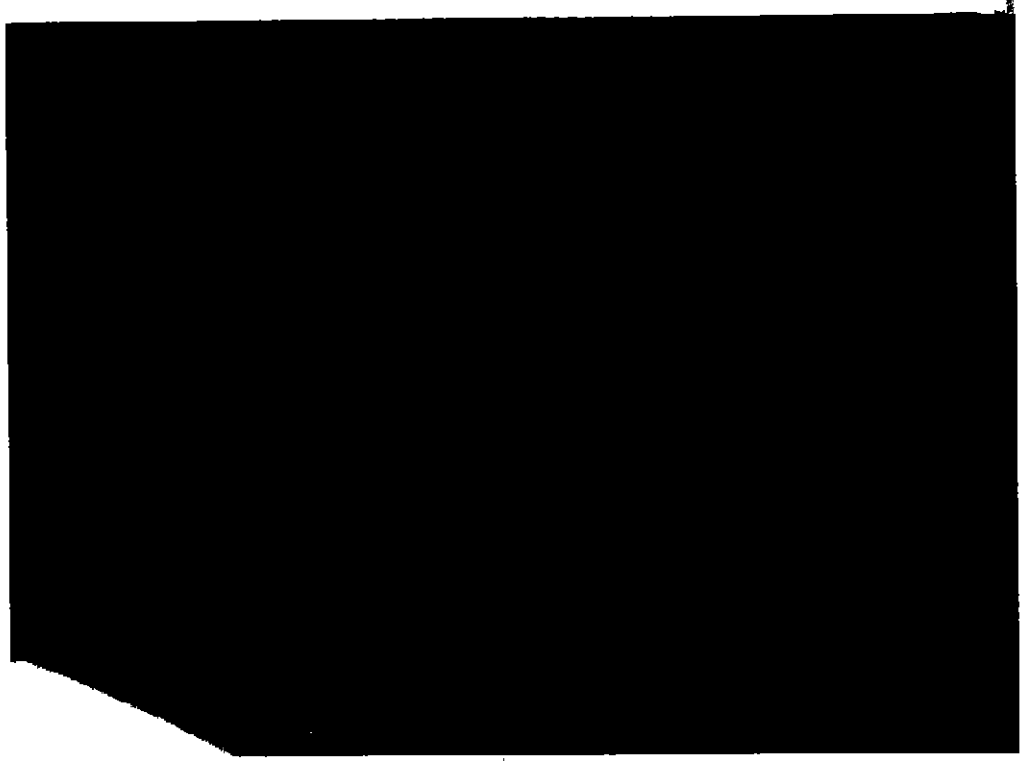
Chlordane

Chlordane was used primarily as an insecticide on non-agricultural crops, animals, and for termite control (*WHO, 1984*). Velsicol Chemical Company, the sole U.S. producer of chlordane, began production in 1946 (*Dearth, 1990*). Restrictions on its use began in 1978 when the Environmental Protection Agency banned its use as a pesticide for food crops Until 1988, when its use in the U.S. was banned, it was used primarily for underground termite control. Export continued until 1997 when Velsicol Chemical Company stopped all production (*Mattina et al , 1999*). Yearly production figures seem to be unavailable, but it has been estimated that about 20 million pounds a year were used in the U S (*Tashiro et al., 1977*), and more than 70,000 tons were used between 1960 and 1988 (*Dearth et al., 1991*). The peak use of chlordane followed the banning of DDT in 1972 (*Dearth, 1990*).

DDT

The effectiveness of DDT as an insecticide was discovered in 1939. It was initially used for protection of military troops against typhus and malaria then released for commercial sale in 1946 (*WHO, 1979*). It was widely used as an agricultural insecticide until 1972, when it was banned in the U.S.

The U.S. Tariff Commission provides fairly complete production records for DDT from 1947 to 1970 (Appendix I). U.S. production was at 50 million pounds in 1947 and peaked in 1963



at 179 million pounds. In 1970, just prior to banning, production was down to 59 million pounds (*U.S. Tariff Commission*).

Much of the DDT produced in the U.S. was exported. In 1953, U.S. use was at 57 million pounds. It peaked in 1959 at 72 million pounds. In 1970, just prior to banning, use was down to 23 million pounds (*WHO, 1979*). Although its use was banned in the U.S. in 1972, some production for export continued at least through 1994. It was estimated that between 1992 and 1994, 603,356 pounds of DDT were exported from the U.S. (*FASE, 1996*).

Properties

Chlordane

The chlordane that was applied as a pesticide (technical chlordane) was a mixture of approximately 140 different compounds (*Dearth et al., 1991*). The more abundant compounds, those most often analyzed, include γ-chlordane (trans), α-chlordane (cis), trans nonachlor and cis nonachlor. In a detailed analysis of technical chlordane, Dearth (1990) determined the percent abundance of the compounds in the technical mixture to be 13, 11, 7, and 2.2 percent, respectively. Reported properties of these compounds are listed in Table 1-1.

Compound	Formula & Molecular Wt.	Solubility (mg/l)	Vapor Pressure (mmHg)	Henry's Law Constant ($atm*m^3/mol$) @25C
γ-chlordane	$C_{10}H_6Cl_8$, MW=409.78	0.056	$5.03x10^{-5}$	$4.84x10^{-4}$
α-chlordane	$C_{10}H_6Cl_8$, MW=409.78	0.056	$3.60x10^{-5}$	$3.47x10^{-4}$
Trans nonachlor	$C_{10}H_5Cl_9$ MW=444.23	0.0104	$2.78x10^{-5}$	$2.48x10^{-5}$
Cis nonachlor	$C_{10}H_5Cl_9$ MW=444.23	0.0104	$1.25x10^{-5}$	$2.48x10^{-5}$

Table 1-1. Properties of abundant technical chlordane components reported in Howard, 1997.

These components of technical chlordane are hydrophobic which results in a strong affinity for particle adsorption. Once deposited in the sediment column, the compounds are relatively immobile. However, despite the low aqueous solubility and vapor pressure, trace amounts of chlordane compounds have been found in ocean water and both indoor and outdoor air (*Louis et al., 1987, Anderson et al., 1988, Kawano et al., 1988*).

The low-polarity, low-solubility chlordane compounds accumulate throughout the food chain. This can especially be seen with trans nonachlor. Trans nonachlor has a lower aqueous solubility than the other compounds and therefore tends to accumulate more. This will be discussed in detail in chapter 3.

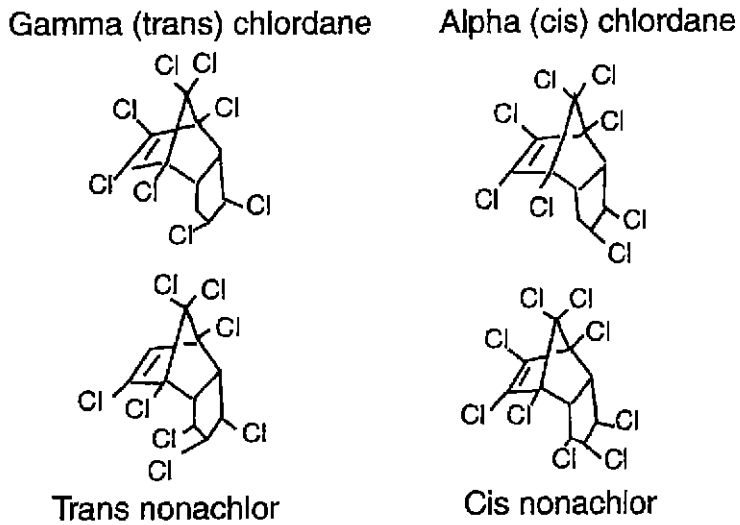


Figure 1-1. Structures of abundant technical chlordane components.

DDT

DDT that was applied as a pesticide was not pure pp'- DDT. A typical mixture was reported by the WHO (1979) (Table 1-2).

Compound	Approximate % in Technical Mixture	Vapor Pressure 25°C (atm) - log P	Aqueous Solubility 25°C -log C_w^{sat}
pp'-DDT	77.1	9.87	7.85
op'-DDT	14.9		
pp'-DDD	0.3		
op'-DDD	0.1		
op'-DDE	4		
pp'-DDE	0.1		

Table 1-2. Typical percent of DDT compounds in a technical mixture. Vapor pressure and solubility data from Schwarzenbach et al., 1993.

The properties of DDT and related compounds are similar to those of chlordane. They have a strong affinity for particle adsorption and will therefore remain relatively immobile once deposited in the sediment column. The low aqueous solubility also results in bioaccumulation in the food chain. Vaporization can and does occur. This creates a concern for atmospheric transport (*Rapaport et al., 1985, Bopp et al., 1995*).

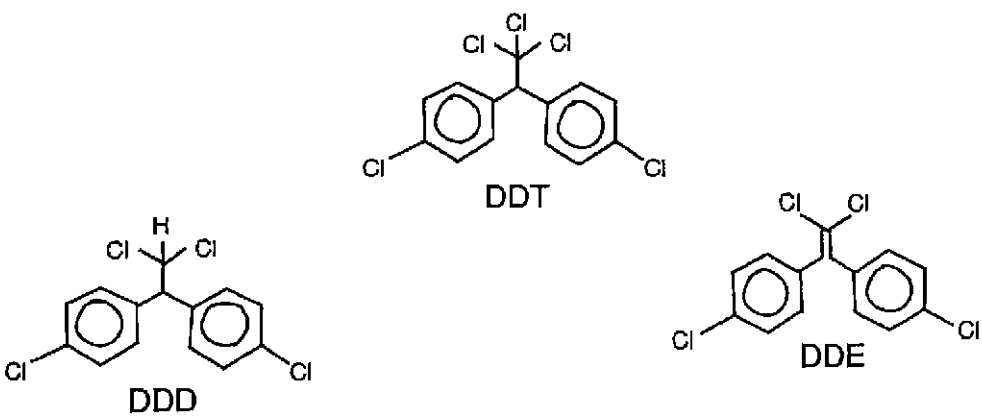


Figure 1-2. Structures of DDT and related compounds.

Sediment Core Dating

Dated sediment cores have been extremely useful tools for developing contaminant chronologies in the Hudson River and New York/New Jersey Harbor. This is most successful in areas with continuous net sedimentation rates on the order of 1 to 2 cm per year (*Bopp et al., 1982, Bopp et al., 1991, Bopp et al., 1993, Bopp et al., 1998*).

The dating is done by gamma ray spectroscopy for analyses of particle reactive radionuclides including ^{137}Cs and ^{7}Be. The source of the ^{137}Cs is from atmospheric testing of nuclear weapons. In 1954, significant amounts of ^{137}Cs could be detected in water bodies. In the mid sixties, just prior to the banning of atmospheric testing, there was a peak in ^{137}Cs deposition (Ritchie and McHenry, 1990). Several natural water systems, including the lower Hudson, receive additional ^{137}Cs inputs from nuclear reactor effluent. The known history of such releases often provides additional dating information (*Olsen et al., 1981, Bopp et al., 1982, Chillrud, 1996*).

^{7}Be is produced in the atmosphere by cosmic ray spallation of nitrogen and oxygen. It has a half-life of only 53 days. Consequently, ^{7}Be is found on suspended particles and on recently-deposited surface sediments (*Bopp et al., 1991*).

Chapter 2. DDT and Chlordane in Hudson River and New York/New Jersey Harbor Sediment

Introduction

As discussed in Chapter 1, both DDT and chlordane are persistent in the environment. With a strong tendency to adsorb onto particles, there is significant transport with suspended particles and deposition in the sediment column. Biodegradation may occur, altering the relative concentrations. Unfortunately, the metabolites are generally of equal or greater toxicity and are also persistent (*WHO, 1979, 1984*).

With the use of dated sediment cores, it has been possible to create a temporal picture of DDT and chlordane contamination within the Hudson River and the NY/NJ Harbor complex. Significant sources to the harbor have been classified, and possible fresh sources of DDT have been identified (*Bopp et al., 1998*).

The focus in this chapter will be to extend the DDT and chlordane chronologies previously developed (*Bopp et al., 1982, Bopp et al., 1993, Bopp et al., 1998*). With the collection of sediment cores in the 1990s and analysis of chlorinated pesticides in these cores, the sediment and contaminant records have been extended to the mid to late 1990s for many areas of the harbor complex. Where new data is available, it will be presented with the data discussed in previous work in order to show the complete temporal picture. In such cases, results from two different labs will be reported. Data designated "Bopp" refers to packed column ECGC analyses carried out at the Lamont-Doherty Geological Observatory between 1977 and 1990. Details are provided by Bopp (1979). The more recent analyses ("Axys") were done at Axys Analytical Services, Ltd. employing HRGC with MS detection and quantification following procedures specified in their contract with the NYS Department of Environmental Conservation (Axys, 1999). Results of "Axys" analyses of archived samples previously analyzed by "Bopp" can be seen in Table A4-1. Data comparability was generally very good.

Results and Discussion

Previous work has developed DDT and chlordane chronologies for portions of the Hudson River and the NY/NJ Harbor (*Bopp et al., 1993, Bopp et al., 1998).* From sediment cores taken from the NY/NJ Harbor complex (Figure 2-1), the mainstem of the Hudson River, and reservoirs for the NYC municipal water supply, trends in DDT and chlordane contaminant history were developed through the mid eighties (*Bopp et al., 1998*). Additional detail on these chronologies including extension into the 1990s at several sites is reported below. Also presented are the first data on DDT and chlordane chronologies in the Upper Hudson and in Central Park Lake.

Chlorinated pesticide analyses of dated sediment cores have provided information regarding direct inputs to the harbor complex. Cores taken from the Muscoot and Ashokan Reservoirs, part of the NYC municipal wastewater supply, give an indication of inputs to suburban and rural watersheds, respectively. Cores from Jamaica Bay and Newtown Creek give an indication of municipal wastewater inputs (*Bopp et al., 1998*). Newtown Creek is a tidal embayment of the East River (Figure 2-1) that receives direct input of effluent from one of the largest secondary sewage treatment plants in NYC. Freshwater inputs to Jamaica Bay, a coastal embayment a few miles east of the mouth of the Hudson (Figure 2-1), are dominated by secondary sewage treatment effluent and combined sewer overflow.

Bopp et al. (1998) detected chlordane in all of the samples representing the mid eighties from within the harbor complex. γ-chlordane concentrations ranged from 11 ppb in the upper harbor to 77 ppb in the upper Passaic River. Overall, the western side of the harbor shows elevated concentrations, primarily in the upper Hackensack, the Passaic, Arthur Kill and Kill Van Kull. This clearly indicates a source of chlordane to the western portion of the harbor. As of now, this source remains unidentified.

The samples taken from Newtown Creek and Jamaica Bay indicate that municipal wastewater contributions are significant to the harbor complex. A 1988 sample from Jamaica Bay had 22 ppb γ-chlordane, and a sample from Newtown Creek had 28 ppb.

Less than 1 ppb γ-chlordane was detected in sediment from the Hudson mainstem deposited in 1986, and less than 2 ppb was detected from the mid 1960s. Less that 0.5 ppb was detected in the reservoir sediment. This would indicate that chlordane contamination to the harbor comes form direct inputs to the harbor and is not significantly influenced by the Hudson River or atmospheric contributions.

Bopp et al. (1998) also analyzed DDT compounds in the harbor sediment deposited in the mid 1980s and prior. As with chlordane, concentrations of DDT compounds are highest in the western harbor. A large contributor to this contamination is from the 80 Lister Avenue Superfund site where DDT was produced between about 1939 and 1958 (documents provided by the NJDEP). Peak pp'-DDD concentrations in Newark Bay were found in sediment deposited in and before the early 1950s (Bopp et al., 1993), consistent with the dominance of an 80 Lister Avenue source. Evidence of this "unusual" temporal pattern (in most systems, DDT levels peak in the 1960s or early 1970s) is also seen in the Raritan Bay and Arthur Kill chronologies discussed below.

pp'-DDD concentrations from the mid to late 1980s ranged from 18 ppb in Jamaica Bay sediment to 590 ppb in the Arthur Kill. A 1986 sample with only 6 ppb pp'-DDD from the Hudson mainstem indicates that the pp'-DDD contribution to the harbor from the upper Hudson basin is insignificant. It was suggested that there is a relatively fresh source of DDT to the area around Staten Island. Consistent with a fresh source, the parent to metabolite ratio, pp'-DDT/pp'-DDD, in cores taken near Staten Island averaged about 0.87. This is much higher than the average of about 0.2 found in the other sites from the lower Hudson basin (*Bopp et al., 1998*).

Raritan Bay

pp'-DDD and γ-chlordane chronologies have been developed for Raritan Bay (Figure 2-1), an estuarine embayment between the NY/NJ Harbor and NY Bight. Sediment core RB17 was collected from Raritan Bay in 1980. Although this core did not have an ideal ^{137}Cs profile, approximate sediment deposition years could be assigned on the basis of its $^{239,240}Pu$ profile and ^{137} Cs profile (*Bopp et al., 1993a*). By assuming the top was deposited in 1980, the year of collection, and a ^{137} Cs peak of 324 +/- 25 pCi/kg at 12-15 cm coincided with peak global fallout in 1963, the upper sections have a sedimentation rate of about 0.7 cm/yr. A strong peak in fallout $^{239,240}Pu$ at the same depth supports this assignment. There is a small, unexplained increase in ^{137} Cs at the bottom of RB17 (27-30cm). A sedimentation rate of 1.2 cm/yr has been assigned to the sections below the ^{137} Cs peak. With this rate, the core extends to sediment deposited in the early 1950s, consistent with detectable ^{137}Cs in the bottom section.

Figures 2-2 and 2-3 show the pp'-DDD and γ-chlordane in the Raritan Bay core from about the early 1950s to 1980. pp'-DDD peaked in the mid 1950s at 62 ppb. There was a significant decline to about 9 ppb in 1980. γ-chlordane peaked in the mid 1960s at about 7 ppb and remained between 3 and 6 ppb through 1980. Although pp'-DDD was detected in all sections of the core, and γ-chlordane was detected in all sections later than about 1956, levels are significantly lower than those found in the harbor. Bopp et al. (1993a) proposed that this is due to both dilution and desorption.

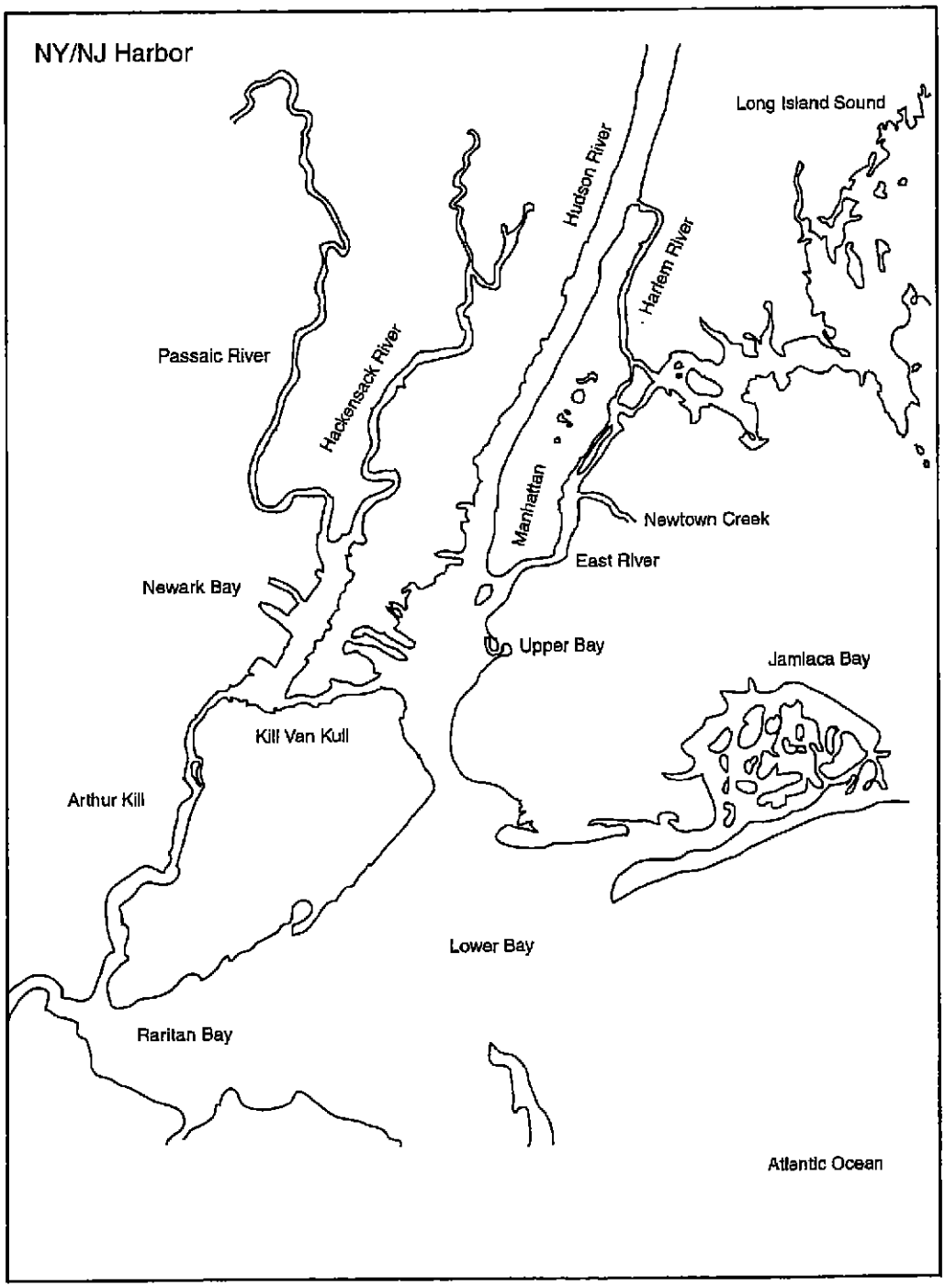


Figure 2-1. NY/NJ Harbor complex.

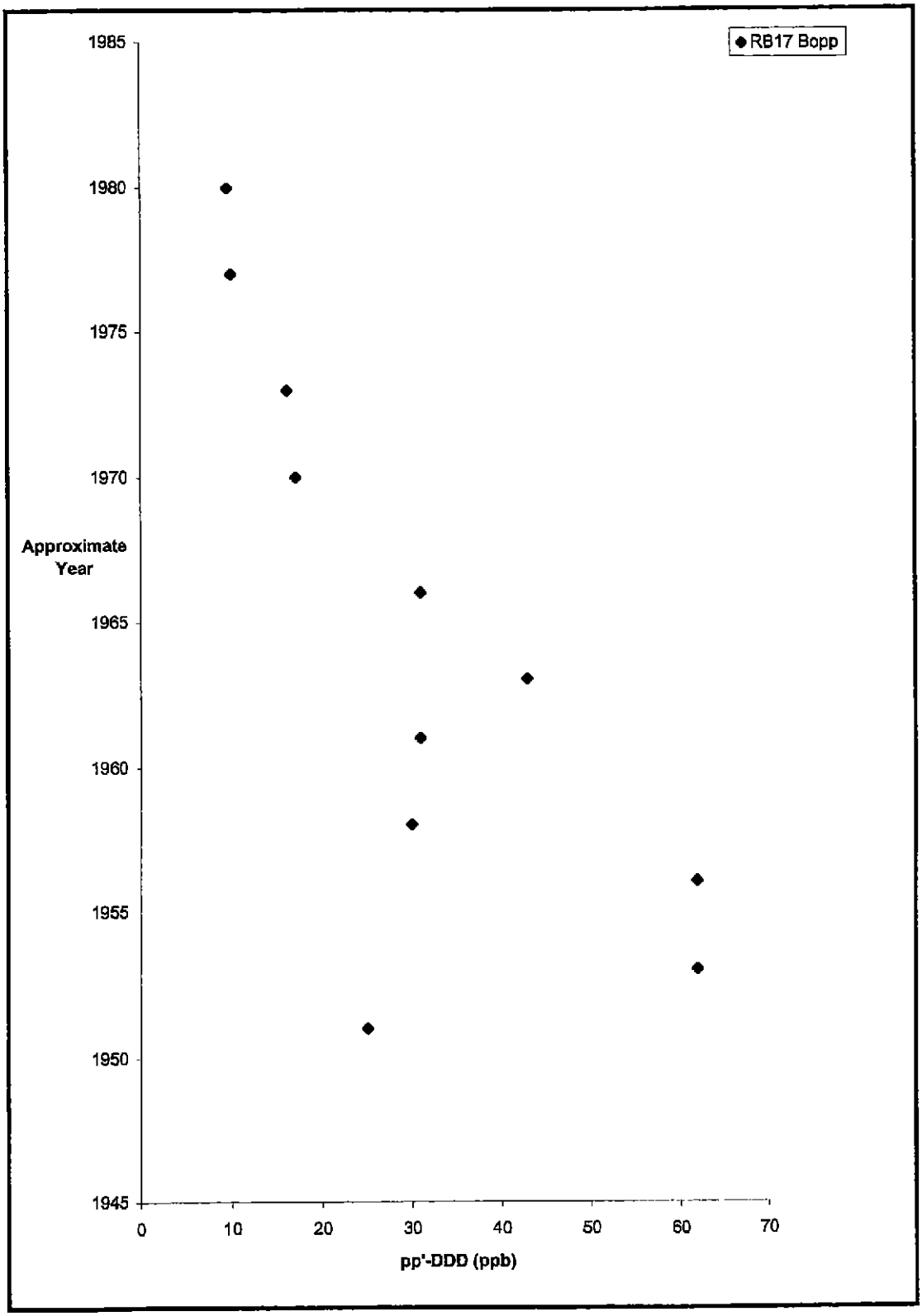


Figure 2-2. pp'-DDD in sediment from Raritan Bay, core RB17.

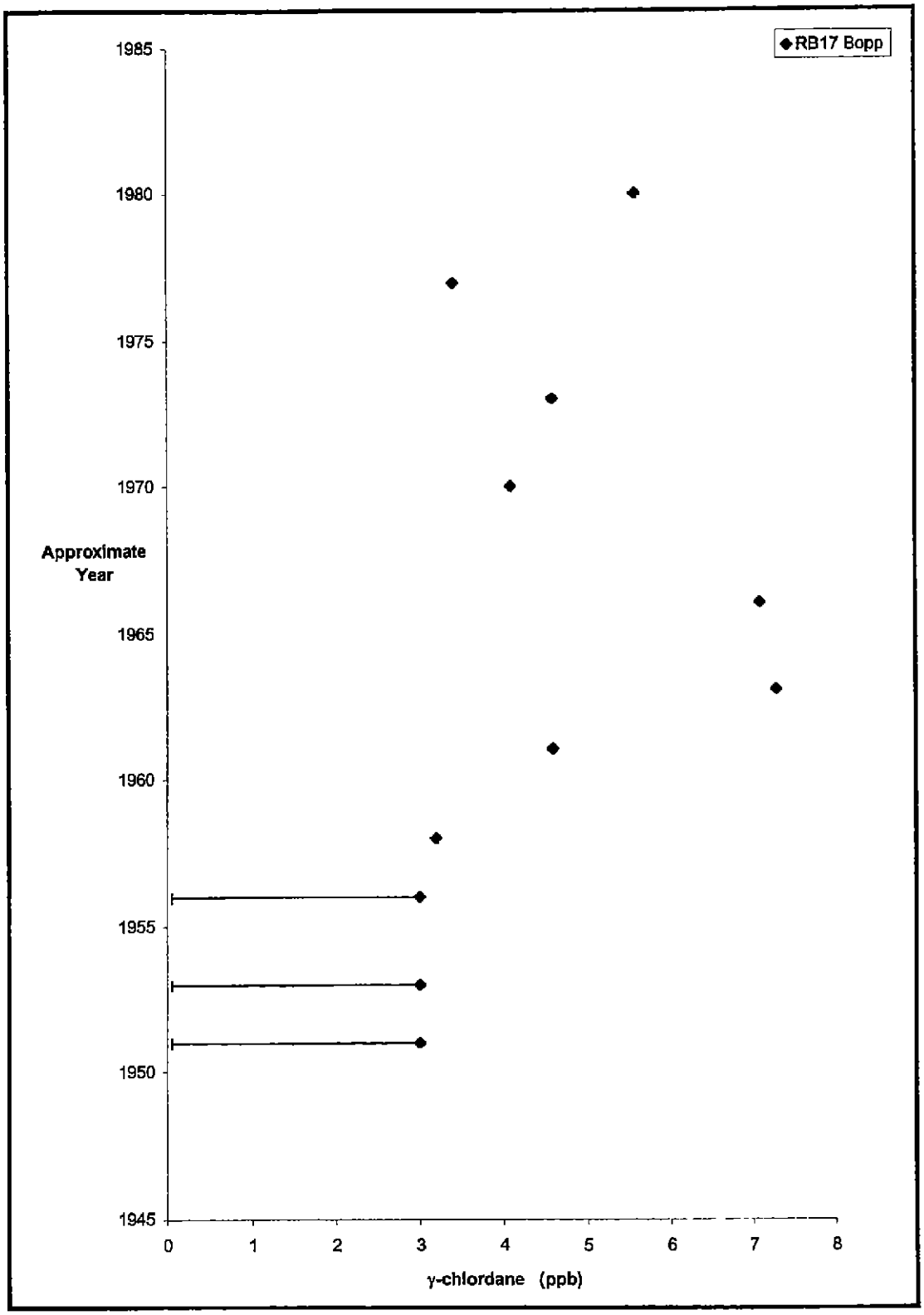


Figure 2-3. γ-chlordane in sediment from Raritan Bay, core RB17.
Error bars indicate < values detected.

Newtown Creek

Newtown Creek is located on the eastern side of the harbor complex and is a tidal embayment of the East River (Figure 2-1). There is a direct input of effluent from a secondary sewage treatment plant. Discharge from Newtown Creek is one of the largest sources of municipal wastewater to the harbor (*Bopp et al., 1998*).

No historical sediment records exist for Newtown Creek, but sediment core tops from 1987, 1990, 1996 and 1998 have been dated to the year of collection based on ^{7}Be. DDT and chlordane analyses of these core tops give an indication of the input to the harbor through waste water. pp'-DDD decreased in Newtown Creek from 62 ppb in 1987 to 18 ppb in 1990 however, it increased to 36 ppb in 1996 (Table 2-1). The 1998 sample showed little change with 37 ppb pp'-DDD. Between 1990 and 1996, there was a significant increase in total DDT (the sum of op and pp-DDD, DDE, and DDT with non-detects as zero) from 50 ppb in 1990 to 80 ppb in 1996 (Appendix IV). There was a small decline to 72 ppb in 1998. Not all of the DDT compounds were analyzed for the 1987 sample so total DDT was not calculated.

γ-chlordane in Newtown Creek also decreased between 1987 and 1990 (Table 2-1). In 1987 it was at 28 ppb and down to 6.4 ppb in 1990. Similar to pp'-DDD, there was an increase in chlordane after 1990. γ-chlordane increased to 11 ppb in 1996 and 13 ppb in 1998. Total chlordane (the sum of α and γ-chlordane, trans and cis nonachlor, oxychlordane and heptachlor epoxide with non-detects as zero) increased between 1990 and 1996 and again in 1998 from 19 to 29 to 37 ppb (Appendix IV).

The increase in DDT and chlordane levels between the 1990 and more recent samples was not expected. However, the factor of four decrease in levels between the 1987 and 1990 samples represents a more rapid improvement than might be expected (Bopp et al., 1982). In an effort to better explain this data, an investigation of plant operations and of PCB, trace metal, and dioxin data in these samples is currently underway.

Core	Section (cm)	Control number	Year	pp'-DDD (ppb)	γ-chlordane (ppb)
NC3 (Bopp)	0-2	CN2019A	1987	62	28
NC6 (AXYS)	0-2	CN2102A	1990	18	6.4
NC9 (AXYS)	0-2	R1093A	1996	36	11
NC10 (AXYS)	0-2	R1227A	1998	37	13

Table 2-1. pp'-DDD and γ-chlordane concentrations in Newtown Creek sediment. "Bopp" and "AXYS" refer to samples analyzed using packed column ECGC and HRGC with MS detection, respectively.

Upper NY/NJ Harbor Near the Statue of Liberty

Chlorinated pesticide analysis of dated sediment sections from the upper NY Harbor near the Statue of Liberty has enabled the development of chlordane and DDT chronologies from the 1950s to 1998 (Figures 2-4, 2-5). The core mp –1.7W was dated on the basis of ^{137} Cs and ^{60} Co (*Bopp and Simpson, 1989, Chillrud, 1996*). Three constraints were used in estimating the deposition rate for this core including a ^{137} Cs peak and detectable ^{60} Co at 6-8 cm from Indian Point nuclear reactor inputs in the early 1970s *(Bopp et al., 1982, Chillrud, 1996)*, a large ^{137} Cs peak from global fallout and no detectable ^{60} Co at 20-24 cm from the mid 1960s, and very low ^{137} Cs at 36-40 cm from the early to mid 1950s at the start of global fallout. There was no ^{7} Be detected at the surface of the core, but it was assumed that the top was deposited between 1978 and 1979. This was based on the ^{137} Cs profile and the presence of elevated ^{60} Co activities at the top of the core, which suggests fairly continuous deposition. With an estimated deposition rate of 0.9 cm/yr in the top several sections of the core and 1.8 to 2.0 cm/yr in the rest of the core, it extends from about 1955 to 1978.

The deposition rate of core mp –1.65W was estimated to be 6 cm/yr based on ^{7} Be, ^{137} Cs, and ^{60} Co. With this estimation, the core extends from about 1975 to 1984, the year of collection (*Bopp and Simpson, 1989, Chillrud, 1996*).

In 1994 and 1998, surface samples were taken to extend the contaminant chronologies from the upper NY Harbor. Both samples, mp –1.69 and mp –1.7C, had detectable levels of ^{7}Be and were therefore assigned dates that were consistent with the year of collection.

Both pp'-DDD and γ-chlordane have declined steadily from the early 1970s to 1998, showing the effectiveness of the ban of these pesticides to this area of the harbor. pp'-DDD was first detected in the mid 1950s (Figure 2-4). The very low levels of both pp'-DDD and γ-chlordane in the deepest section of this core are from below a mud/sand boundary *(Bopp et al., 1989)* and should not be interpreted as indicating that cleaner sediments were deposited in the early 1950s. The highest levels were detected between about 1961 and the early 1970s with a peak at 138 ppb in 1971. After the early 1970s, levels began to decline. This is consistent with the banning of DDT in 1972. These concentrations are much lower than those found in the western portion of the harbor, suggesting that inputs from production at the 80 Lister Avenue site did not fully extend to the upper harbor, or there is mixing and dilution from the Hudson sediments. In 1998, pp'-DDD had decreased to 7 ppb. Total DDT declined from 211 ppb in 1964 to 20 ppb in 1998 (the sum of op and pp-DDD, DDE, and DDT with non-detects as zero) (Appendix IV). This could not be calculated for all sections because not all were analyzed for each DDT component.

γ-chlordane was first detected in the early 1950s and increased steadily until the mid 1970s (Figure 2-5). It peaked in 1974 at 49 ppb and declined to 2 ppb in 1998. Total chlordane decreased from 51 ppb in 1964 to 5 ppb in 1998 (the sum of α and γ-chlordane, trans and cis nonachlor, oxychlordane and heptachlor epoxide with non-detects as zero) (Appendix IV). As with pp'-DDD, γ-chlordane levels are not as high in the upper harbor as they are in the western side of the complex.

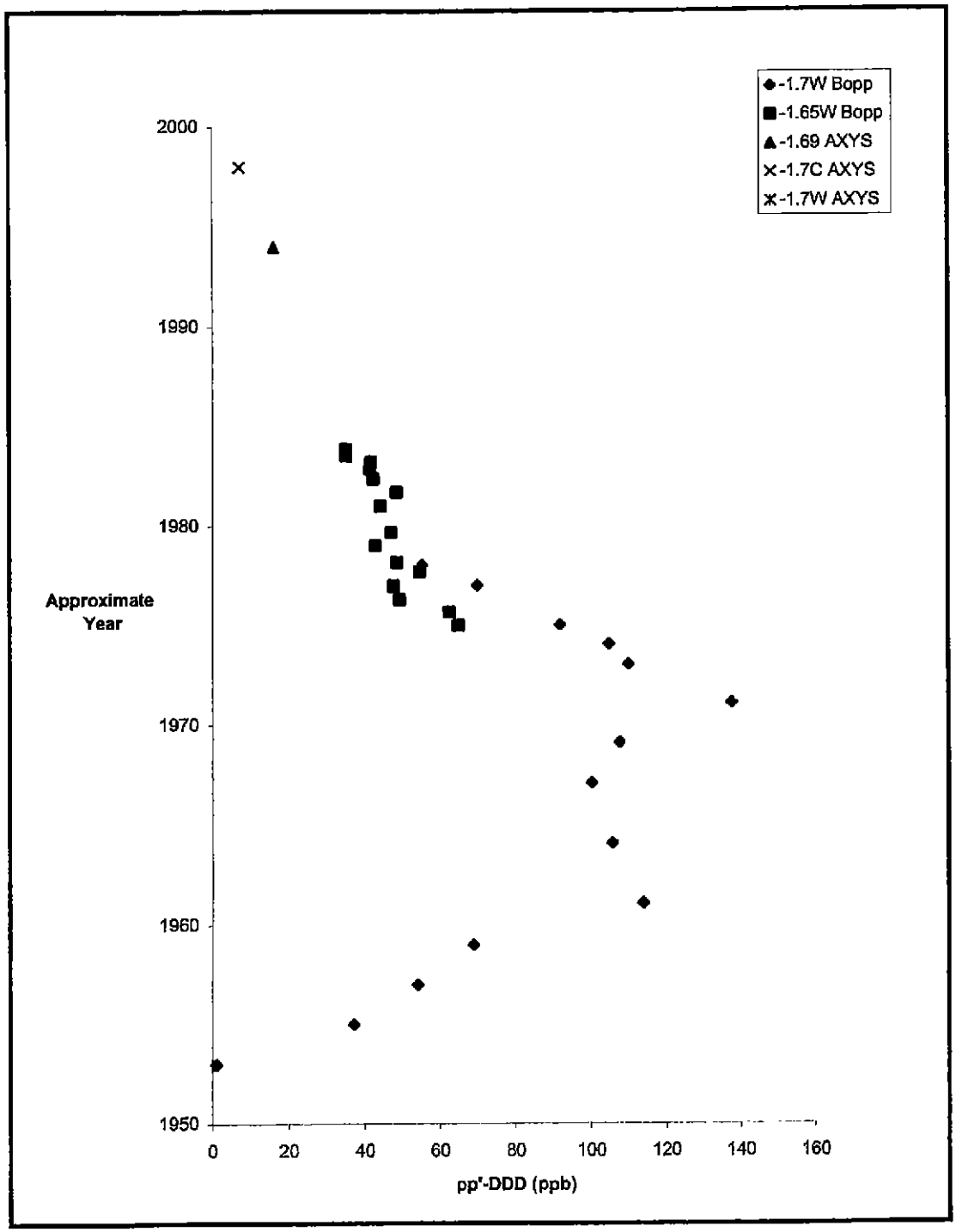


Figure 2-4. pp'-DDD in sediment from the upper NY/NJ Harbor near the Statue of Liberty.

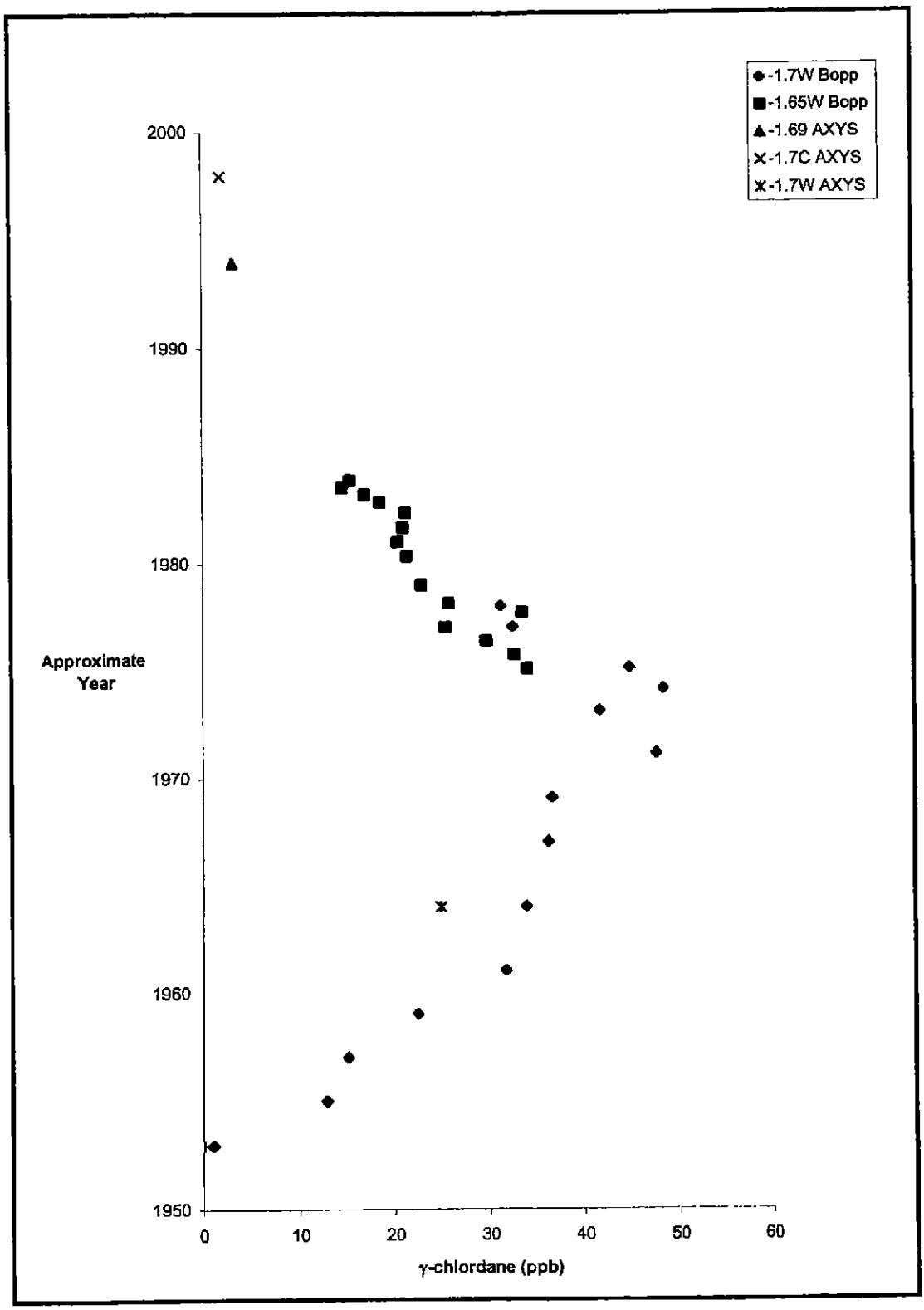


Figure 2-5. γ-chlordane in sediment from the upper NY/NJ Harbor near the Statue of Liberty. Error bar indicates a < value detected.

Harbor Transects

Sediment core tops collected from the upper NY Harbor and the harbor mainstem with detectable ^{7}Be were analyzed for chlorinated pesticides. The number in the core name is the mile point, the distance in statute miles from the southern tip of Manhattan, negative being downstream (south) and positive being upstream (north). The E and W denote whether the core was taken on the east (NY) or west (NJ) side of the channel. These core tops provided data for the development of DDT and chlordane chronologies from 1982 to 1998. As seen in Figures 2-6, 2-7 and Table 2-2, there has been a steady and significant decline in both pp'-DDD and γ-chlordane. From the 1982 to 1984 samples, the average pp'-DDD was 40 +/- 8 ppb in the harbor transects. This decreased to 9 +/- 4 ppb in 1998. There was a similar drop in γ-chlordane from an average of 17 +/- 2 ppb in the 1982-1984 samples to 2 +/- 0.48 ppb in 1998.

Unlike the clear temporal trend of pp'-DDD, there is no obvious spatial trend. It might be expected that the sites further downstream or on the western side of the channel would show elevated levels due to the significantly higher levels found in the western portion of the complex, but this is not the case. This could be due to mixing within the harbor and dilution of the high concentrations by sediment coming in from the Hudson. For γ-chlordane, however, at all time points, the farthest downstream sample (mp –1.6 to –2) has the highest concentration (Figure 2-7), consistent with a significant source from the western portion of the harbor complex.

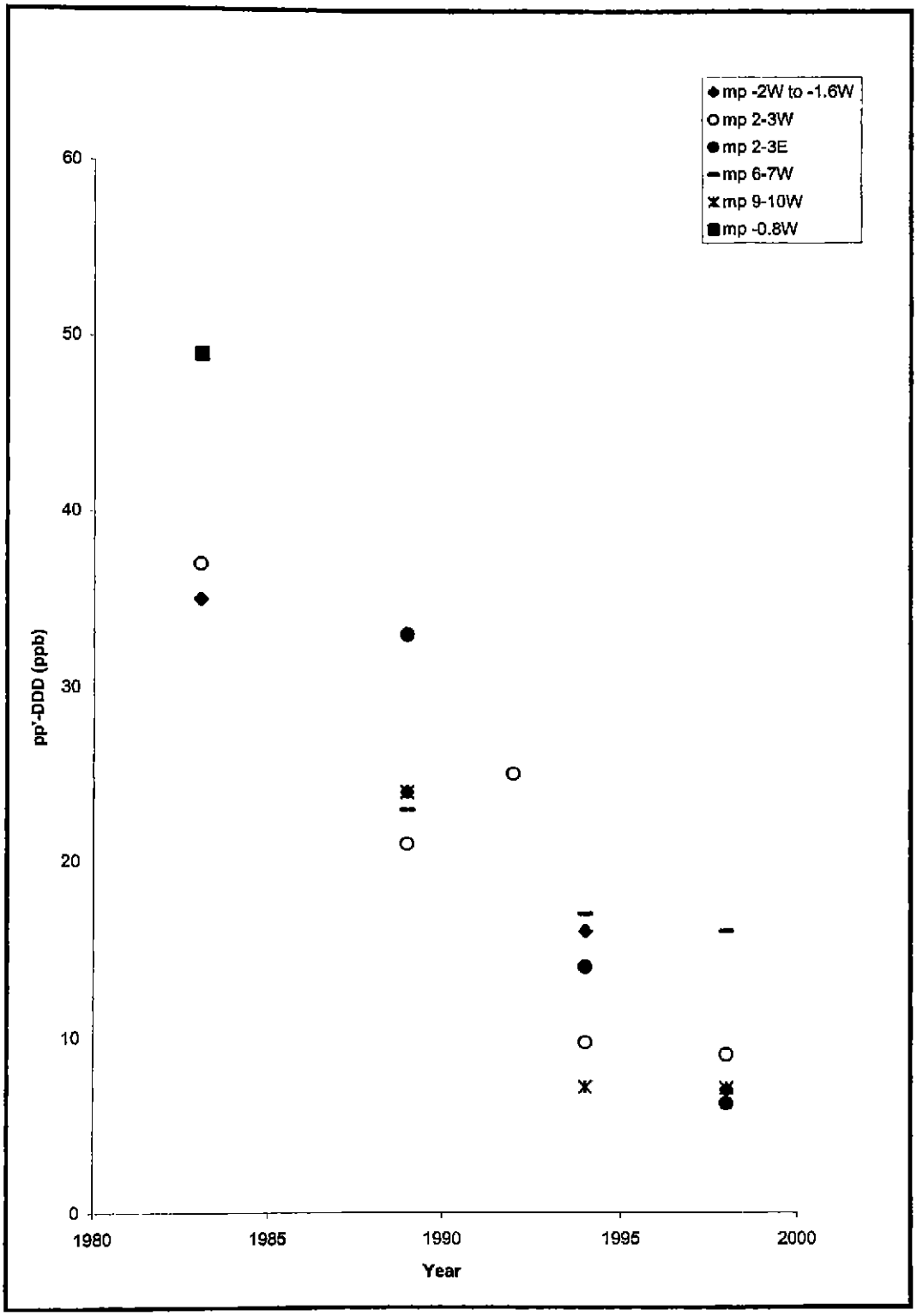


Figure 2-6. pp'-DDD in harbor transect core tops from 1982 to 1998. The samples from 1982 to 1984 were analyzed by Bopp. All others were analyzed by AXYS.

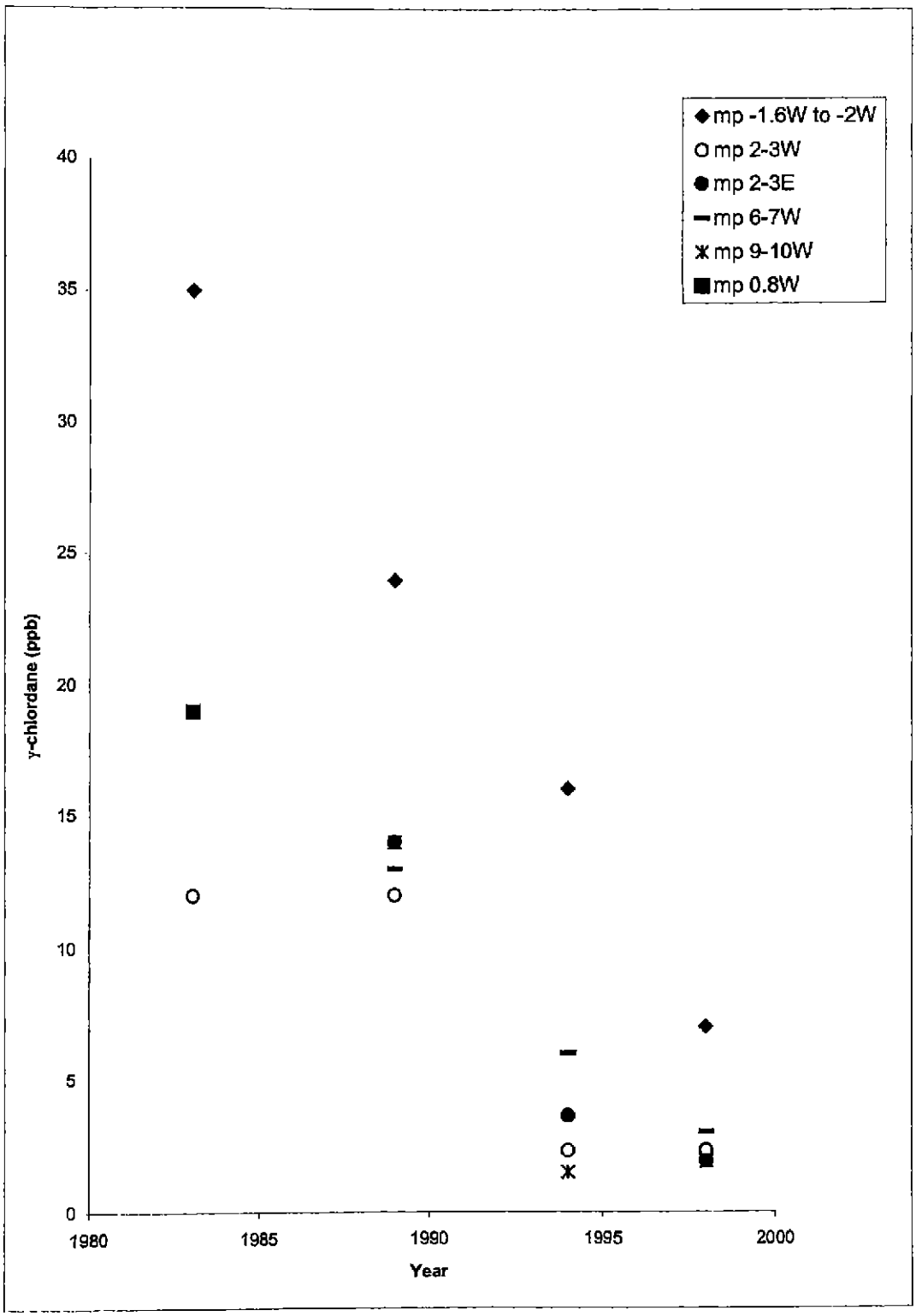


Figure 2-7. γ-chlordane in harbor core top transects from 1982 to 1998. The samples from 1982 to 1984 were analyzed by Bopp. All others were analyzed by AXYS.

NY Harbor Transects
0-2 cm
Concentrations in ppb

1982-1984 transects

	pp'-DDD	γ-chlordane
-1.65W	35	15
-0.8W	49	19
2.35W	37	12
Average	40	15
1σ	8	4

1989-1990 transects

	pp'-DDD	γ-chlordane
-1.68W	24	11
2.34W	21	12
2.73E	33	14
6.3W	23	13
9.7W	24	14
Average	25	13
1σ	5	1

1992 transects

	pp'-DDD	γ-chlordane
2.4W	25	

1994 transects

	pp'-DDD	γ-chlordane
-1.69W	16	3.2
2.33W	9.7	2.3
2.76E	14	3.6
6.31W	17	6
9.71W	7.2	1.5
Average	13	3
1σ	4	2

1998 transects

	pp'-DDD	γ-chlordane
-1.7C	7	1.9
2.77E	6.2	1.9
2.34W	9	2.3
6.4W	16	3
9.72W	7.1	1.9
Average	9	2
1σ	4	0.48

Table 2-2. pp'-DDD and γ-chlordane in NY Harbor sediment transects.
The 1982-1984 samples were analyzed by Bopp. All others were analyzed by AXYS.

Kill Van Kull

Three sediment cores have been used in the development of a temporal picture of DDT and chlordane in the Kill Van Kull. Core KVK1 was collected in 1985. ^{7}Be was detected in the top three sections of the core, indicating very rapid recent deposition. Unfortunately, no constraints can be placed on the rest of the core by using the ^{137}Cs profile. ^{137}Cs is still detected at the bottom of the core at 36- 41 cm with an activity of 324 +/-21 pCi/kg. There is a small peak of 475 +/- 30 pCi/kg at 16-20 cm, but this cannot be assigned with any certainty to either the 1963 fallout peak or the 1971 peak discharge from the Indian Point nuclear reactors. All that can be said is the bottom of the core was deposited after the mid 1950s.

Two core tops, KVK3 and KVK4, collected from the Kill Van Kull in 1996 and 1998, have been dated by the presence of ^{7}Be. DDT and chlordane analysis of these sections has extended the chronologies through 1998. Figures 2-8 and 2-9 show that pp'-DDD and γ-chlordane have declined significantly over the past few decades, but levels remain much higher than in the eastern side of the harbor complex.

Although there are complications with dating core KVK1, it can be said that there was a large peak in pp'-DDD sometime after the early 1950s (Figure 2-8). pp'-DDD increased from 420 ppb at 36-41 cm to 1885 ppb at 24-28 cm. This peak is not consistent with production at 80 Lister Ave. between 1939 and 1956, but the exceptionally high levels suggest a more recent and significant local source.

The sections analyzed from 1985, 1996 and 1998 were dated using ^{7}Be, therefore the assigned years are correct within about a year. Between 1985 and 1996, there was a significant decline in pp'-DDD from 322 ppb to 140 ppb. In 1998, it was down to 110 ppb. Total DDT went from 373 ppb in 1996 to 208 ppb in 1998 (the sum of op and pp-DDD, DDE, and DDT with non-detects as zero) (Appendix IV).

pp'-DDT/pp'-DDD for the Kill Van Kull had an average of 0.86. All of the sections except for 1998 had a ratio that was much higher than the typical range of about 0.2. This indicates a fresh source of DDT, perhaps a local direct discharge as suggested above and possibly involving illegal dumping. Between 1996 and 1998, the parent to metabolite ratio decreased from 0.66 to 0.15.

Chlordane levels are higher in the Kill Van Kull than in the eastern side of the complex. γ-chlordane peaked sometime after the mid 1950s at 274 ppb (Figure 2-9). In 1985, 40 ppb were detected. This declined significantly in 1996 and 1998 when there was 15 ppb and 14 ppb, respectively. Total chlordane was 30 ppb in 1996 and 1998 (the sum of α and γ-chlordane, trans and cis nonachlor, oxychlordane and heptachlor epoxide with non-detects as zero) (Appendix IV).

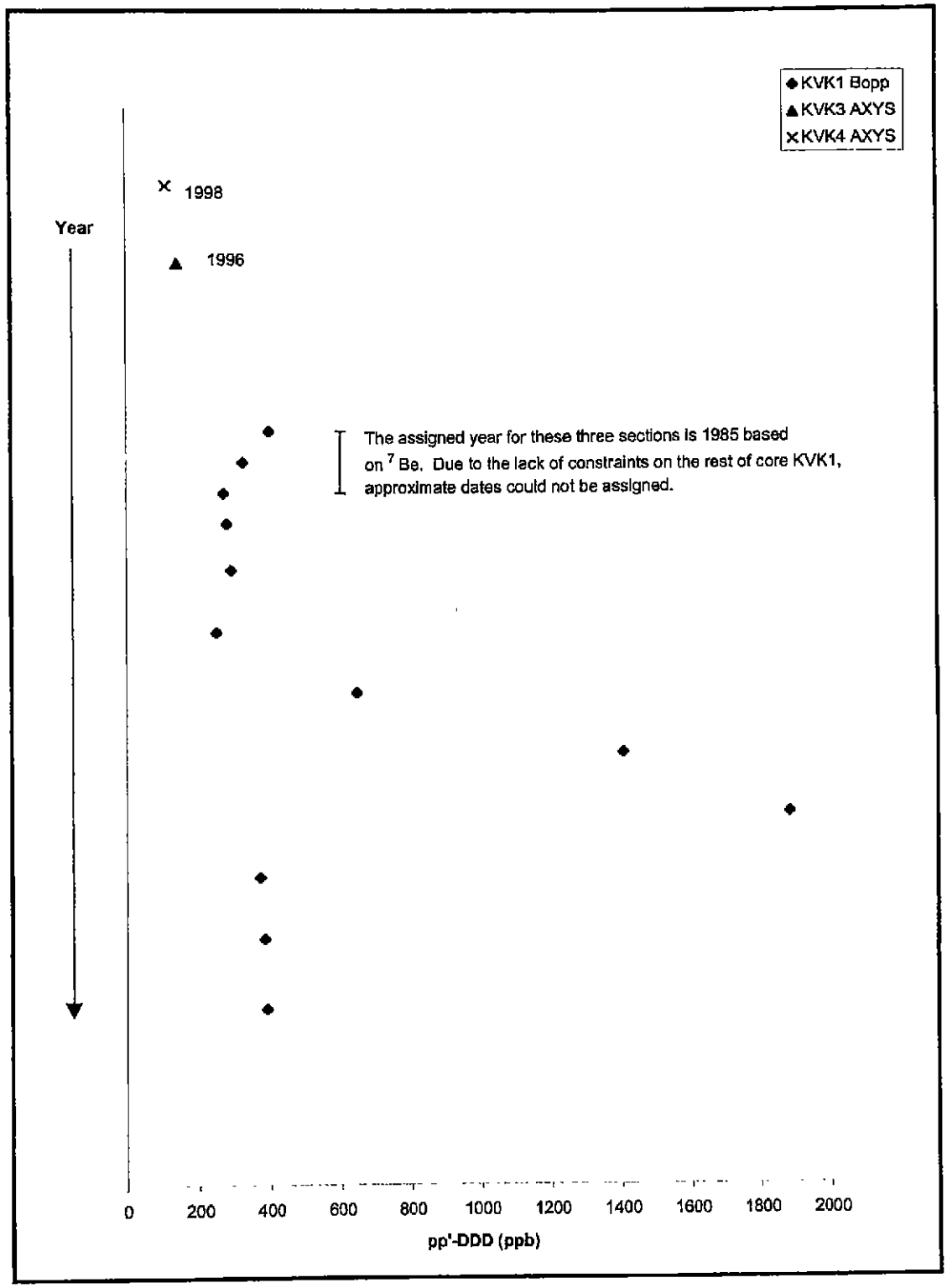


Figure 2-8. pp'-DDD in Kill Van Kull sediment.
Approximate years were not assigned for most sections of core KVK1 due to lack of constraints for dating.

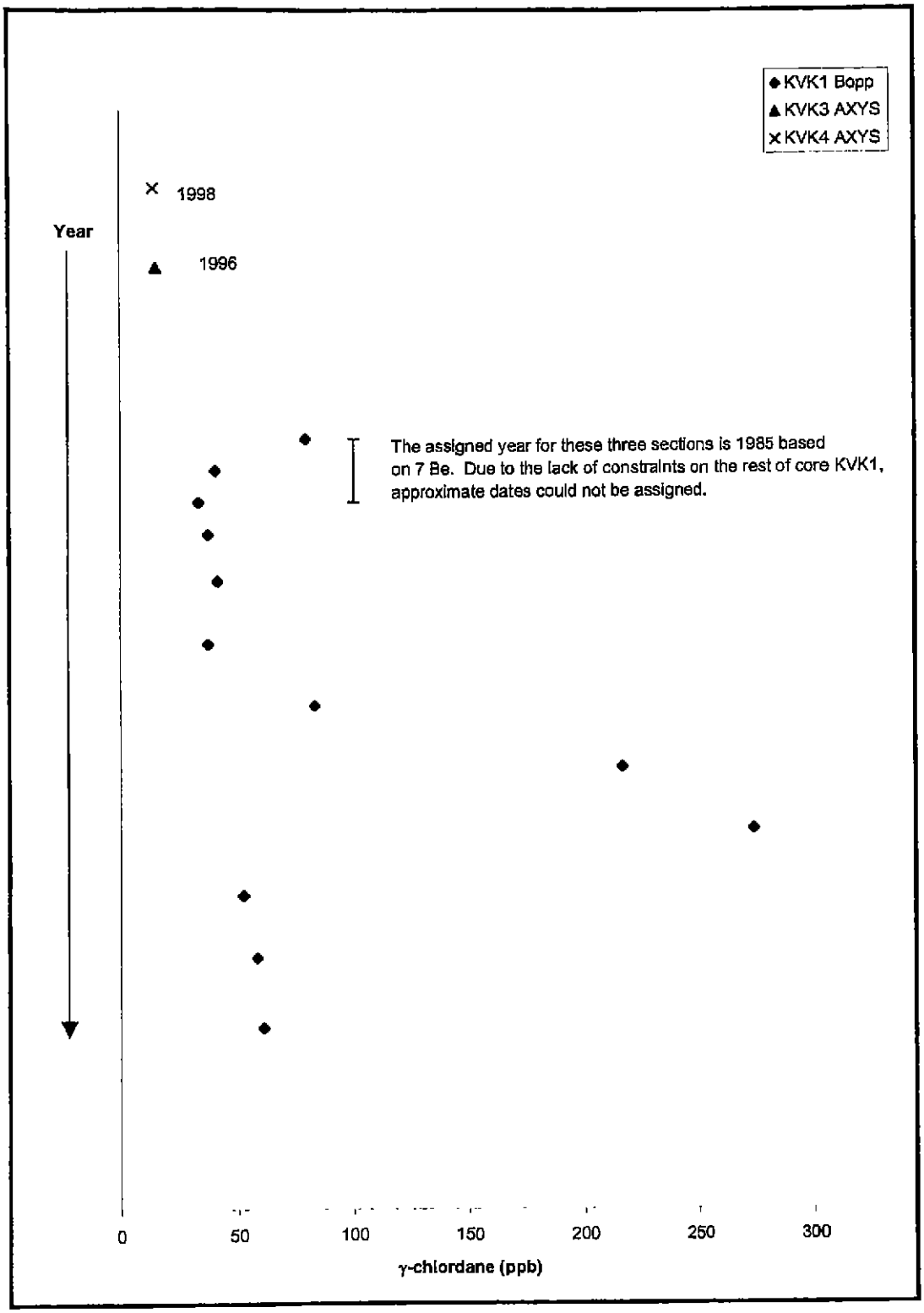


Figure 2-9. γ-chlordane in Kill Van Kull sediment.
Approximate years were not assigned for most sections of core KVK1 due to lack of constraints for dating.

Newark Bay

Chlorinated pesticide analyses of dated sediment cores taken from Newark Bay have enabled the development of DDT and chlordane chronologies from the 1930s to 1995 (Figures 2-10, 2-11). Three cores were dated on the basis of ^{137}Cs and ^{7}Be. pp'-DDD was first detected at significant levels in the early 1940s at 210 ppb. Levels peaked at 490 ppb in about 1948 and declined significantly in the late 1950s. This profile coincides with DDT production at the 80 Lister Avenue Superfund site where production began in the about 1939 and stopped in 1958 (documents provided by NJDEP). These concentrations are not as high as the others found in the west side of the complex however, pp'-DDE, the other primary metabolite of DDT, is found at very high levels (Appendix IV). 1100 ppb were detected in 1958. This had declined to 34 ppb in 1995. In the early 1980s, there was an increase in pp'-DDD that coincides with a high freshwater discharge from the Passaic River in April, 1984 (*Bopp et al., 1991*). In 1995, pp'-DDD was down to 26 ppb. Total DDT decreased from 1822 ppb in 1958 to 82 ppb in 1995 (the sum of op and pp-DDD, DDE, and DDT with non-detects as zero) (Appendix IV).

γ-chlordane was first detected at significant levels in the early 1960s. It peaked in 1966 at 49 ppb and declined to 3.6 ppb in 1995. The 1984 high freshwater discharge from the Passaic River can also be seen in γ-chlordane levels.

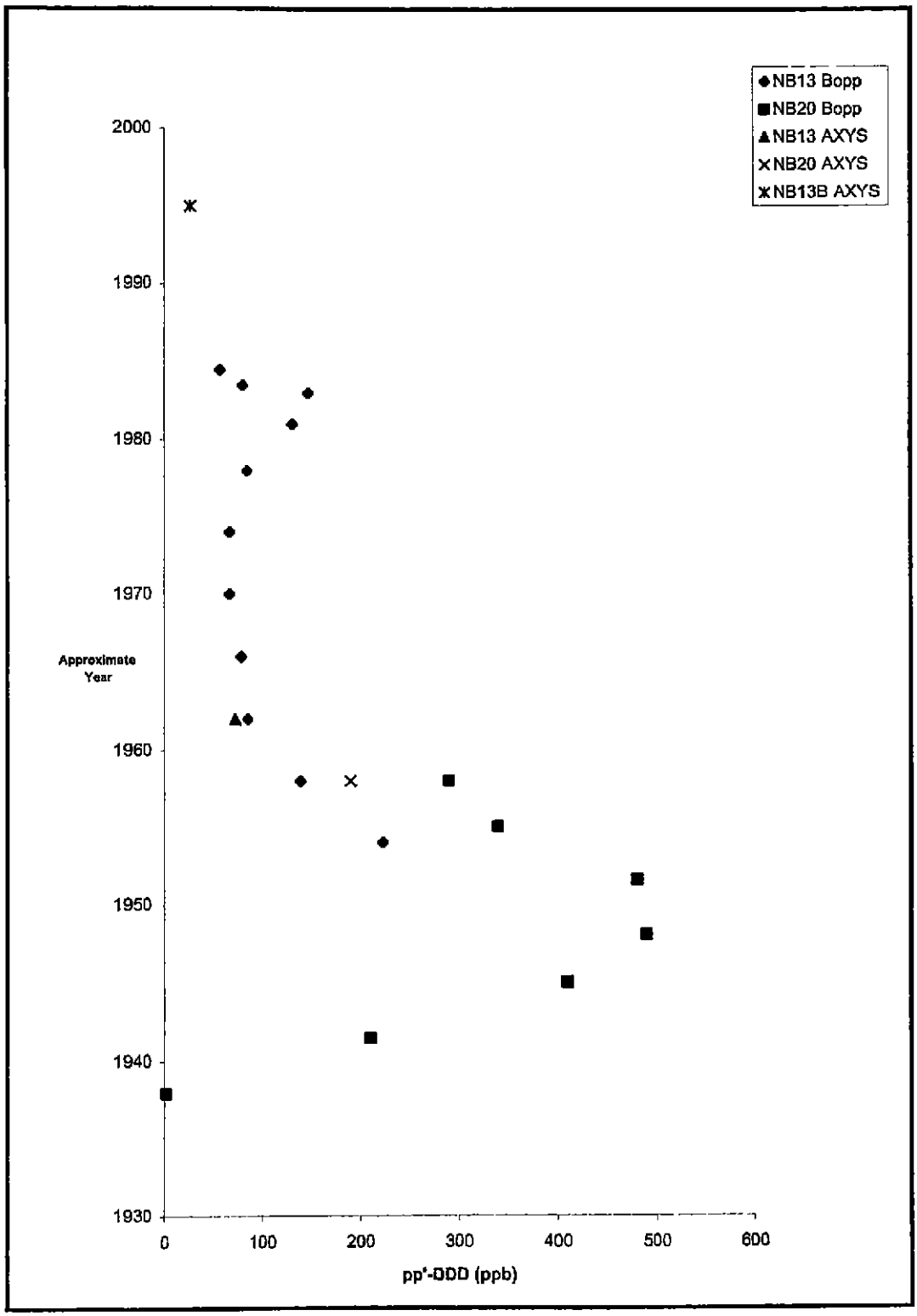


Figure 2-10. pp'-DDD in Newark Bay sediment.

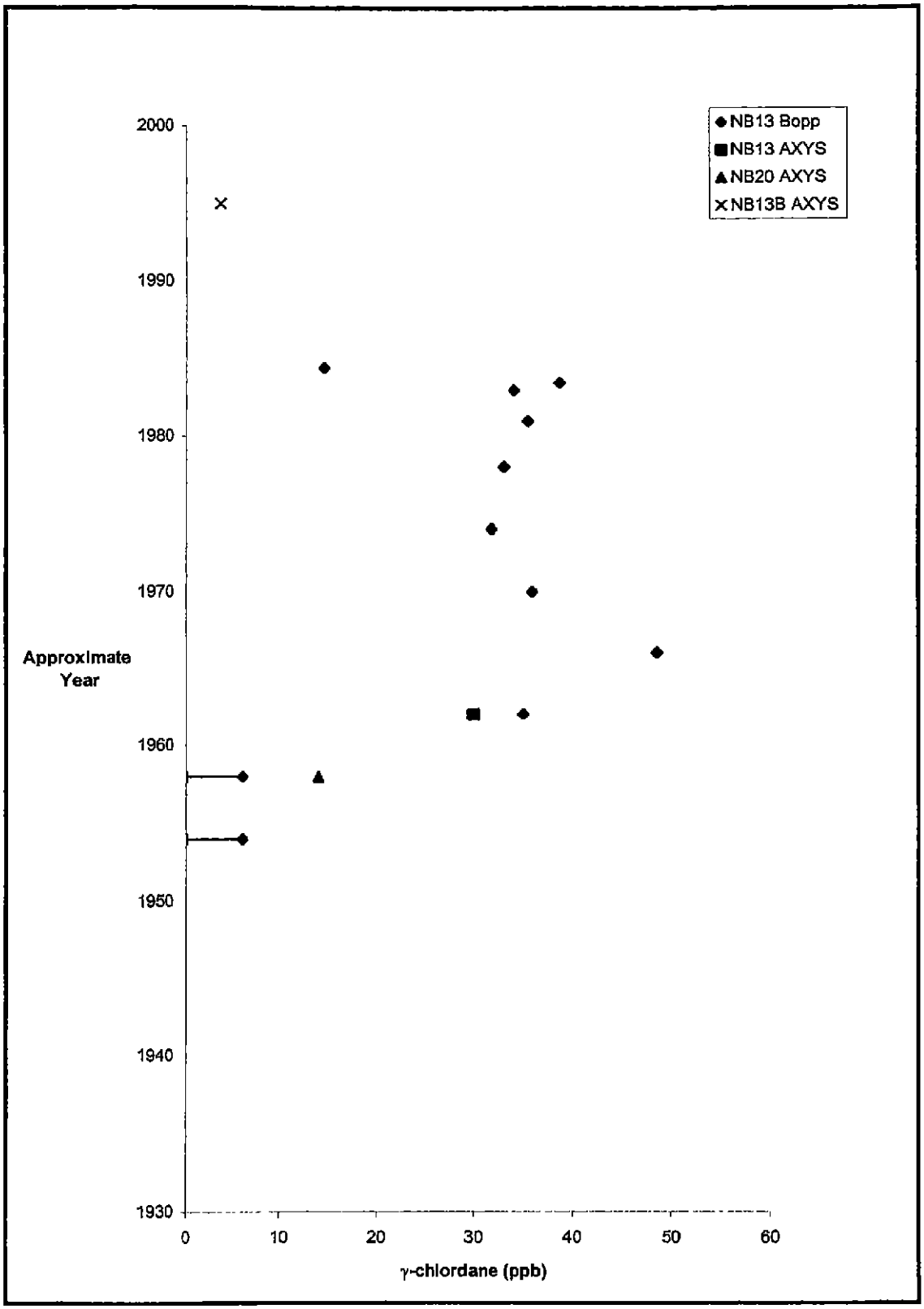


Figure 2-11. γ-chlordane in Newark Bay sediment.
Error bars used to indicate < values detected.

Arthur Kill

Two cores collected in 1982 and 1996 from the Arthur Kill have been dated and analyzed for chlorinated pesticides. Although taken relatively close to one another, the two cores show significant differences in historical temporal DDT and chlordane trends. The cores also have very different net particle accumulation rates as indicated by their ^{137}Cs profiles (Figure 2-12). Core Kill 14 was collected in 1982 and dated primarily on the basis of ^{137}Cs. A sedimentation rate of 1.3 cm/yr was estimated between the ^{137}Cs peak at 8-12 cm and the first detectable ^{137}Cs at 20-24cm. Extrapolation of this sedimentation rate puts the bottom of the core as being deposited in the 1920s. Pb analysis of sections of the core support the estimated sedimentation rate. The highest levels were found between the 1920s and 1940s, which is consistent with lead smelting (*Chillrud, 1996*). In order to date the sections of the core above the 8-12 cm ^{137}Cs peak, it was assumed that the top section was deposited in 1982, the year of collection. For these sections, a sedimentation rate of 0.47 cm/yr was used.

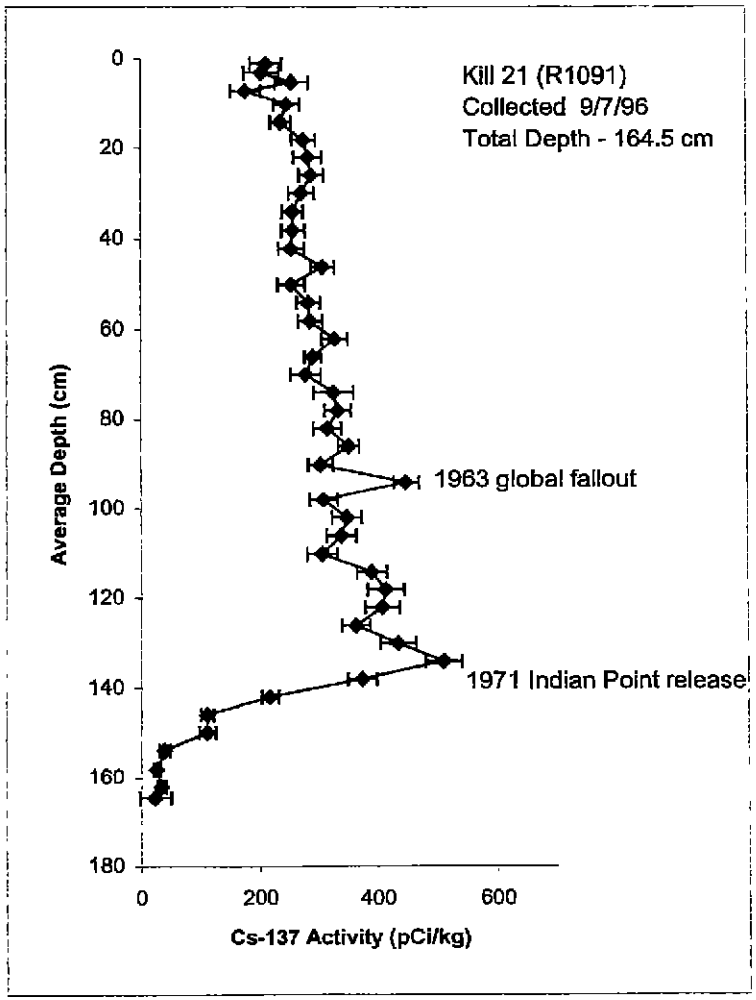
The dating of core Kill 21 is better constrained because of the presence of ^{7}Be at the surface and a ^{137}Cs peak assigned to 1971 discharges from the Indian Point nuclear reactors. Three different sediment accumulation rates were used to date Kill 21. 3.8 cm/yr was used between the surface, 1996, and 94 cm, the Indian Point ^{137}Cs peak. 5 cm/yr was used between 94 cm and 134 cm, the global fallout ^{137}Cs peak, and 3 cm/yr was used below this to the first presence of 137 Cs at 164.5 cm.

DDT levels in core Kill 14 are fairly consistent with production at the 80 Lister Avenue site on the lower Passaic River (Figure 2-13). Production began in about 1939 and stopped in 1958. Between the late 1930s and early 1940s, pp'-DDD levels in core Kill 14 increased from 36 ppb to about 2000 ppb. Total DDT was at 5810 ppb in 1941 (the sum of op and pp-DDD, DDE, and DDT with non-detects as zero) (Appendix IV).

pp'- DDD declined significantly in the late 1940s to 400 ppb. There was a relatively small increase to 560 ppb in the early 1950s, which remained fairly constant through the late 1970s. Unfortunately, this core has relatively poor temporal resolution between the 1960s and 1982 (the date of collection).

Chlorinated pesticide analysis was done on five sections from core Kill 21 extending from 1960 to 1996. Unfortunately, the record in this core only reaches back to the early 1950s so it would not record the 80 Lister Avenue DDT production peak. There are, however, very high levels (2600 ppb pp'-DDD) in deepest section analyzed (ca. 1960) that could be related to later stages of 80 Lister Avenue DDT production. pp'-DDD levels in the core declined to 1000 ppb in 1963 then to 100 ppb in 1972. Sometime between 1972 and 1985, all DDT compounds increased significantly. pp'-DDD increased to 280 ppb, and pp'-DDT went from 46 ppb (1972) to 650 ppb. By 1996, pp'-DDD concentrations had increased to 520 ppb, and pp'-DDT stayed at 650 ppb. This is a clear indication of a fresh source of DDT to the area that further supports this suggestion in Bopp et al. (1998) and the analysis of the Kill van Kull data presented above. The parent to metabolite ratio increased from 0.46 in 1972 to 2.32 in 1985. In 1996, this ratio was 1.25, but the only reason for the decrease was an increase in pp'-DDD. Total DDT went from 551 ppb in 1972 to 1576 in 1996 (Appendix IV).

γ-chlordane analyses were completed on a limited number of samples from each core (Figure 2-14). As expected, γ-chlordane was not detected in samples from Kill 14 dating from the 1940s and earlier. Maximum levels of about 120 ppb were found in sections dating from the 1960s and 1970s. γ–chlordane in core Kill 21 peaked in the mid 1960s sample at 70 ppb. There is a steady decline to 15 ppb in 1996. Total chlordane was at 44 ppb in 1996 (the sum of α and γ-chlordane, trans and cis nonachlor, oxychlordane and heptachlor epoxide with non-detects as zero) (Appendix IV).



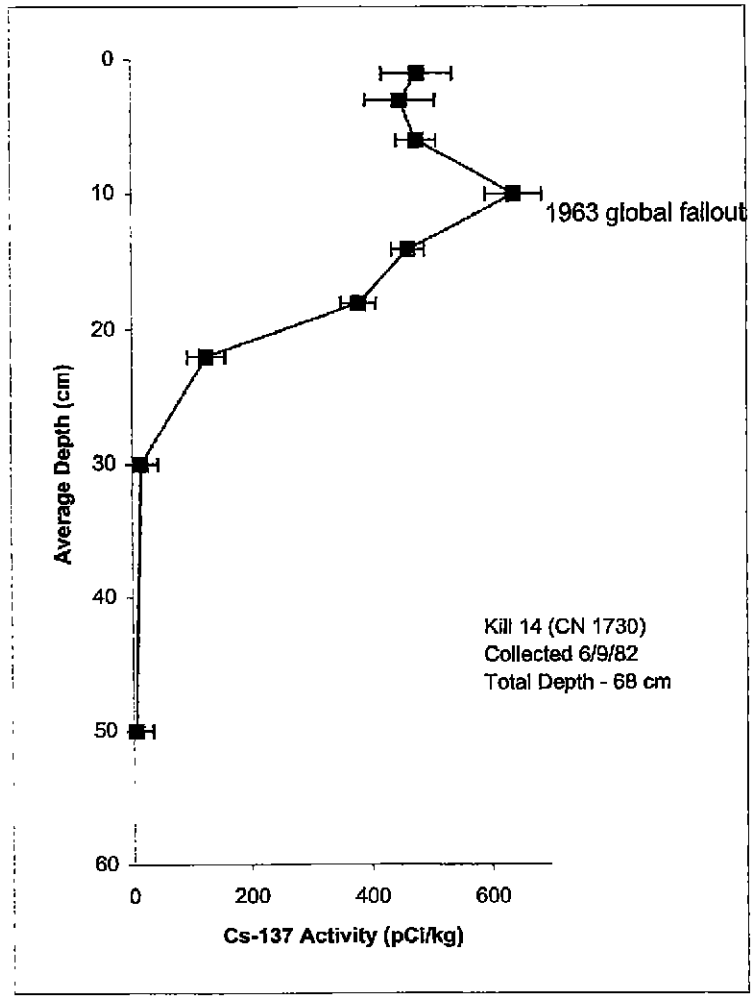


Figure 2-12. ^{137}Cs plots for cores Kill 14 and Kill 21 from the Arthur Kill.

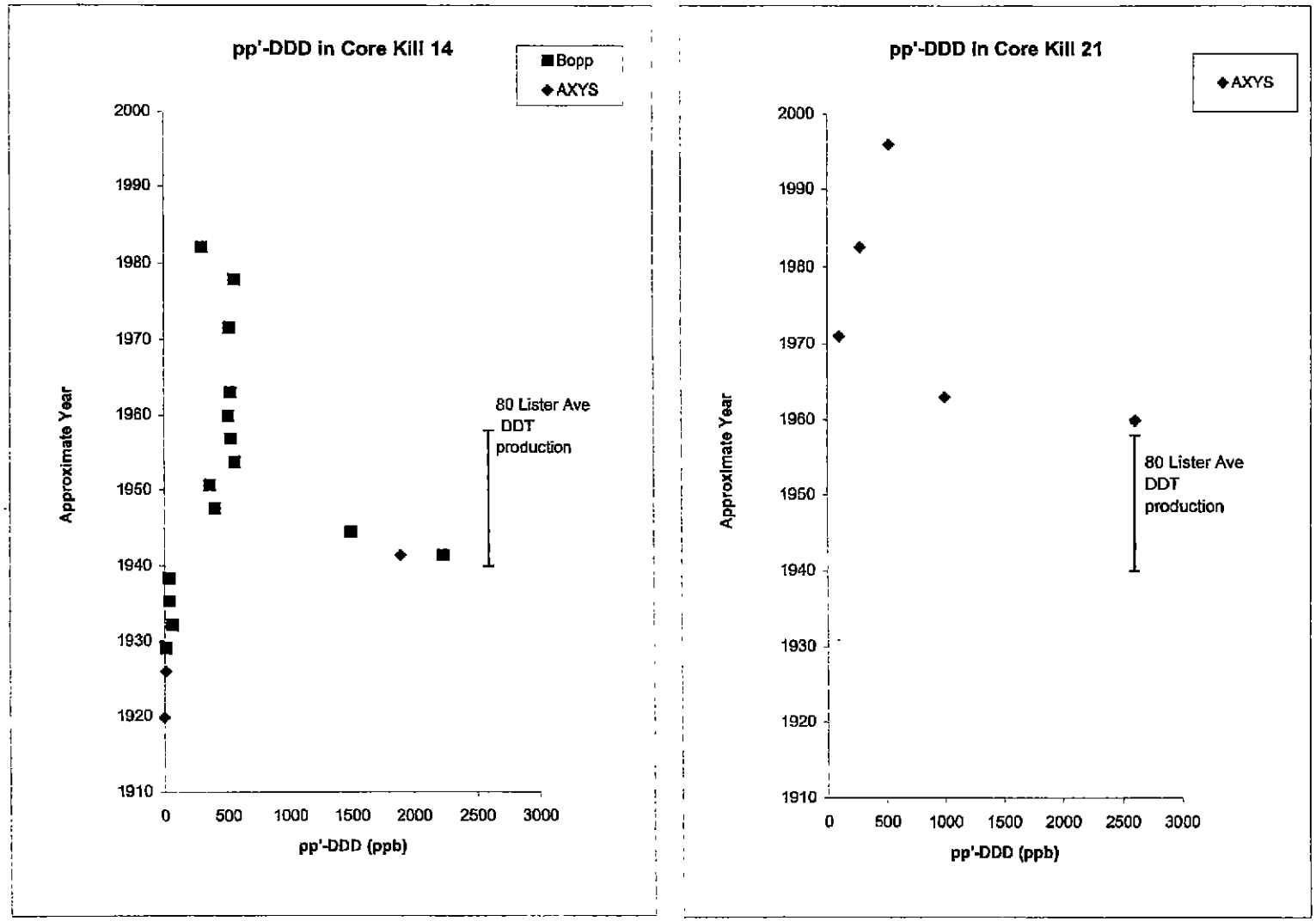


Figure 2-13. pp'-DDD in Arthur Kill sediment, cores KILL14 and KILL21

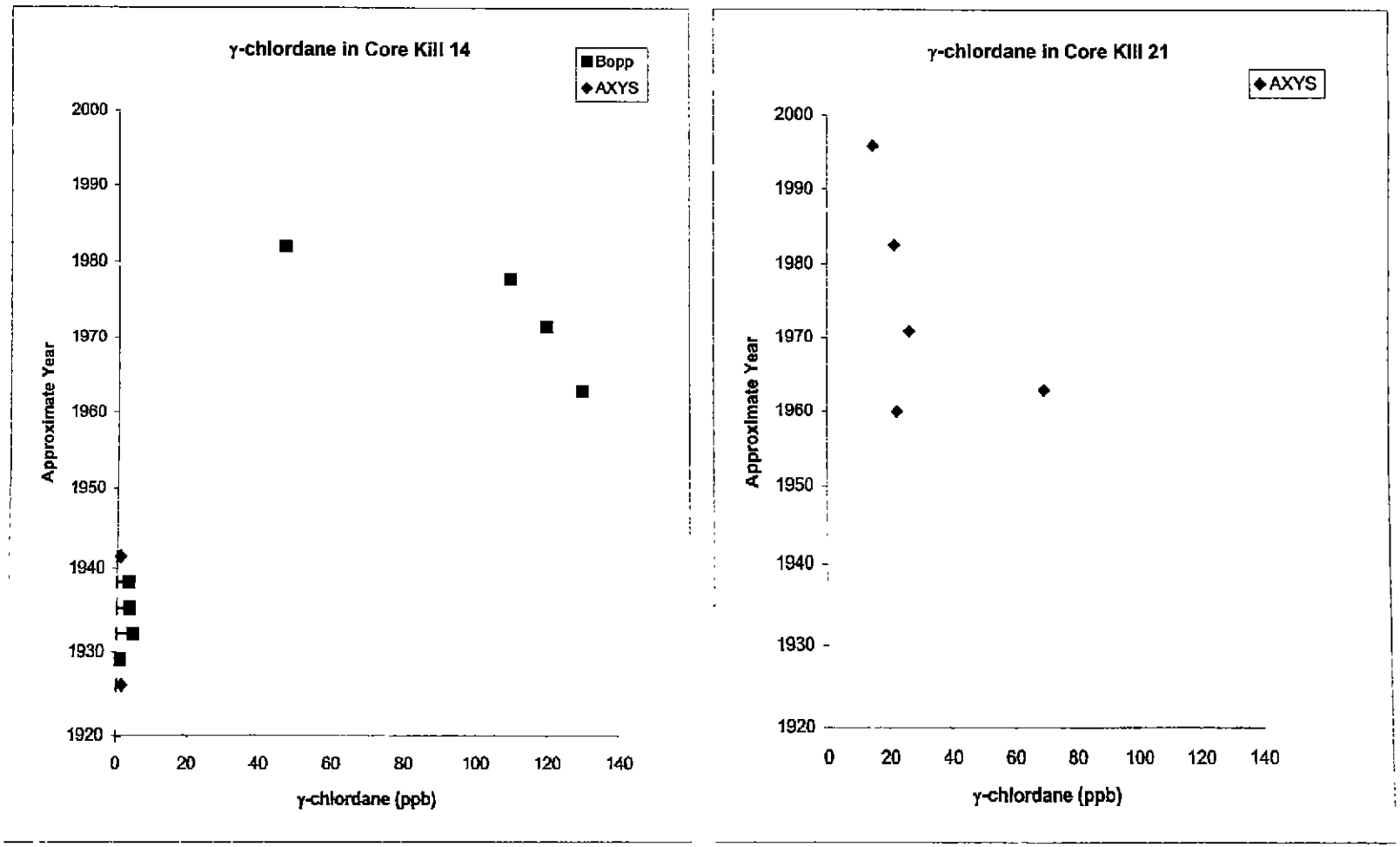


Figure 2-14. γ-chlordane in Arthur Kill sediment, cores KILL14 and KILL21.
Error bars indicate < values detected

Tidal Hudson

Cores taken from the tidal Hudson at mile points 88.6 and 91.8 were dated on the basis of a ^{137}Cs and ^{239,240}Pu peak from global fallout, the deepest detection of these nuclides, ^{7}Be at the surface, and a PCB peak associated with the removal of the first dam downstream of the GE input of PCBs to the upper Hudson (*Bopp et al., 1982, Chillrud, 1996*). With this model, sedimentation rates were estimated for core 88.6 as 1.3 cm/yr for 0-14cm, 4 cm/yr for 14-26cm, 0.85 cm/yr for 26-34cm and 2.5 cm/yr for 34-56 cm. Sedimentation rates for core 91.8 were estimated to be 1.6 cm/yr for 0-6 cm, 1.9 cm/yr for 6-26 cm, and 0.9 cm/yr for 26-53 cm. With these estimates, core 88.6 extends from about 1954 to 1986, and core 91.8 extends from about 1936 to 1975. In 1995 and 1998, three more cores were taken from the tidal Hudson at mile points 88.6 and 120.2. The tidal Hudson sedimentation record from this area was extended to 1998 on the basis of ^{7} Be in the core tops (Figures 2-15, 2-16).

The DDT levels in the tidal Hudson are much lower than those detected in the harbor. pp'-DDD was first detected at significant levels in the early to mid 1950s and peaked in about 1963 at 29 ppb. Levels remained fairly constant until the early 1970s when a steady decline began. This is consistent with the banning of DDT in 1972. In 1998, pp'-DDD had declined to 0.79 ppb, and total DDT was about 4 ppb (the sum of op and pp'-DDD, DDE, and DDT with non-detects as zero) (Appendix IV).

Chlordane concentrations in the tidal Hudson are quite low, especially when compared to those in the harbor. γ-chlordane levels were less than 5 ppb throughout the past several decades and less than 1 ppb in the 1998 sample. Total chlordane was also less than 1 ppb in 1998 (the sum of α and γ-chlordane, trans and cis nonachlor, oxychlordane and heptachlor epoxide with non-detects as zero) (Appendix IV).

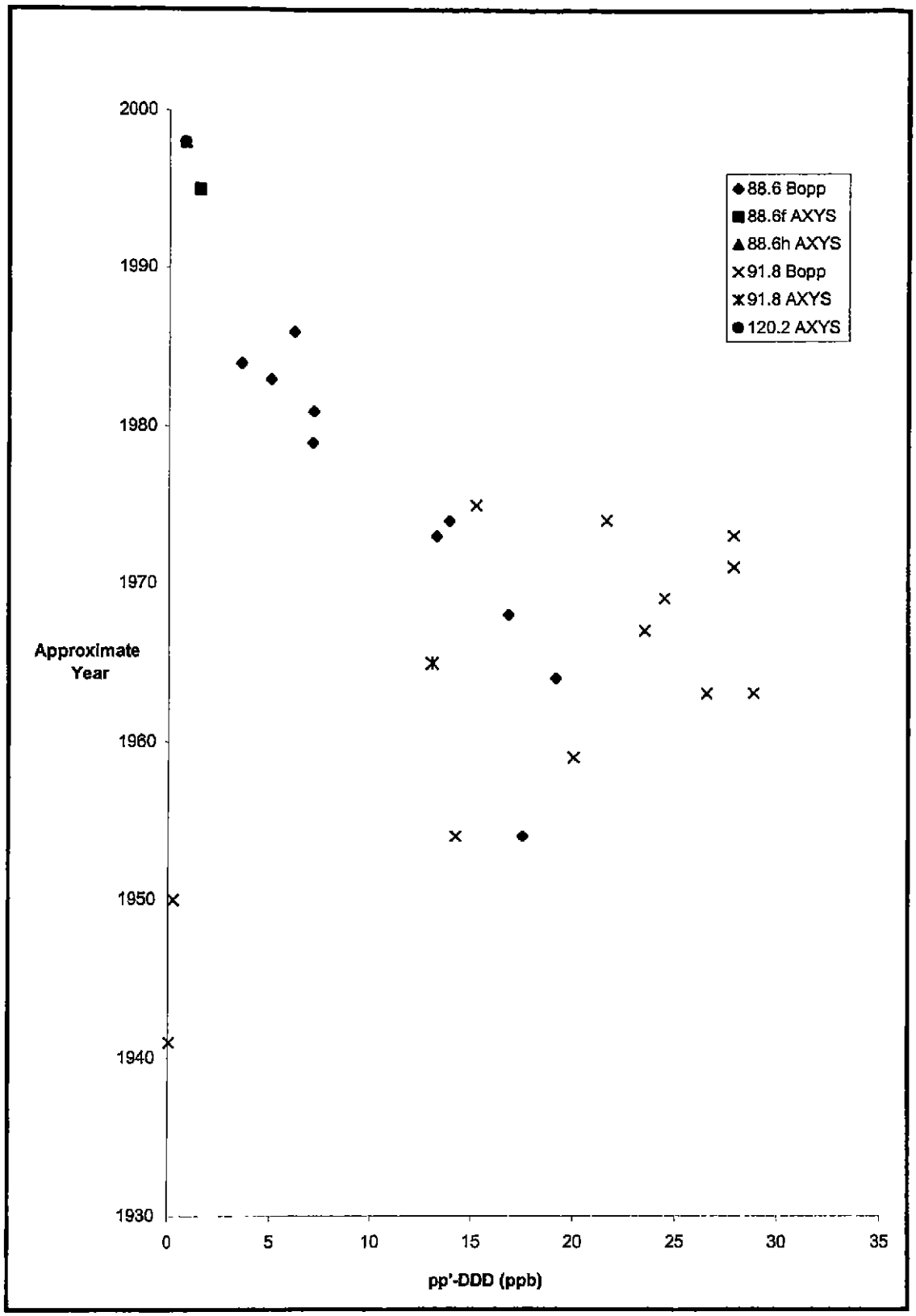


Figure 2-15. pp'-DDD in sediment from the tidal Hudson River.

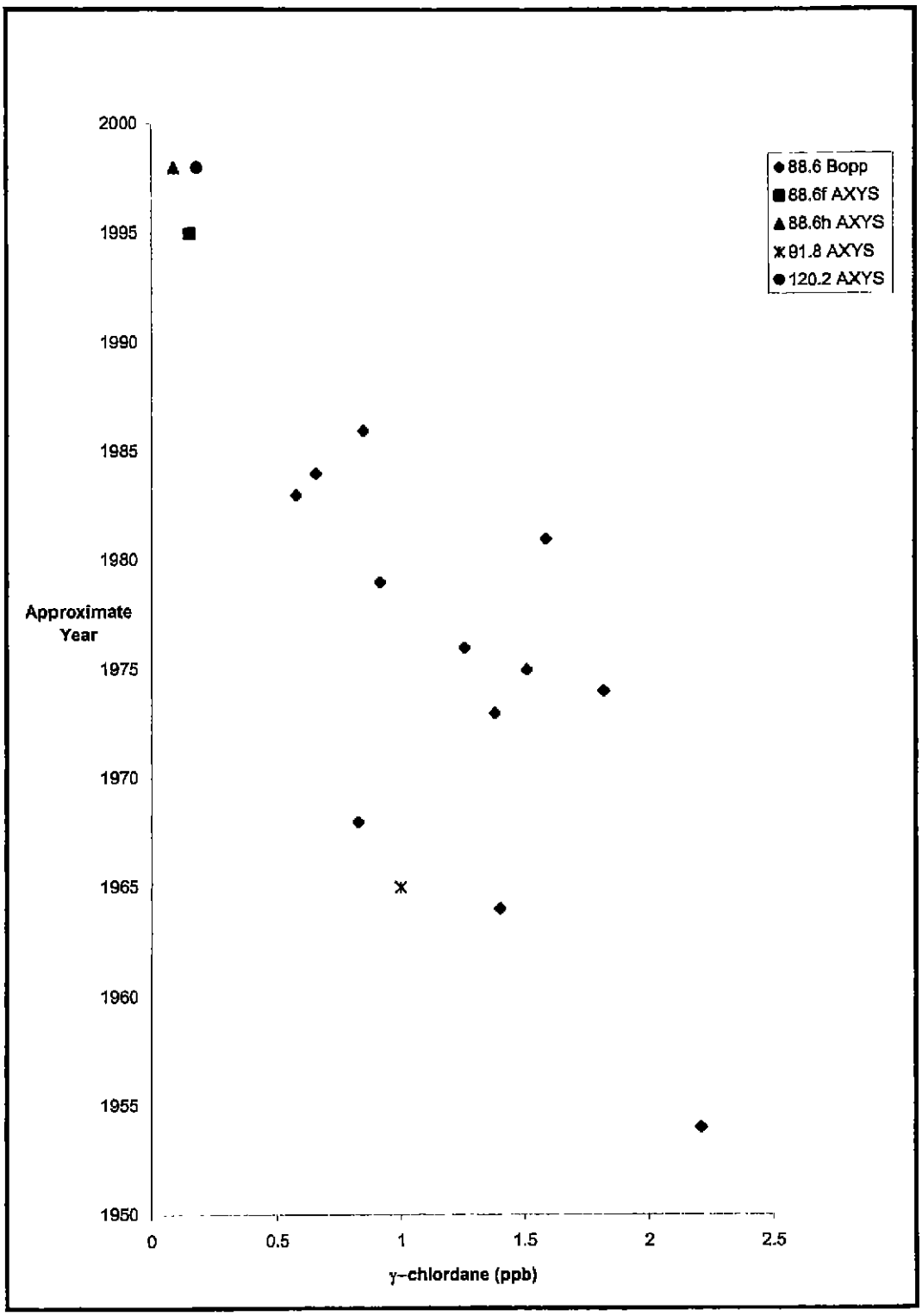


Figure 2-16. γ-chlordane in sediment from the tidal Hudson River.

Upper Hudson Basin

Chlorinated pesticide analysis of dated sediment sections from five cores taken from the upper Hudson River and the Mohawk River has provided some of the first historical and recent DDT and chlordane data for the upper Hudson basin (Table 2-3). Cores were taken from the Hudson River at mile points 188.5 and 188.6 near the Thompson Island Dam and from mile point 163.6, just above lock 2. Two cores, MOH10V and MOH12, were taken from the Mohawk River.

pp'-DDD and γ–chlordane concentrations are much lower in the upper basin than those found in the harbor. The highest pp'-DDD concentration detected, 18 ppb, was in the mid 1960s section of core 188.5. The levels were down to less than 2 ppb in 1996. γ-chlordane was highest in the mid 1960s also, but only at 1.7 ppb. This had decreased to less than 1 ppb by 1996.

Core	Section (cm)	Control number	Year	pp'-DDD (ppb)	γ-chlordane (ppb)
163.6 V	2-4	R1129B	1997	0.95	0.36
163.6V	36-40	R1129L	1970s	1.2	0.75
188.5	24-28	CN1852H	Mid 1960s	18	1.7
188.6	40-44	CN2113M	Mid 1960s	7.8	1.1
MOH 12	0-2	R1147A	1997	1.7	ND (0.22)
MOH 10V	0-2	R1100A	1996	1.3	0.18 (NDR)
MOH 10V	64-68	R1100S	Mid 1960s	12	ND (0.81)

Table 2-3. pp'-DDD and γ-chlordane concentrations in the upper Hudson basin. NDs are non-detects. The numbers in parentheses are detection limits. NDRs were flagged by AXYS when quantification standards were not met.

Central Park

Sediment cores collected in 1996 from the "rowboat lake" in Central Park have been used to determine the history of atmospheric deposition of lead (*Chillrud et al., 1999)*, mercury (*Kroenke et al., 1998, 2002*), PCBs and dioxins *(Chaky et al., 1998, Chaky, 2002)*. Several sections from one of these cores, CPE, have been analyzed to provide historical information on levels of compounds derived from DDT and chlordane use. Using a constant sedimentation rate of 0.44 cm/yr determined from ^{7}Be and ^{137}Cs, the core extends back from the year of collection (1996) to the late 1800s. Various models may be used to estimate the sediment rate below the ^{137} Cs bearing sections (*Chaky, 2002*), but for the purpose of this discussion, a constant sedimentation rate can be assumed.

This core contained much higher pp'-DDD levels than the cores collected from the harbor complex (Figure 2-17). The high levels suggest direct application of DDT to the lake surface or adjacent drainage basin. Between the mid 1950s and early 1960s, pp'-DDD increased from 42 ppb to 3100 ppb. Levels remained above 1500 ppb in the two more recent samples that were analyzed. Because DDT was no longer used in the U.S. after 1972, this increase is most likely due to inputs from the drainage basin or redistribution of highly contaminated sediment from shallower areas of the lake.

γ-chlordane was first detected at significant levels in the early 1960s at 25 ppb (Figure 2-18). Between then and the 1990s, there has been little change in the levels. In a mid 1970s sample, 17 ppb were detected. This increased slightly to 21 ppb in the sample from the 1990s.

The slow decline of γ-chlordane and persistent high levels of pp'-DDD suggest a continuous source to the lake, possibly from runoff. Atmospheric deposition could also contribute, but the levels seem too high for this to be a major source. To help elucidate the

situation, analyses of additional samples from the lake core, analyses of Central Park soil samples, and atmospheric flux modeling are currently being pursued.

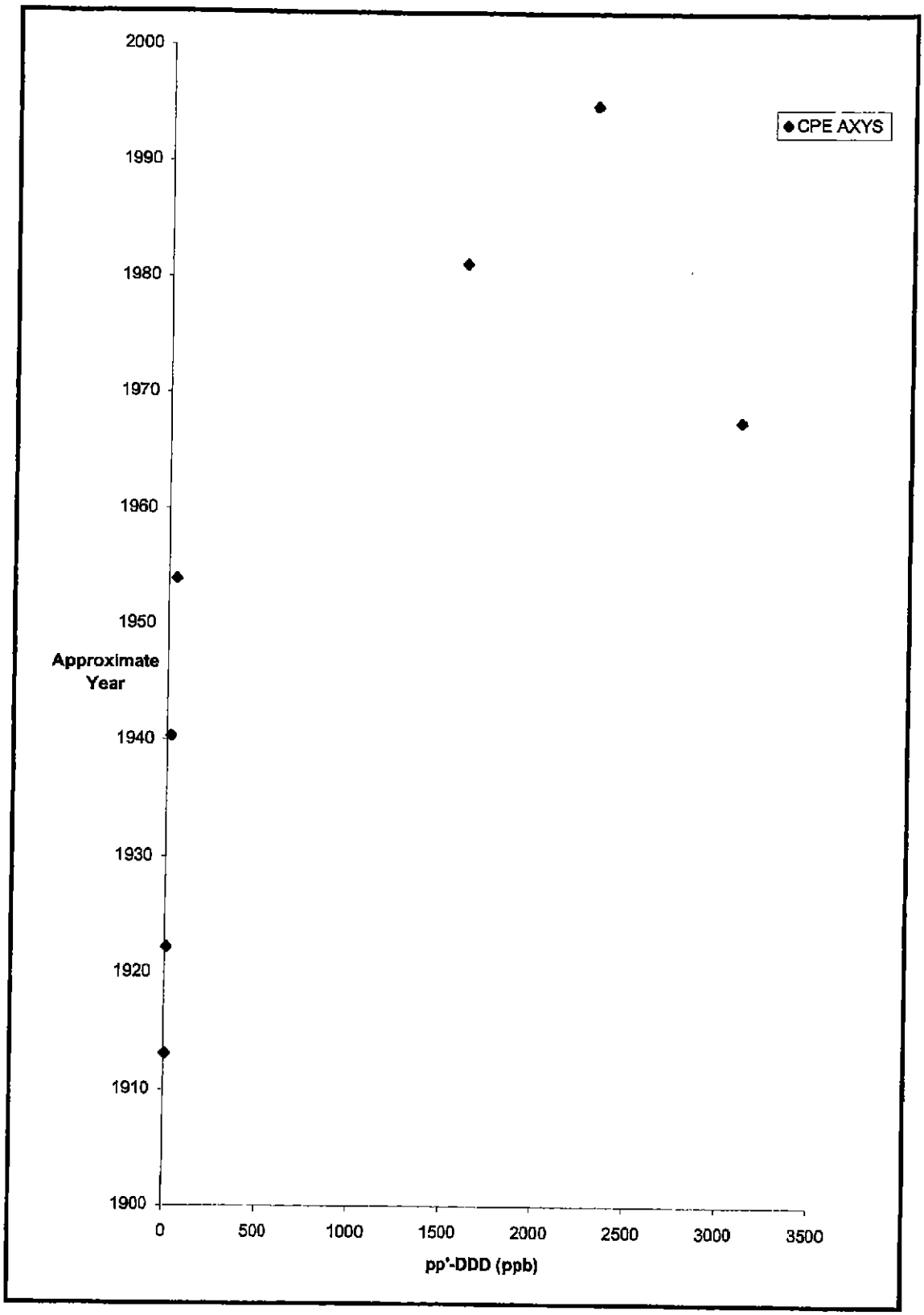


Figure 2-17. pp'-DDD in sediment from Central Park Lake in Manhattan.

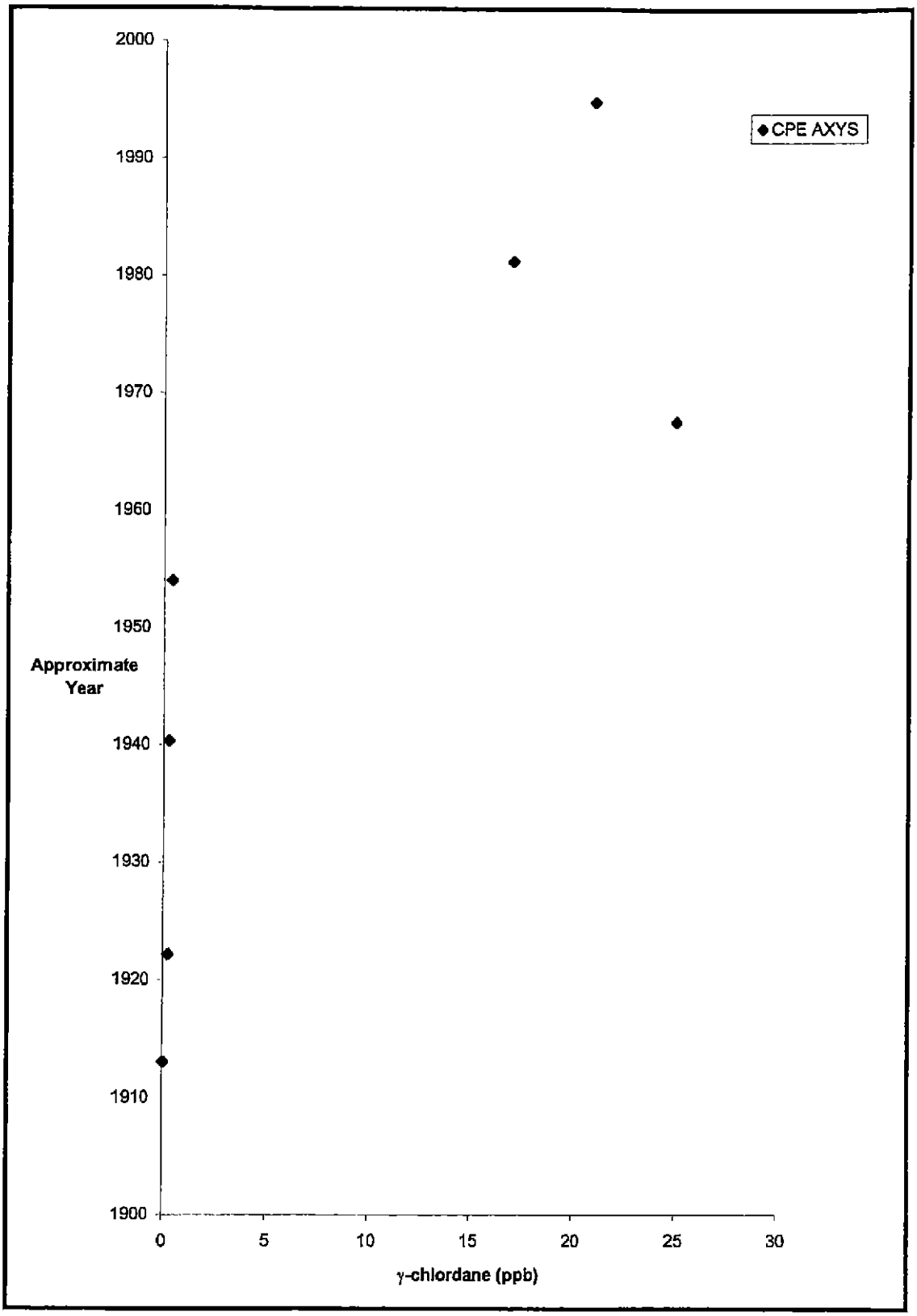


Figure 2-18. γ-chlordane in sediment from Central Park Lake in Manhattan.

Relative Concentrations of DDT and Chlordane Compounds in Hudson River and NY/NJ Harbor Sediment

The typical tracers used for DDT and chlordane contamination in sediment are pp'-DDD and γ-chlordane. γ-chlordane is the most abundant of the technical chlordane components and undergoes little or no alteration in the sediment column. Typically, pp'-DDD is considered the primary metabolite of DDT in sediment under anaerobic conditions. The other primary metabolite, pp'-DDE, can be difficult to quantify in samples with high PCB concentrations due to peak interference (Bopp et al., 1982). Although these compounds work well as tracers, it is important to monitor the other compounds when possible, especially in the case of DDT where there is a much wider range of relative concentrations. In many of the upper Hudson basin and harbor samples, pp'-DDE was detected at higher concentrations than pp'-DDD. The core collected from Raritan Bay in 1980, RB17, has much higher concentrations of pp'DDE than pp'-DDD (Figure 2-19). Observation of the other samples shows that there is no correlation between location or depth of the sample and the relative concentrations. All DDT and chlordane data can be found in Appendix IV.

Analysis of all DDT compounds can give evidence of preferential degradation, production, and similar behavior of the isomers. The ratio for the DDD isomers, op'-DDD/pp'-DDD remains fairly consistent from the technical mixture to sediment, suggesting similar behavior. In the technical mixture, op is about 30 % of pp-DDD (*WHO, 1979*). Two samples from the Kill Van Kull have 38% and 24% for op to pp-DDD. Thirteen samples from Newark Bay have an average of 0.43 +/- 0.08 with values ranging from 0.35 to 0.63. Twenty-one samples from the Arthur Kill have op/pp-DDD ratios ranging from 0.17 to 0.63 with an average of 0.43 +/- 0.12. Three samples from Newtown Creek have an average of 0.33 +/- 0.05. Thirty samples from the upper harbor near the Statue of Liberty have ratios ranging from 0.27 to 0.38 with an average of 0.32 +/- 0.03. Seven samples from the upper Hudson mainstem and the Mohawk River

had ratios ranging from 0.16 to 0.36 with an average of 0.25 +/- 0.07. Four samples from the tidal Hudson ranged from 0.19 to 0.35 with an average of 0.27 +/- 0.1.

The DDT isomers in the harbor sediment do not show as consistent behavior. The ratio of the parent isomers, op'-DDT/pp'-DDT in a typical DDT technical mixture is about 0.2 (*WHO, 1979*). Analysis of the harbor and Hudson mainstem sediment gives a fairly wide range for this ratio. In two samples from the Kill Van Kull, op'-DDT/pp'-DDT was 0.12 and 0.29. This ratio ranged from <0.02 to 0.14 in three samples from Newark Bay. Five samples from the Arthur Kill ranged from 0.01 to 0.52 with an average of 0.12 +/- 0.23. Three samples from Newtown Creek ranged from <0.01 to 0.38. Three samples from the upper harbor near the Statue of Liberty had the greatest variance in the op'-DDT/pp'-DDT ratio. They ranged from <0.03 to 1.5. Six samples from the upper Hudson mainstem and the Mohawk River ranged from 0.30 to 0.91 with an average of 0.48 +/- 0.31 for four samples that had detected levels of both isomers. Four samples from the tidal Hudson had ratios ranging from <0.03 to <0.42. op'-DDT was not detected in any of these samples with detection limits of about 0.1 ppb.

In a typical technical DDT mixture, the op'-DDE/pp'-DDE ratio is about 40 (*WHO, 1979*). This is significantly lower in all of the sediment samples and much more similar to the "parent" (op'-DDT/pp'-DDT) ratio of about 0.2. In all the harbor and Hudson mainstem samples, this ratio is less than 0.5.

The relative concentrations of the abundant chlordane components remain fairly consistent from the technical mixture to sediment. There was little spread in the ratios from the Hudson basin and harbor samples. Five samples from the upper Hudson and the Mohawk River had γ-chlordane to α-chlordane ratios ranging from 0.95 to 1.62 with an average of 1.18 +/- 0.28. This ratio is about 1 in the technical mixture (*Dearth et al., 1991*). γ to α-chlordane in nine samples from the Arthur Kill ranged from 0.88 to 1.52 with an average of 1.16 +/- 0.22. The widest spread was from Newark Bay where eleven samples ranged from 0.74 to 2.69 with an

average of 1.10 +/- 0.54. From Newtown Creek, three samples ranged from 0.94 to 1.08 with an average of 1.01 +/- 0.07. Thirty samples from the upper harbor near the Statue of Liberty ranged from 0.71 to 0.98 with an average of 1.04 +/- 0.30, and fifteen samples from the Kill Van Kull ranged from 0.93 to 1.56 with an average of 1.19 +/- 0.23.

The trans nonachlor to (γ +α-chlordane) ratio in the technical mixture is about 0.32 (*Dearth et al., 1991*). In the Hudson and harbor samples a somewhat lower ratio, averaging about 0.25, is observed. This is a somewhat puzzling observation. As discussed below in Chapter 3, trans nonachlor is significantly more persistent in food chains than γ or α-chlordane, so "environmental" chlordane should tend to have a higher ratio than technical chlordane. In addition, preferential partitioning of trans nonachlor to particles as indicated by its five-fold lower aqueous solubility (Howard, 1997) would be expected to increase the ratio found in sediments. In three samples from the upper Hudson River, this ratio ranged from 0.14 to 0.27 with an average of 0.19 +/- 0.07. From the Arthur Kill, five samples ranged from 0.13 to 0.29 with an average of 0.21 +/- 0.06. This ratio in two samples from the Kill Van Kull was 0.18 and 0.21. Three samples from Newark Bay ranged from 0.13 to 0.27 with an average of 0.19 +/- 0.07. Newtown Creek has three samples ranging from 0.24 to 0.34 with an average of 0.30 +/- 0.05, and three samples from the upper harbor near the Statue of Liberty ranged from 0.16 to 0.29 with an average of 0.23 +/- 0.7.

The abundant components of technical chlordane appear to be stable in these sediments. The primary chlordane metabolites, oxychlordane and heptachlor epoxide, were only quantified in one of the harbor samples. This was in a Newtown Creek sample from 1998 where they were detected at less than 1 ppb. Out of 29 samples, 3 for heptachlor epoxide and 2 for oxychlordane were reported as detected but did not meet the quantification standards. Typically, these were also less than 1 ppb. Dearth and Hites (1991a) looked at the relative accumulation in people by comparing the parent (α and γ-chlordane and cis and transnonachlor) to metabolite (oxychlordane

and heptachlor epoxide) ratio. By doing the same for sediment and using the detection limits where necessary for the metabolites, the parent to metabolite ratio in the harbor sediments ranged from > 3 to >321.

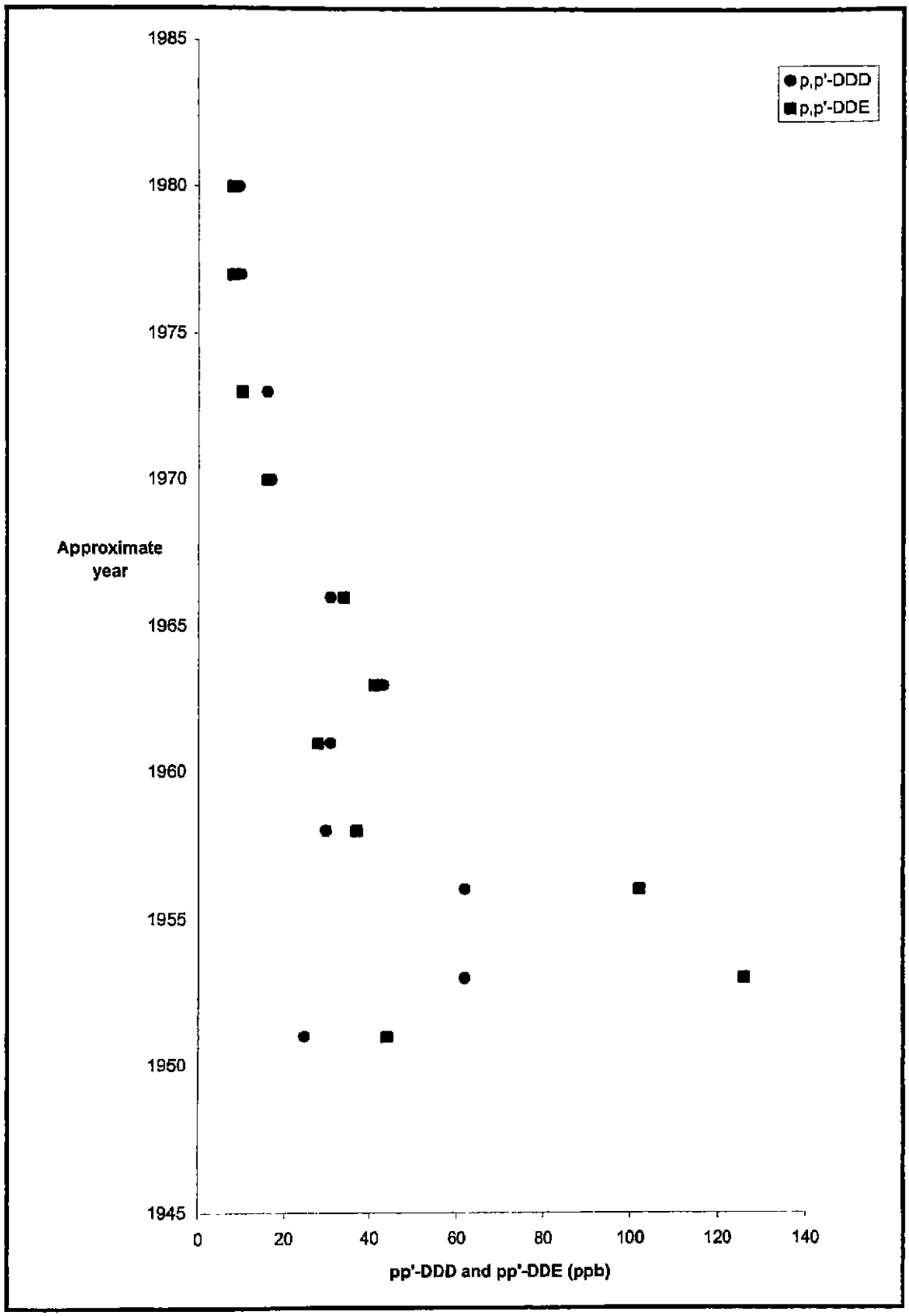


Figure 2-19. pp'-DDD and pp'-DDE in RB17 from Raritan Bay. All analyses were done by Bopp.

Putting the Hudson River and NY/NJ Harbor Data in Perspective

DDT and chlordane data from the NOAA National Status and Trends program will be presented for the purpose of putting the Hudson River and NY/NJ Harbor data in perspective. As a part of the NOAA NST program (*NOAA, 1988*), sediment grab samples were collected at different coastal areas between 1984 and 1987 and analyzed for various contaminants including chlorinated pesticides. Sediment was sampled within 500 meters of a center site. Unfortunately, no radionuclide dating was done on the grab samples. Review of the raw data clearly shows that there were differences in depositional rates within the site area. At one site, San Pedro Harbor, California, six samples collected in 1986 and 1987 had pp'-DDD concentrations that ranged from 19 to 250 ppb.

In the NOAA NST report (1988), the samples at each site, typically between three and six, were averaged and the twenty-five with the highest concentrations were ranked. DDT was ranked by total DDT, and chlordane was included with non-DDT pesticides. For the purpose of putting the harbor concentrations in perspective, the raw data was used to recreate the NOAA NST plots using only pp'-DDD and α–chlordane. γ-chlordane, which was used as the chlordane tracer in the harbor sediments, was not available in the NOAA NST data however, due to the ratio of the two isomers being close to one in sediment, comparison of the two should cause little discrepancy.

Figure 2-20 shows the pp'-DDD in the sites ranked as the top twenty-four for total DDT in the 1988 NOAA NST report. Rather than averaging the concentrations at each site, the highest was used. Comparison of the sediment from the NY/NJ Harbor to those considered to be among the most contaminated with DDT shows the pp'-DDD contamination in the harbor is significant. All samples from the 1990s would rank within the top twenty-four. Most of the sites in the western part of the harbor complex have higher concentrations than all but two or three NOAA

sites. Sediment from the lake in Central Park deposited in the 1990s would rank at the top with 2300 ppb.

Figure 2-21 shows the twenty-five highest α-chlordane analyzed in the NOAA NST program. It should be mentioned that the raw data used was updated after the publication of the 1988 report (http://ccmaserver.nos.noaa.gov/NaandT/New_NSandT.html). There were samples collected in 1990 that were used in the creation of this plot. Comparison of the chlordane data for the harbor shows that sediment from the western side of the complex, the Arthur Kill, and Kill Van Kull, and from Newtown Creek and the Central Park Lake, would be ranked among the top twenty-five. Samples from the Passaic and Hackensack Rivers have chlordane levels higher than any reported at the NOAA sites.

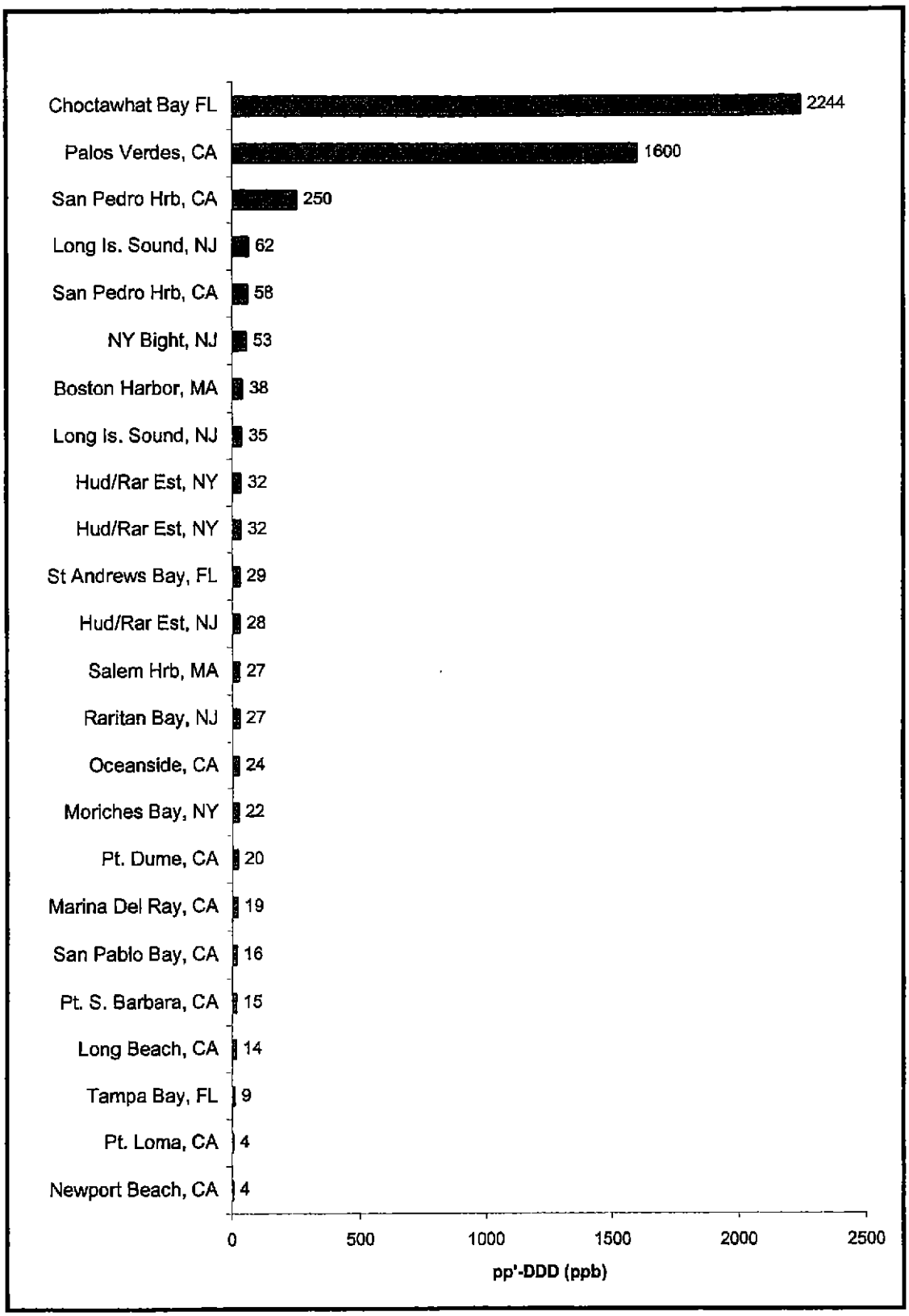


Figure 2-20. Sites ranking among the top 24 for DDT contamination (NOAA, 1988). Data for pp'-DDD is from raw data from NOAA NST report.

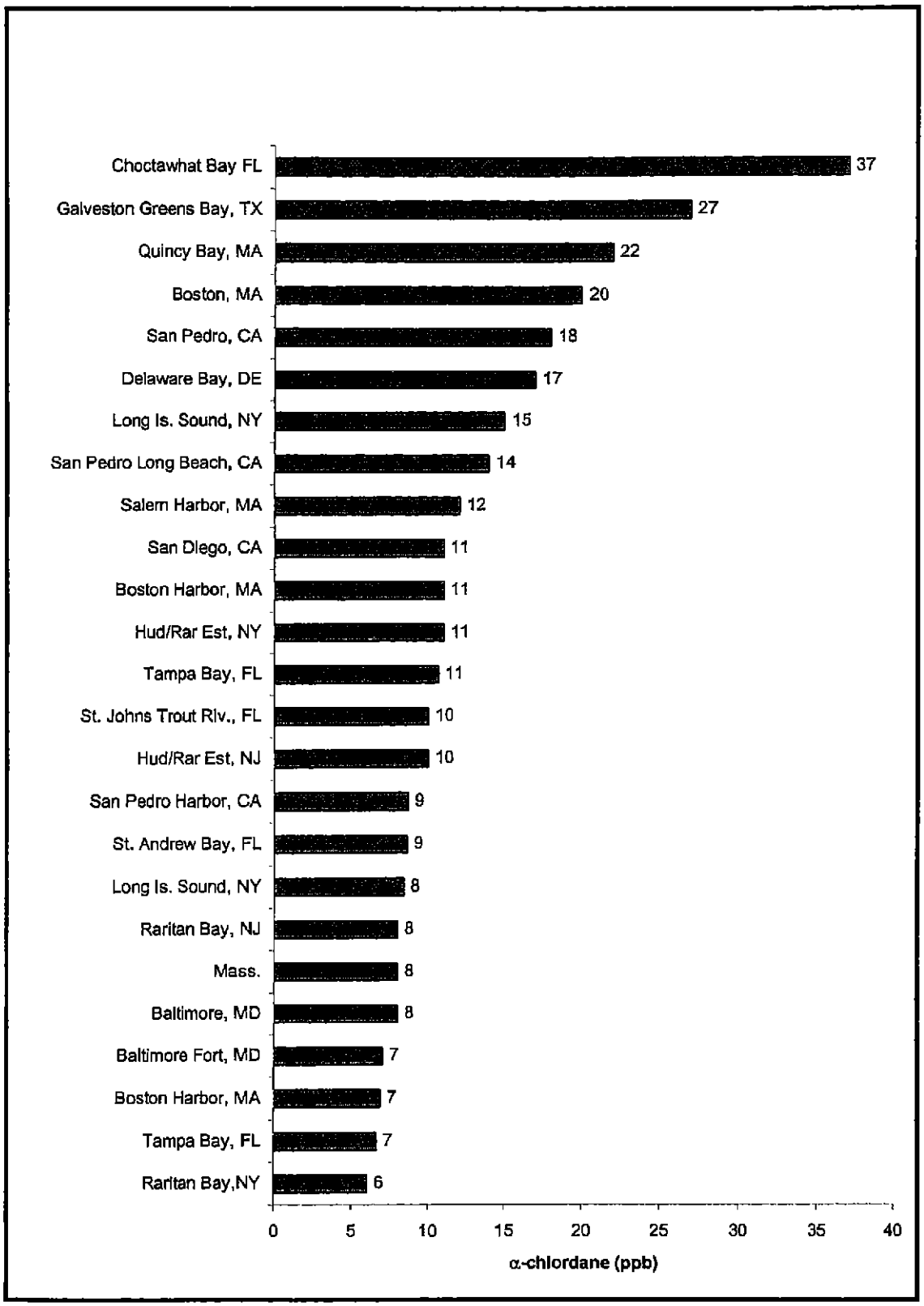


Figure 2-21. Sites ranking among the top 25 for α-chlordane contamination. Data used is from raw data from NOAA NST report (1988).

Further Evidence of Fresh DDT Inputs Near the Arthur Kill

As discussed previously in the chapter, there is strong evidence of a fresh source of DDT contamination to the Arthur Kill. This source may be due to improper disposal. Sometime between the 1970s and the mid 1980s, there was a significant spike in DDT contamination. Based on analyses of samples from core Kill 21, in the early 1970s, pp'-DDD was 100 ppb and pp'-DDT was 46 ppb. By the mid 1980s, pp'-DDD had increased to 280 ppb and pp'-DDT increased to 650 ppb. In 1996, pp'-DDD levels were even higher (520 ppb) while pp'-DDT remained at about 650 ppb. Some fish samples from the DEC database indicate that the contamination in the sediment is making it into the aquatic food chain.

Throughout most of the NY/NJ Harbor complex, the range in DDT levels in fish is relatively small (Appendix V). There are detectable levels, but they are far below the FDA action limit of 5000 ppb, and the concentrations are similar. Two notable exceptions are Morses Creek and Sawmill River, both tributaries to the Arthur Kill. These locations are shown in Figure 2-22. Analyses of American eels from Morses Creek show high levels of DDT. A few of them are above the FDA action limit however, pp'-DDD and pp'-DDE dominate, so the influence of a "fresh source" (i.e. a high relative abundance of pp'-DDT) is not apparent. Data can be seen in Table 2-4.

pp'-DDE	op'-DDE	pp'-DDD	op'-DDD	pp'-DDT	op'-DDT	pp'-DDT/ pp'-DDE	Σ DDT
0.74	ND(.01)	0.86	0.01	0.08	ND(.01)	0.11	1.69
1.5	0.01	1.8	0.08	0.21	ND(.01)	0.14	3.60
1.9	ND(.01)	3.3	0.07	0.23	ND(.01)	0.12	5.50
1.9	0.03	4.6	0.1	0.266	ND(.01)	0.14	6.90
1.4	0.03	5.1	0.13	0.14	ND(.01)	0.10	6.80

Table 2-4. DDT compounds in American eels from Morses Creek. Concentrations in ppm.

Analysis from two American eels, a red breasted sunfish, and a carp from the Sawmill River, also near the Arthur Kill, show evidence of recent exposure to DDT (Table 2-5). The total concentrations are not as high as those from Morses Creek, but the parent to metabolite ratios are much higher, ranging from 0.47 to 1.15. The highest ratio was found in a carp, which are good indicators of localized contamination (*Jaffe et al., 1985*). Unfortunately, there was only one analyzed from this area.

Species	pp'-DDE	op'-DDE	pp'-DDD	op'-DDD	pp'-DDT	op'-DDT	pp'-DDT/ pp'-DDE	Σ DDT
red breasted sunfish	0.07	-	0.03	0.01	0.03	0.01	0.47	0.13
Carp	0.19	-	0.07	0.02	0.22	0.01	1.15	0.50
American eel	0.25	-	0.09	0.00	0.16	0.00	0.64	0.50
American eel	0.19	-	0.14	0.02	0.13	0.03	0.66	0.51

Table 2-5. DDT compounds in fish from Sawmill River. Concentrations in ppm.

The fish data from the Sawmill River and Morses Creek indicate that the influence of the source of the recent high levels of DDT in the Arthur Kill is not confined to the sediment. It is accumulating in fish, which should be a cause for concern. This data may be helpful in determining where to concentrate when looking for the source of the fresh DDT to the Arthur Kill and Kill Van Kull. The American eels from Morses Creek do have elevated levels, but the parent to metabolite ratios are reasonably small. This contamination could be connected to the production of DDT at the 80 Lister Avenue site, or it might reflect rapid alteration of a more recent source. In the case of the Sawmill River, the situation is a bit clearer. While total DDT concentrations are well below the FDA action limit, the parent to metabolite ratios strongly indicate a fresh source. Analysis of dated sediment cores and additional fish samples from these two sites would allow a much more detailed description of local DDT sources and their significance.

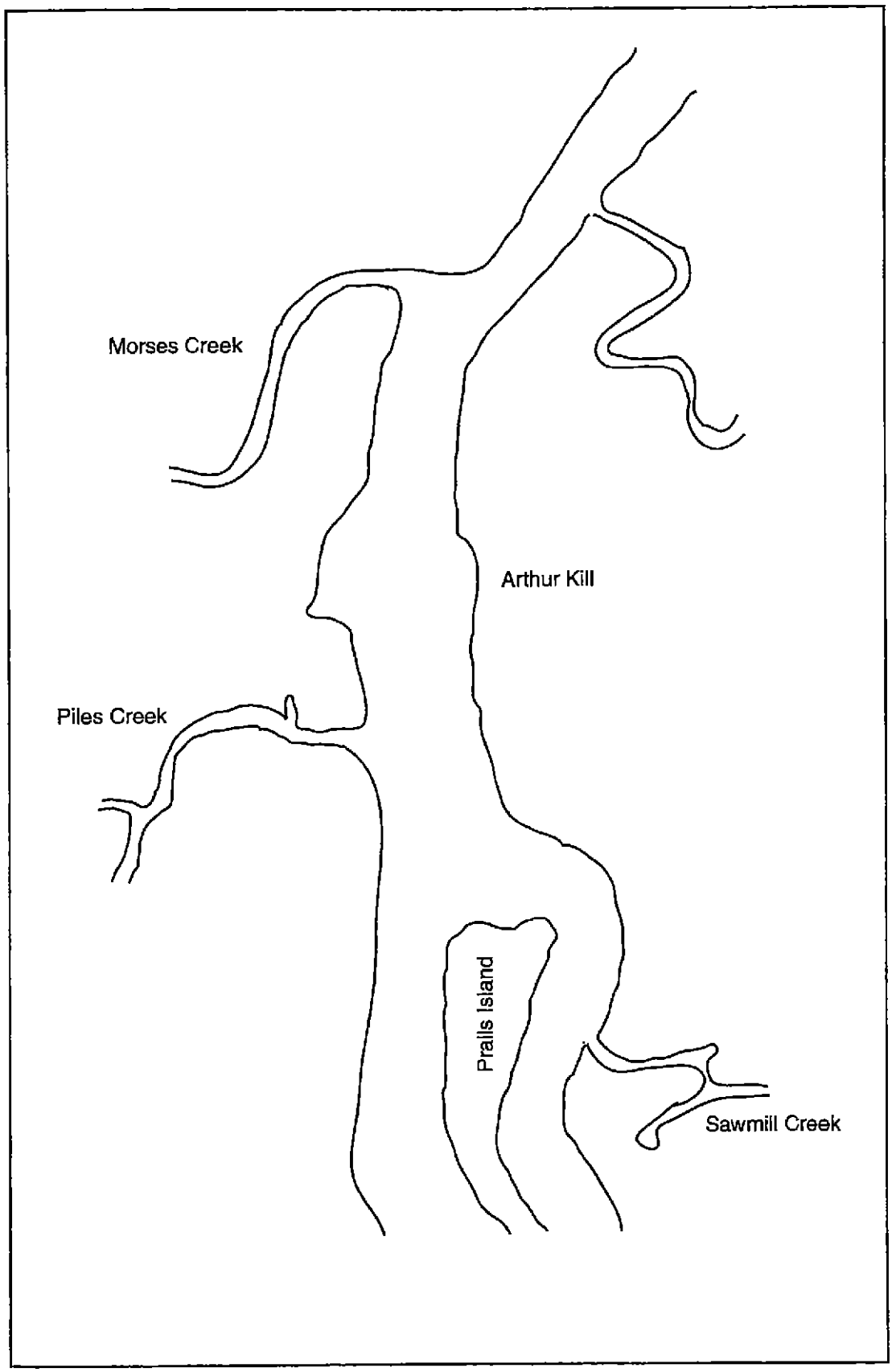


Figure 2-22. Tributaries to the Arthur Kill

Chapter 3. Tracing Chlordane Residues in Fish and Crustaceans from the NY/NJ Harbor Complex

Introduction

Residues of technical chlordane and its metabolites have been found in many fish and crustacean species throughout the NY/NJ Harbor complex. In some cases, the total concentrations are near or above the FDA action limit of 300 ppb. The action limit is the concentration at which the FDA will take legal action to remove the product from the market (*U.S. FDA, 2000*). In the case of fish and crustaceans, this would entail advisories including limiting or banning consumption.

Dearth and Hites (1991a) looked at the extent of chlordane accumulation and metabolism in people by comparing the parent (α and γ-chlordane and trans and cis nonachlor) to metabolite (oxychlordane and heptachlor epoxide) ratios to those of fish. They found that the components of technical chlordane are metabolized much more extensively by humans and reported a range of P/M ratios for humans to be 0.32 to 3.2. The fish P/M ratios ranged from 2.1 to 210. Bioaccumulation factors were also calculated for human blood. These factors normalized to γ-chlordane are 240 for trans nonachlor, 85 for cis nonachlor, and 1.5 for α-chlordane.

This chapter will focus on tracing relative chlordane concentrations in American eels, striped bass, and the hepatopancreas of the blue crab and the American lobster from the NY/NJ Harbor complex. P/M ratios will be presented, but an extensive database developed and maintained by the New York State Department of Environmental Conservation has provided enough data to look at the relative behaviors of the individual compounds in more detail. Differences in the relative abundances in fish and crustaceans from those observed in sediment are related to accumulation and metabolic processes. Such differences have been observed in several other studies (*Kawano et al., 1988, Gooch et al., 1990).*

Analysis

Unless otherwise noted, all fish and crustacean data were taken from a database supplied by the New York Department of Environmental Conservation. Ron Sloan, Michael Kane, and Dennis Keane were especially helpful in this regard. This database provides extensive contaminant data including PCBs, chlorinated pesticides and metals in fish and crustaceans collected from the Hudson River basin. The database is regularly updated as new samples are collected and analyzed. The data discussed in this thesis were taken from the June, 2001 version of the database. In this version, there are over 28,000 samples from water bodies throughout New York State. Reported are samples from the 1970s through 2000, however, not all samples were analyzed for all contaminants. The samples discussed in this chapter were collected throughout the 1990s. The standard NYSDEC method was used for sample preparation, and analysis was done by gas chromatography using a fused silica capillary column with electron capture detection (*Butcher, 1997*).

Results and Discussion

Once taken in by organisms, the relative concentrations of technical chlordane are altered by accumulation and metabolic processes. The major components of chlordane found in sediment are α and γ-chlordane at a ratio of about 1. Trans nonachlor is also detected, but at lower concentrations. The average relative concentration of trans nonachlor to (α + γ-chlordane) in the NY/NJ Harbor complex sediment and in technical chlordane is about 0.3. The primary metabolites of technical chlordane, oxychlordane and heptachlor epoxide, were detected in only one of the sediment samples at concentrations less than 1 ppb (Appendix IV). Using detection limits for the metabolites, the parent to metabolite ratios ranged from about >3 to >320. The major components found in fish and crustaceans are trans nonachlor, oxychlordane and heptachlor epoxide.

Twenty-four fillet samples from American eels collected from the NY/NJ Harbor complex were analyzed for all chlordane components. The samples were collected in 1993 and 1994. Of the 24 samples, 5 of them had no detected chlordane (with detection limits of 10 ppb). The total chlordane ranged from 40 to 370 ppb. Those that had the highest levels were found at the end of Newtown Creek and in the creek at the Bordon Ave. Bridge however, not all eels from these locations had elevated levels. Three of the samples had levels that exceeded the FDA action limit.

The γ–chlordane/α-chlordane ratios in the eels range from <0.09 to 0.50 with an average of 0.26 +/- 0.10 (Table 3-1). The average was calculated for those with detectable γ-chlordane. Both α and γ–chlordane are metabolized to oxychlordane through 1,2-dichlorochlordene however, various studies as well as the DEC fish and crustacean data show that γ-chlordane is the preferentially metabolized isomer (*Gooch et al., 1990, Kawano et al., 1988*). This results in a decrease of γ-chlordane/α-chlordane when compared to that of the technical mixture and of sediment. Table 3-2 shows the average concentrations of the abundant chlordane components normalized to α-chlordane in the technical mixture, sediment, fish, and crustaceans.

Another metabolite of technical chlordane is heptachlor epoxide. This is formed via the breakdown of heptachlor, which is a component of technical chlordane, as well as a pesticide on its own. α and γ-chlordane have also been found to metabolize to heptachlor, but it has been considered a weak metabolic pathway (*Brimfield et al., 1979, Tashiro, 1977*). This complicates the interpretation of heptachlor epoxide data. Typically, heptachlor epoxide is either comparable to or less than oxychlordane in fish and crustaceans. Of the 24 eels sampled, 17 had detectable levels of oxychlordane, and only 7 had detectable levels for heptachlor epoxide (Appendix V).

Due to a lower aqueous solubility and a slower metabolism rate than that of α and γ-chlordane, trans nonachlor tends to preferentially bioaccumulate. (*Kawano et al., 1988, Dearth et al., 1991*). The rate of metabolism of trans nonachlor was found to be extremely slow in people

(*Tashiro et al., 1978*). The data presented here indicates that this is also true for fish and crustaceans. The average relative concentration of trans nonachlor to α-chlordane plus γ-chlordane in the NY/NJ Harbor complex sediment samples is about 0.3. For the NY/NJ Harbor eels the ratio is higher, ranging from 0.50 to 0.62 with an average of 0.56. Even if oxychlordane is added to the α and γ-chlordane, the ratio in the eels is still greater than in sediments, ranging from 0.50 to > 2 with an average of 0.74. The non-detects were not used in the calculation of the average (Table 3-1). This indicates that there is preferential accumulation of trans nonachlor in the eels even after accounting for the metabolism of α and γ-chlordane by adding oxychlordane. This is, of course, a simplified model that does not consider relative rates of excretion (unknown), metabolic intermediates (not measured), or other metabolic pathways (poorly characterized). Figure 3-1 shows the average relative concentrations of the technical chlordane components from sediment to zooplankton to American eels. The ratios for zooplankton used in the figure are averages from Kawano et al. (1988).

The DEC fish database has enabled us to get a detailed graphical representation of the relative behavior of chlordane components in fish and crustaceans from the NY/NJ Harbor. Figure 3-2 shows the relative behavior of trans nonachlor and α-chlordane in eels collected from the harbor. There is a remarkable linear relationship between the two components in the eels indicating that the combined effects of accumulation and metabolism for trans nonachlor and α-chlordane are very predictable. Including γ-chlordane makes little difference because of the low relative concentrations (Figure 3-3). The average ratio of trans nonachlor to α–chlordane in the eels is 1.24. This ratios in technical chlordane and sediment is about 0.64 (*Dearth et al., 1991*) and 0.50, respectively. From this data, preferential accumulation of trans nonachlor is evident. At the level of eels, bioaccumulation of trans nonachlor is about 2 times greater than α-chlordane (Figure 3-2), 3.3 times greater than α- + γ-chlordane (Figure 3.3), and 2.4 times greater than α- + γ-chlordane + oxychlordane (Figure 3.4).

Species	Total chlordane (ppb)	$\frac{\gamma - chlordane}{\alpha - chlordane}$	$\frac{transnonachlor}{\alpha + \gamma + oxy}$	$\frac{P}{M}$
Blue crab hepatopancreas [1]	70 to 430	0.2 to <1	0.32 to 1.6	0.8 to 2.33
American lobster hepatopancreas [1]	100 to 210	<0.33 to <1	0.29 to 0.75	0.71 to 1.5
Striped bass [1,2]	20 to 230	<0.25 to 0.50	0.67 to 1.2	>3 to >15
American eels	40 to 370	<0.09 to 0.5	0.5 to > 2	<3 to >18

Table 3-1. Relative chlordane concentrations in fish and crustaceans from the NY/NJ Harbor. [1]Calculation done without γ-chlordane. Most or all were non-detects. [2] Calculation done without heptachlor epoxide or γ-chlordane. Most or all were non-detects.

Matrix	γ-chlordane/ α-chlordane	Trans nonachlor/ α-chlordane	Cis nonachlor/ α-chlordane	Oxychlordane/ α-chlordane
[1] Technical chlordane	1.01	0.64	0.18	-
[2] Sediment	1.20	0.50	0.30	-
[3] Zooplankton	0.68	0.74	0.27	0.15
[4] Striped Bass	[6] <0.26	1.3	0.78	0.40
[4] Eels	0.26	1.5	0.92	0.74
[4] Blue crab and lobster hepatopancreas	[6] <0.20	3.2	2.4	3.9

Table 3-2. Average concentrations of chlordane components normalized to α-chlordane. Only detections were used in the calculations. [1] *Dearth et al., 1991.* [2] Data is reported in Appendix IV. [3] *Kawano et al., 1988.* [4] Data is reported in Appendix V. [6] Due to the high frequency of non-detects for γ-chlordane, a < value is reported.

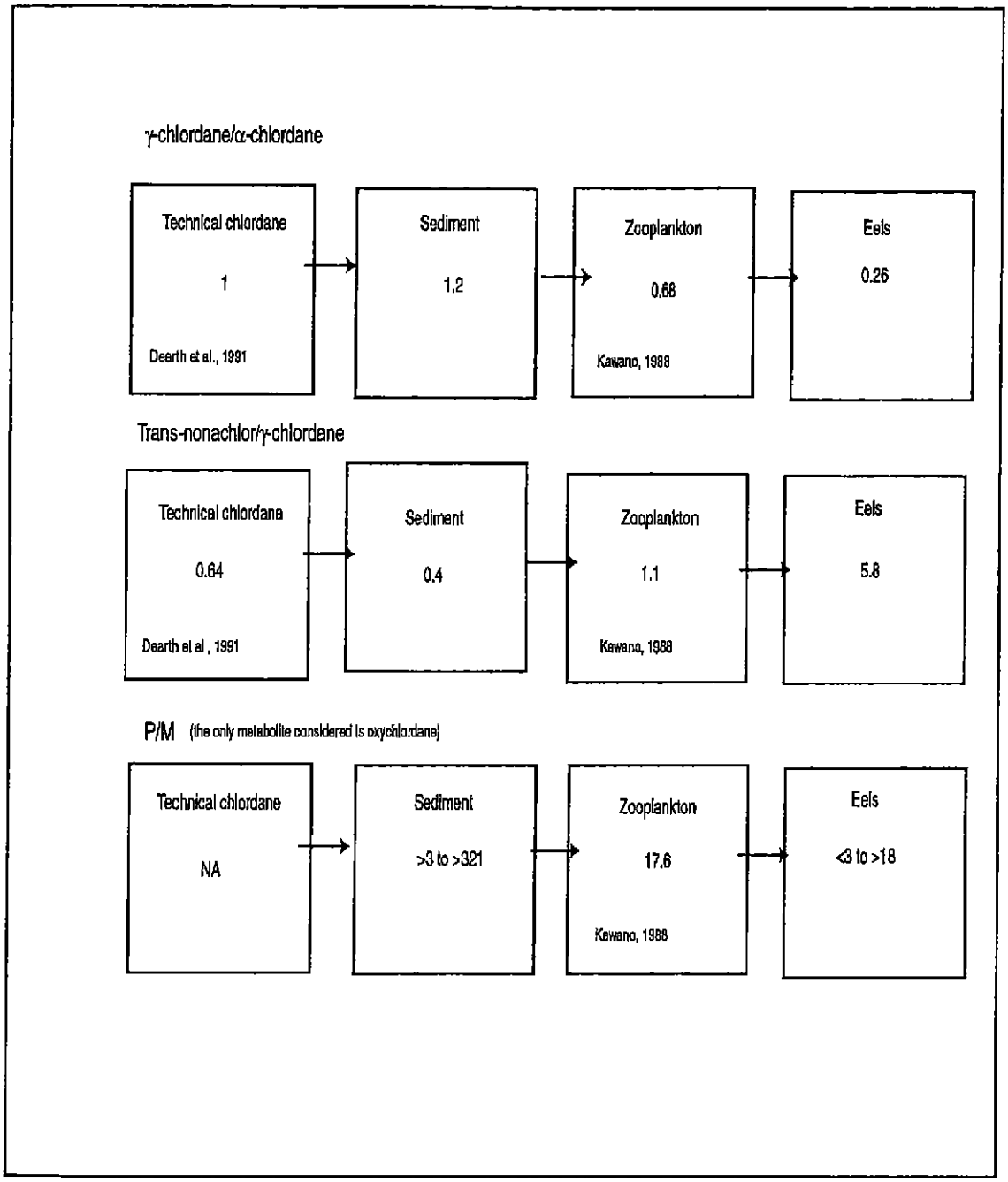


Figure 3-1 Relative concentrations of chlordane components from technical chlordane to American eels from the NY/NJ Harbor

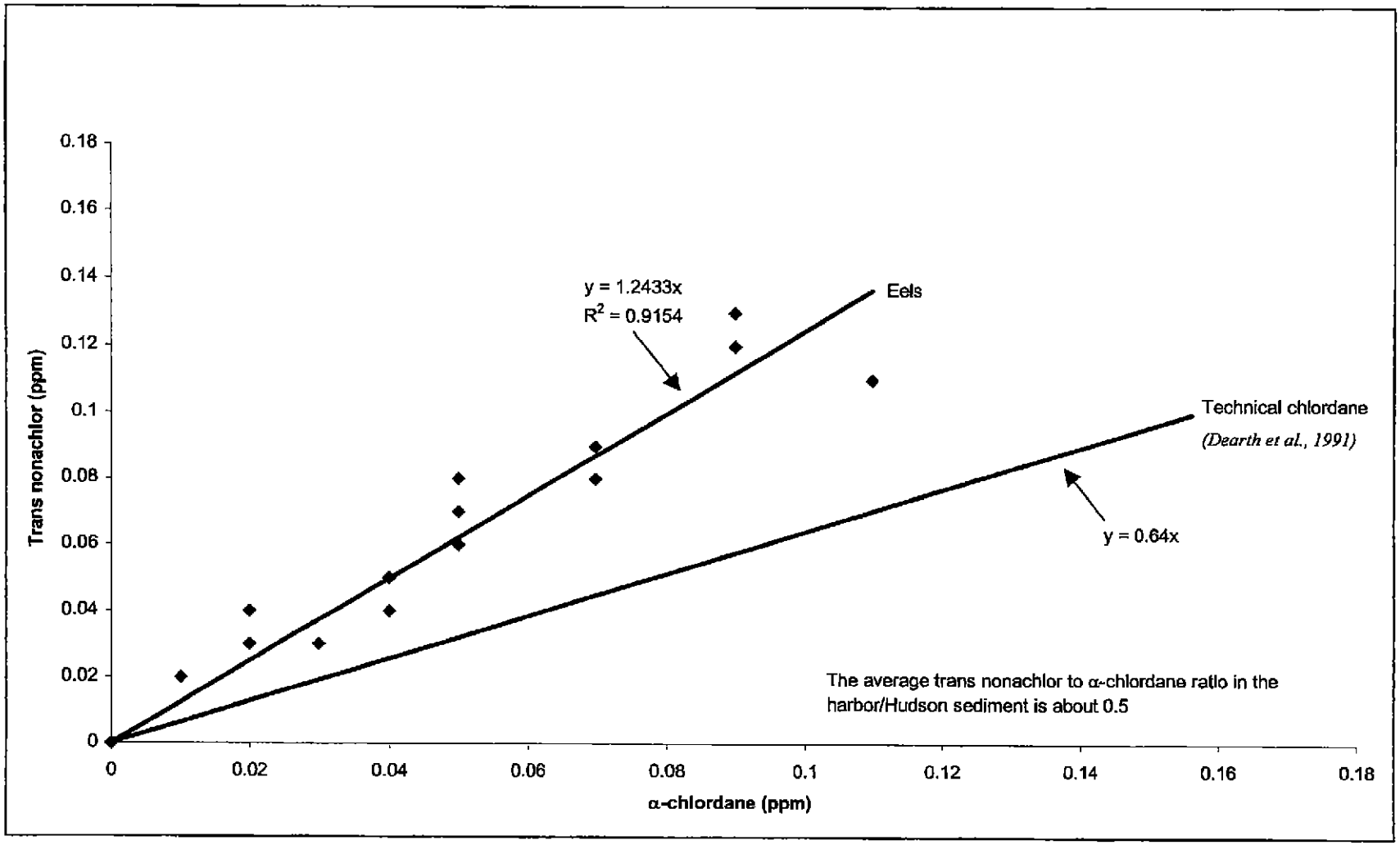


Fig. 3-2. Trans nonachlor vs. α-chlordane in eels from the NY/NJ Harbor. 19 samples used. 5 flagged ND not used.

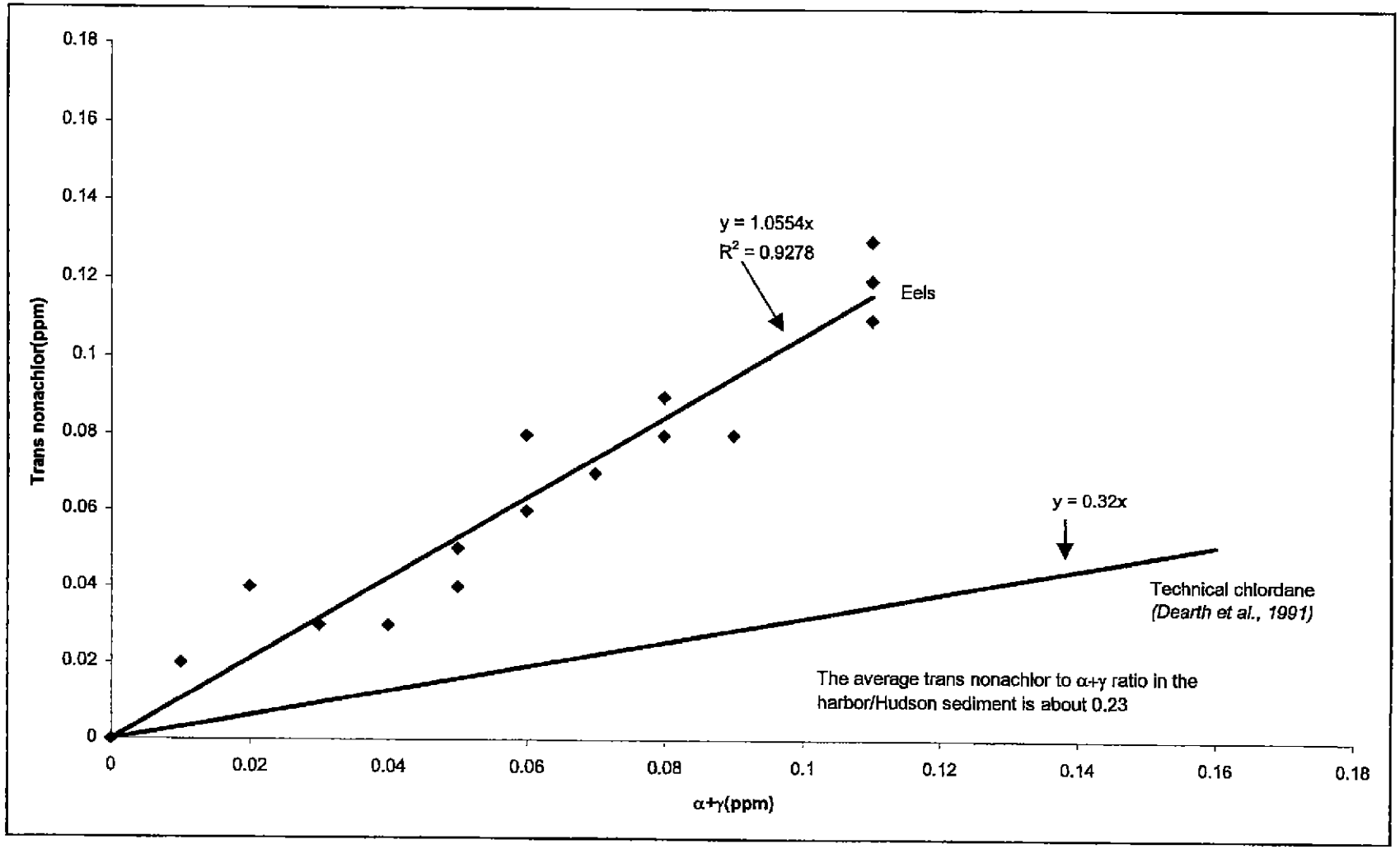


Fig. 3-3. Trans nonachlor vs. α+γ-chlordane in eels from the NY/NJ Harbor. 19 samples used. 5 flagged ND for trans non and α not used.

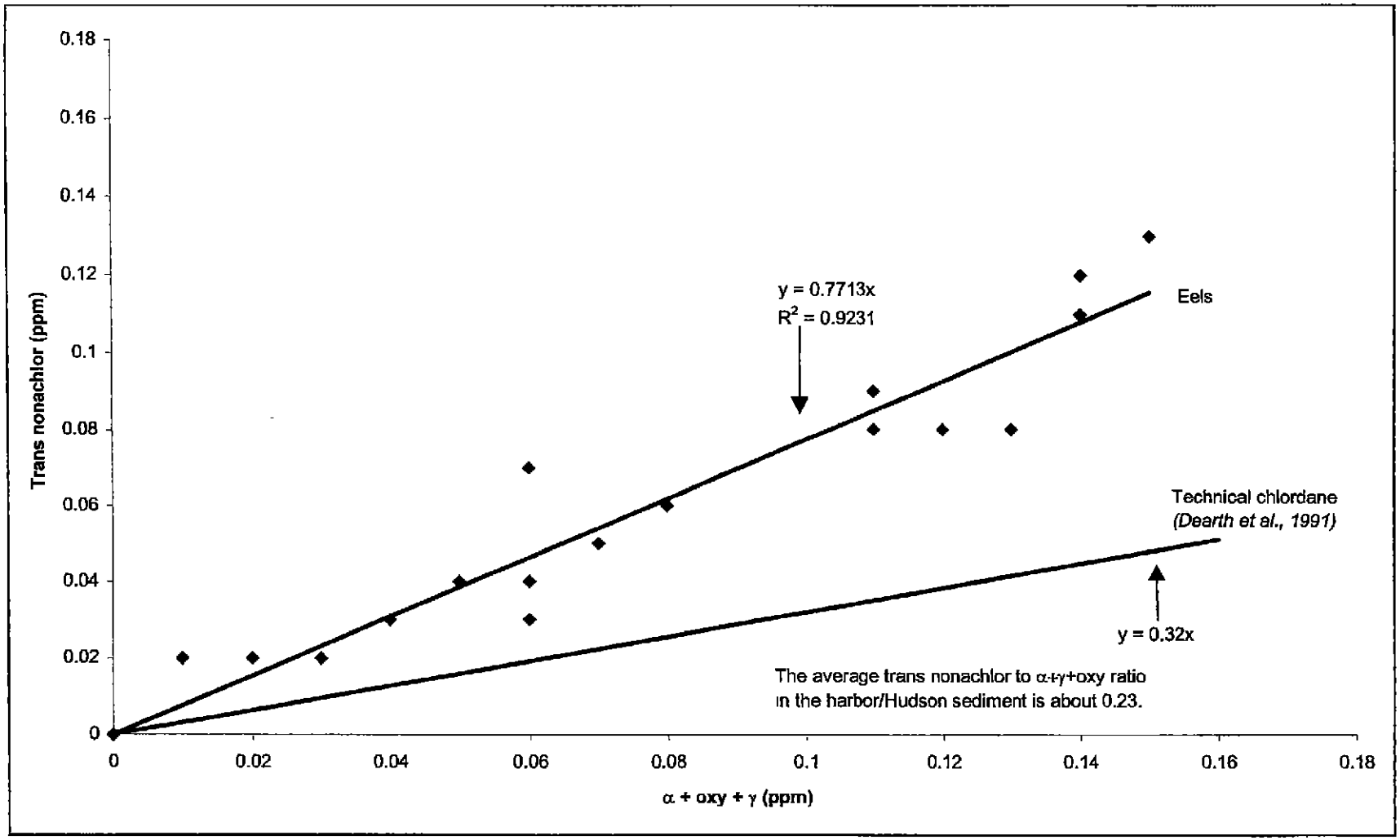


Fig. 3-4. Trans nonachlor vs. α+γ+oxy in eels from the NY/NJ Harbor. 19 samples used. 5 flagged ND for trans non and α not used.

Very similar behavior of the chlordane components is seen in striped bass collected from the harbor. Out of 86 striped bass sampled from the harbor in 1993, only 14 had detectable levels of γ-chlordane with detection limits 0.01 ppm. None of those sampled had total chlordane levels that exceeded the FDA action level (300 ppb). Concentrations ranged from 20 to 230 ppb. For those with detected γ-chlordane, the γ/α ratio was 0.32 +/- 0.11. The decrease in this ratio from sediment shows the preferential metabolism or excretion of γ-chlordane as was seen in the eels. There were 59 samples with no detectable γ-chlordane, oxychlordane or heptachlor epoxide. As with the eels, this could be due to excretion or partial metabolism to 1,2-dichlorochlordene. Out of the 86 samples, there were 25 with detectable oxychlordane and only 2 with heptachlor epoxide. The trans nonachlor to (α+γ+oxychlordane) ratio in the striped bass averaged 0.9, indicating that trans nonachlor is accumulating. Figure 3-5 shows the changes in the average relative concentrations from sediment to the striped bass.

Figure 3-6 shows that the relative behavior of trans nonachlor and α-chlordane in striped bass from the harbor is the same as in the eels. There is more scatter in the points, but the average ratio and the relative bioaccumulation factor are the same as for the eels, 1.2 and 1.9, respectively. As in the eels, the combined effects of accumulation and metabolism for trans nonachlor and α-chlordane are very predictable. Preferential accumulation of trans nonachlor is evident and is about 2 times greater than that of α-chlordane.

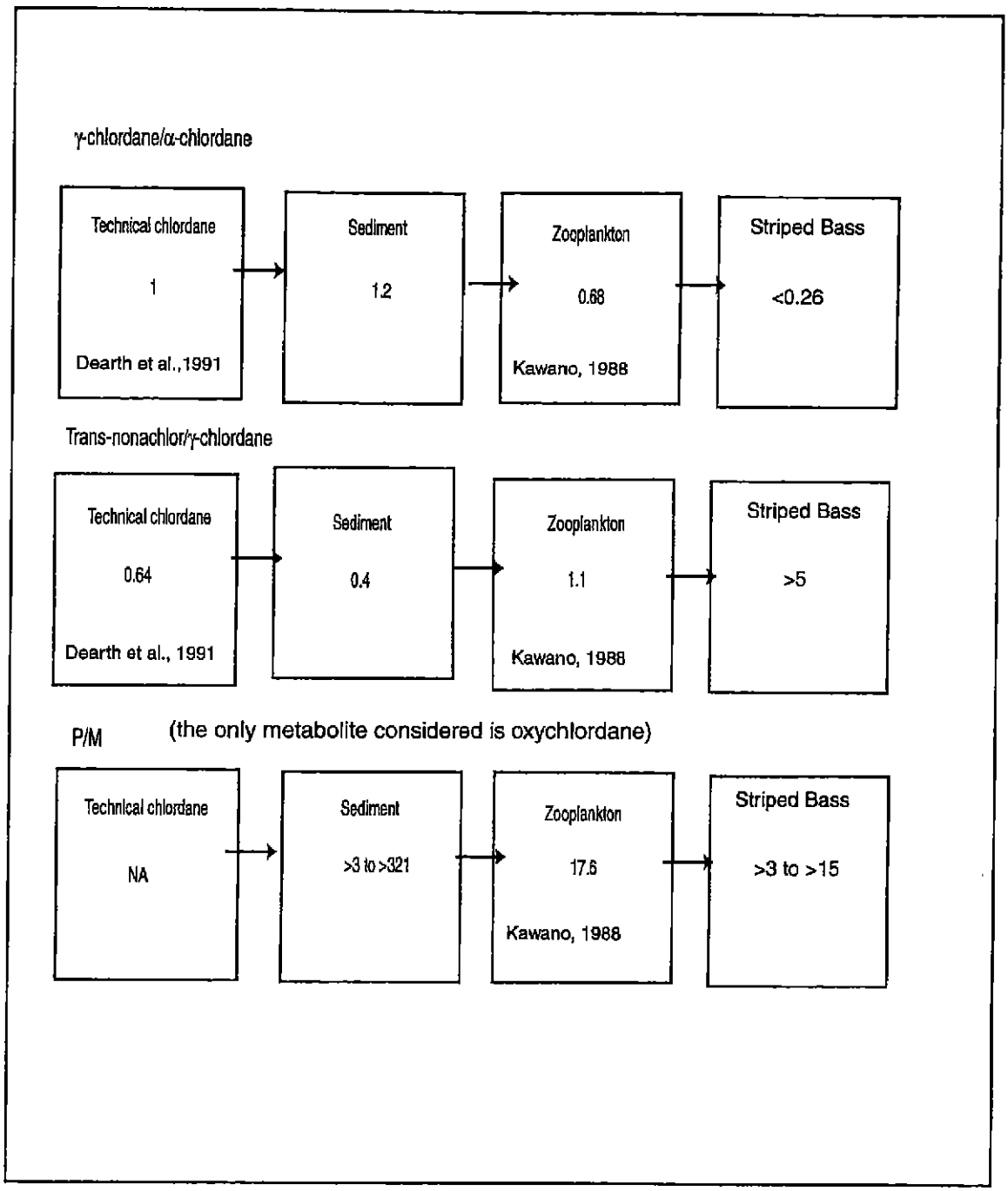


Figure 3-5 Relative concentrations of chlordane components from technical chlordane to striped bass from the NY/NJ Harbor

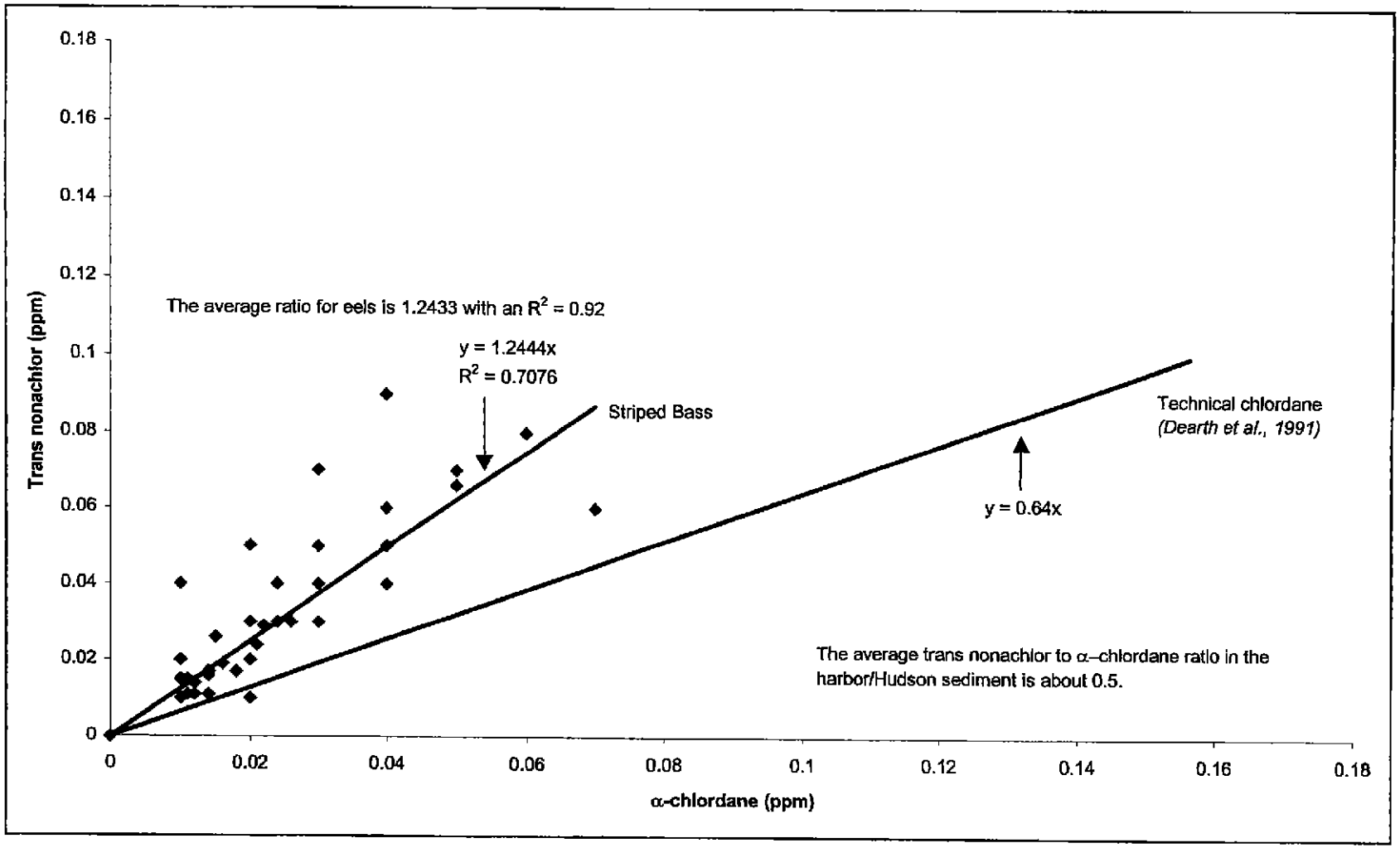


Fig. 3-6. Trans nonachlor vs. α-chlordane in striped bass from the NY/NJ Harbor. 86 samples used.

The behavior of the chlordane components in the hepatopancreas of the blue crab and lobster is quite different from that observed in the eels and striped bass. Out of 30 samples from the harbor complex collected in 1993, 28 had detectable levels of chlordane. The total concentrations in the hepatopancreas ranged from 70 to 430 ppb, but these values did not seem to have any correlation with location. 7 of the samples exceeded the FDA action limit. Out of the 30 samples, only 2 had detectable levels of γ-chlordane with detection limits of 0.01 ppm. Those two had γ/α ratios of 0.2. As with the eels and striped bass, this decrease in ratio from that of sediment reflects the preferential metabolism or excretion of γ-chlordane over α-chlordane however, with the hepatopancreas, 28 of the 30 samples had detectable oxychlordane and heptachlor epoxide. The two samples where there was none detected had no other detected components either. This suggests that metabolism may be quicker or more complete in the hepatopancreas and that the loss of γ-chlordane is most likely due to metabolism.

The average trans nonachlor to (α+γ+oxychlordane) ratio in the hepatopancreas is 0.59, but there is a much larger spread of the data than in the eels and striped bass. Figure 3-7 shows the difference in average relative concentrations in the blue crab and lobster hepatopancreas from those in sediment.

Figure 3-8 shows that the behaviors of trans nonachlor and α-chlordane are not predictable as they are in the eels and the striped bass. In eels and striped bass, the combined effects of accumulation and metabolism are very predictable. Trans nonachlor is preferentially accumulated over α-chlordane by a factor of about 2. The difference between the eels and striped bass and the hepatopancreas of the blue crabs and lobsters may be due to the more complete metabolism of the chlordane isomers to oxychlordane. The larger fraction of samples with detectable levels of the metabolite and lower parent to metabolite ratios, compared to the eels and striped bass (Table 3-1), indicate that more complete degradation occurs in crab and lobster.

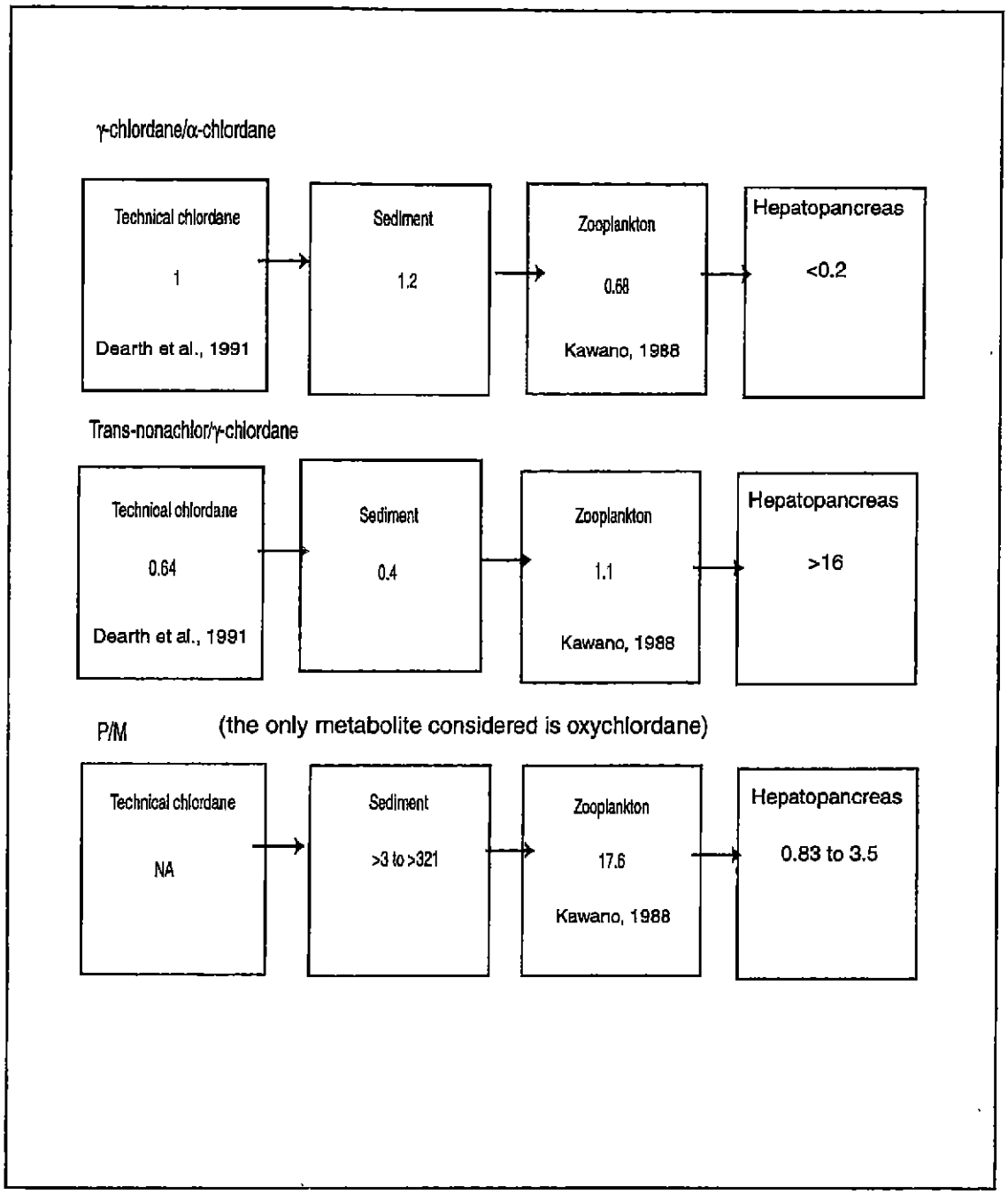


Figure 3-7 Relative concentrations of chlordane components from technical chlordane to blue crab and lobster hepatopancreas from the NY/NJ Harbor

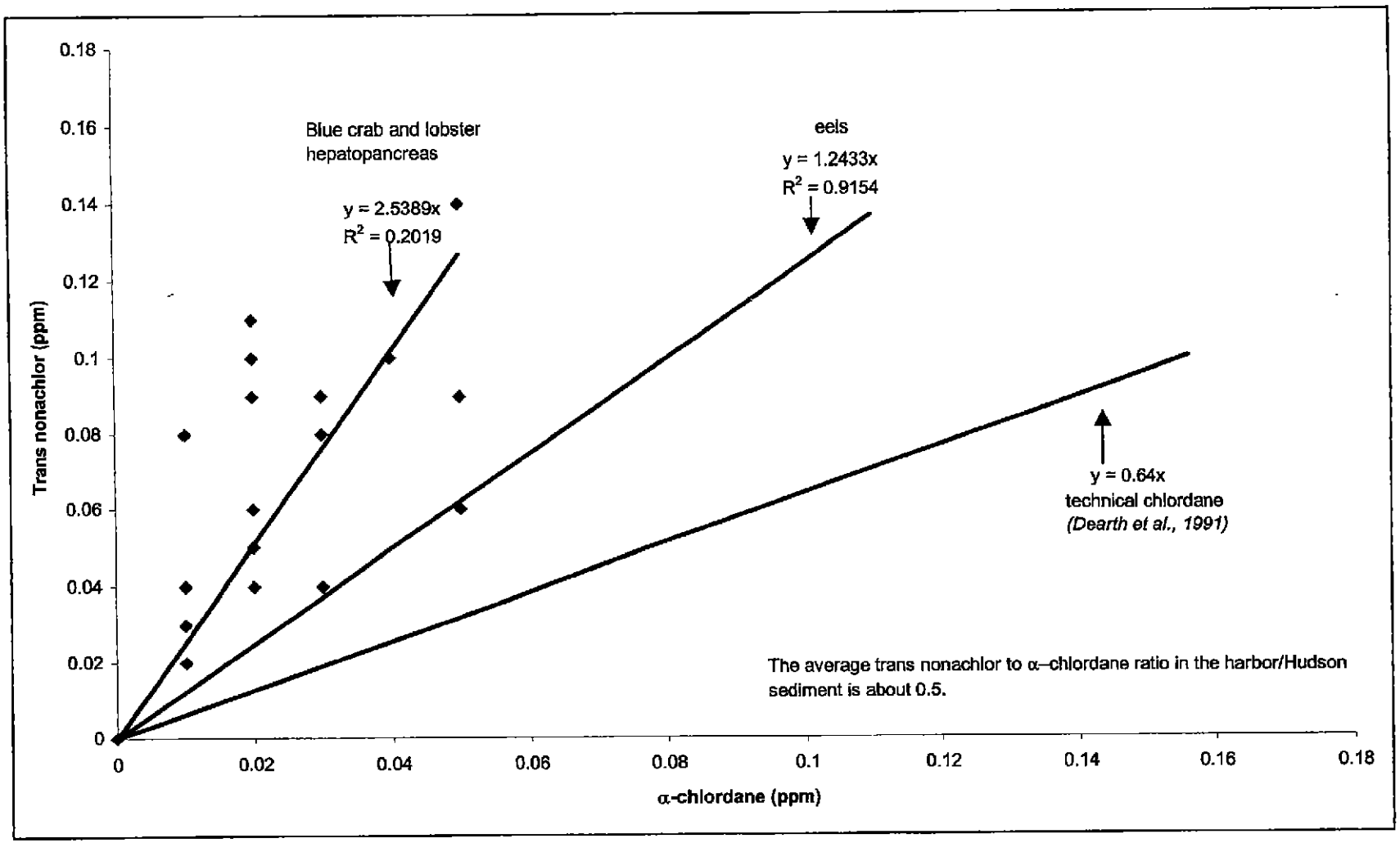


Fig. 3-8. Trans nonachlor vs. α-chlordane in blue crab and lobster hepatopancreas from the NY/NJ Harbor. 28 samples used. 2 flagged ND not used.

Chapter 4. Conclusions

Dated sediment cores have become irreplaceable tools for developing chronologies for pesticides and other particle associated contaminants. With these, we can monitor the decline after bans or restrictions have been implemented, and locate new sources associated with wastewater inputs or improper disposal. Analyses of chlorinated pesticides from cores collected from the Hudson River and the NY/NJ Harbor complex have characterized the extent of chlordane and DDT contamination to the area. These analyses have led to the following conclusions:

- Most areas of the harbor showed a significant decline in both pp'-DDD and γ–chlordane.
- The western side of the harbor complex has higher levels of both pp'-DDD and γ-chlordane than the eastern side. Previous studies have attributed the elevated levels of DDT on the western side to an industrial source (Bopp et al. 1991). The chlordane source to the western side remains poorly characterized.
- The areas of the harbor complex that did not show the typical decline in pp'-DDD were Newtown Creek and the Arthur Kill.
- Newtown Creek, a tidal embayment of the East River located on the eastern side of the harbor complex, receives a direct input of effluent from a secondary treatment plant. There was an increase in both pp'-DDD and γ-chlordane in Newtown Creek between 1990 and 1998, suggesting increased levels of the contaminants from the wastewater effluent. Currently, PCBs, dioxins, and trace metals in these samples, as well as plant operations are being investigated to better explain the cause of this increase.
- There is strong evidence of a fresh source of DDT to the Arthur Kill. Between the 1950s and the early 1970s, pp'-DDD and pp'-DDT declined significantly.

After about 1972, the year DDT use was banned in the U.S., both pp'-DDD and pp'-DDT increased significantly. pp'-DDT levels remained constant from 1985 to 1996, and pp'-DDD increased. This strongly suggests a continuous fresh source of DDT to the area. The increase of the metabolite between 1985 and 1996 is most likely due to the metabolism of the fresh source of DDT over the decade.

- The highest pp'-DDD levels were detected in the Central Park Lake core. The high levels indicate direct application to the lake surface or drainage basin. γ-chlordane and pp'-DDD have similar profiles in the lake sediment, peaking in the late 1960s. Both contaminants increased in sediment deposited between the early 1980s and the 1990s. This is probably due to input from the drainage basin or redistribution of highly contaminated sediment from shallower areas of the lake.

Future work in the harbor should include chlorinated hydrocarbon analysis of recently collected sediment cores from the eastern part of the harbor including Harlem River, East River, the upper and lower bays and Long Island Sound. This would help to fill in the picture of pesticide fate within the harbor complex. New cores should also be collected in the Passaic and Hackensack Rivers. This will be important in determining the source of the chlordane contamination to the western harbor. Cores should also be collected from Sawmill and Morses Creeks to help locate the fresh input of DDT to the Arthur Kill.

Chapter 3 discusses the relative behaviors of the abundant components of technical chlordane in American eels, striped bass and the hepatopancreas of the blue crab and lobster from the NY/NJ Harbor. Extensive data provided by the NYSDEC enabled detailed graphical representation of these behaviors and made it possible to trace the primary components from sediment to fish. The following was observed:

- The parent to metabolite ratio in fish and crustaceans is typically lower than in sediment, as expected, reflecting metabolism in the foodchain.
- In both American eels and striped bass, the combined effects of accumulation and metabolism of trans nonachlor and α-chlordane are very similar.
- The data for the hepatopancreas of the blue crab and lobster suggest that metabolism of the parent compounds is more extensive than in the eels and striped bass. The P/M ratio in the hepatopancreas was lower than that in the striped bass and eels.
- The similar behavior of trans nonachlor and α-chlordane observed in the eels and the striped bass was not seen in the data from the hepatopancreas. This may be due to the more extensive metabolism of the parent compounds.

The data presented and discussed in this thesis illustrate the importance of analyzing the components of technical DDT and chlordane in order to understand the behavior and fate in the environment.

References

Anderson, David J. and Ronald A. Hites. Chlorinated Pesticides in Indoor Air. *Environmental Science and Technology*, Vol. 22, pg. 717, 1988.

AXYS Analytical Services Ltd. NYSDEC Sediment Samples. Organochlorine Pesticide Analysis. AXYS Method CL-S-03/Ver. 1. Case and SDG No: HRC98 09271. Data package 9825: L1320-1 to –16, August 1999.

Bopp, Richard F. The Geochemistry of Polychlorinated Biphenyls in the Hudson River. Ph.D. dissertation, Columbia University, New York, N.Y., 1979.

Bopp, Richard F., H. James Simpson, Curtis R. Olsen, Robert M. Trier, and Nadia Kostyk. Chlorinated Hydrocarbons and Radionuclide Chronologies in Sediments of the Hudson River Estuary, New York. *Environmental Science and Technology*, Vol. 16, pg. 666, 1982.

Bopp, Richard F. and H.J. Simpson. Contamination of the Hudson River – The Sediment Record. Contaminated Marine Sediments Assessment and Remediation, pg. 401-416. National Research Council, National Academy of Sciences, Washington, D.C., 1989.

Bopp, Richard F., Michael L. Gross, Huayi Tong, H. James Simpson, Stephen J. Monson, Bruce L. Deck, and Fredrika C. Moser. A major Incident of Dioxin Contamination: Sediments of New Jersey Estuaries. *Environmental Science and Technology*, Vol. 25, pg. 951, 1991.

Bopp, Richard F., H. James Simpson, Steven N. Chillrud, and David W. Robinson. Sediment-Derived Chronologies of Persistent Contaminants in Jamaica Bay, New York. *Estuaries*, Vol. 16, pg. 608, 1993.

Bopp, Richard F., Steven Chillrud, H. James Simpson, and Alexander Virgilio. Pollutant Chronologies in New York Harbor, Raritan Bay, and Jamaica Bay. Final Report – New Jersey Sea Grant, 1993a. Contract NJMSC R/E-17P.

Bopp, Richard F, David W. Robinson, H. James Simpson, Pierre E. Biscaye, Robert F. Anderson, Huayi Tong, Stephen J. Monson, and Michael L. Gross. Recent Sediment and Contaminant Distributions in the Hudson Shelf Valley, pg. 61-83 in U.S. Dept. Comm. NOAA Tech Report. NMFS 124, 1995.

Bopp, Richard F., Steven N. Chillrud, Edward L. Shuster, H. James Simpson, and Frank D. Estabrooks. Trends in Chlorinated Hydrocarbon Levels in Hudson River Basin Sediments. *Environmental Health Perspectives*, Vol. 106, Supplement 4, 1998.

Brimfield, Alan A. and J.C. Street. Mammalian Biotransformation of Chlordane: In Vivo and Primary Hepatic Comparisons. *Annals New York Academy of Sciences*, pg. 247, 1979.

Butcher, Jonathan B., Thomas D. Gauthier, and Edward A. Garvey. Use of Historical PCB Aroclor Measurements: Hudson River Fish Data. *Environmental Toxicology and Chemistry*, Vol. 16, No. 8, pg. 1618, 1997.

Chaky, D. A., S. N. Chillrud, R. F. Bopp, E. L. Shuster, F. D. Estabrooks and J. Swart. 1998. Chlorinated hydrocarbon contamination of the New York / New Jersey Metropolitan Area: The urban atmospheric influence. EOS, Transactions of the American Geophysical Union 79: S86.

Chaky, D. A. 2002. The geochemistry of polychlorinated biphenyls, dibenzo-p-dioxins and dibenzofurans in recent sediments of the New York Metropolitan Area, Ph.D. dissertation (in progress), Rensselaer Polytechnic Institute, Troy, NY.

Chillrud, Steven N. Transport and Fate of Particle Associated Contaminants in the Hudson River Basin. Ph.D. dissertation, Columbia University, New York, N.Y., 1996.

Chillrud, Steven N., Richard F. Bopp, H. James Simpson, James M. Ross, Edward L. Shuster, Damon A. Chaky, Dan C. Walsh, Cristine Chin Choy, Lael – Ruth Tolley, and Allison Yarme. Twentieth Century Atmospheric Metal Fluxes into Central Park Lake, New York City. *Environmental Science and Technology*, Vol. 33, No. 5, pg. 657, 1999.

Dearth, Mark A. The Complete Analysis of Technical Chlordane and Investigation of Its Metabolism in Rats and Its Accumulation in People. Ph.D. dissertation, Indiana University, 1990.

Dearth, Mark A. and Ronald A. Hites. Complete Analysis of Technical Chlordane Using Negative Ionization Mass Spectrometry. *Environmental Science and Technology*, Vol. 25, No. 2, pg. 245, 1991.

Dearth, Mark A. and Ronald A. Hites. Chlordane Accumulation in People. *Environmental Science and Technology*, Vol. 25, No. 7, pg. 1279, 1991a.

FASE (Foundation for Advancements in Science and Education). FASE Research Report, Spring, 1996.

Gooch, Jay W., Fumio Matsumura, and Matthew J. Zabik. Chlordane Residues in Great Lake Trout: Acute Toxicity and Interaction at the GABA Receptor of Rat and Lake Trout Brain. *Chemosphere*, Vol. 21, No. 3, Pg. 393, 1990.

Howard, P.H. and Meylan, William M. Handbook of Physical Properties of Organic Chemicals. CRC Press Inc., 1997.

Jaffe, Rudolf, Elizabeth A. Stemmler, Brian D. Eitzer, and Ronald A. Hites. Anthropogenic, Polyhalogenated, Organic Compounds in Sedentary Fish from Lake Huron and Lake Superior Tributaries and Embayments. *J. Great Lakes Res*, Vol. 11, No. 2, pg. 156, 1985.

Kawano, Masahide, Tsuyoshi Inoue, Toyohito Wada, Hideo Hidaka, and Ryo Tatsukawa. Bioconcentration and Residue Patterns of Chlordane Compounds in Marine Animals: Invertebrates, Fish, Mammals, and Seabirds. *Environmental Science and Technology*, Vol. 22, No. 7, pg. 792, 1988.

Kroenke, A.E., R.F. Bopp, D.A. Chaky, S.N. Chillrud, E.L. Shuster, F.D. Estabrooks, and J. Swart, Atmospheric Deposition and Fluxes of Mercury in Remote and Urban Areas of the

Hudson River Basin, Abstract, *EOS, Transactions of the American Geophysical Union, 79(17),* Spring Meeting Supplement, S86, 1998.

Kroenke, A.E., D.A. Chaky, R.F. Bopp, S.N. Chillrud, E.L. Shuster, D.C. Walsh, and F.D. Estabrooks. 2002. Mercury deposition in sediments of the NY/NJ Harbor area, submitted to *Environmental Science and Technology.*

Louis, Judith B., and Kenneth C. Kisselbach, Jr. Indoor Air Levels of Chlordane and Heptachlor Following Termiticide Applications. *Bull. Environ. Contam. Toxicol,* Vol. 39, pg. 911, 1987.

Mattina, Mary Jane Incorvia, William Iannucci – Berger, Laure Dykas, and Jennifer Pardus. Impact of Long – Term Weathering, Mobility, and Land Use on Chlordane Residues in Soil. *Environmental Science and Technology,* Vol. 33, No. 14, pg. 2425, 1999.

National Oceanic and Atmospheric Administration (NOAA). National Status and Trends Program for Marine Environmental Quality. NOAA Technical Memorandum NOS OMA 44. A Summary of Selected Data on Chemical Contaminants in Sediments Collected During 1984, 1985, 1986, and 1987. November 1988.

Olsen, C.R., H.J. Simpson, and R.M. Trier. Plutonium, Radiocesium, and Radiocobalt in Sediments of the Hudson River Estuary. *Earth and Planetary Science Letters,* Vol. 55, pg. 377, 1981.

Rapaport, R.A., N.R. Urban P.D. Capel, J.E. Baker, B.B Looney, S.J. Eisenreich, and E. Gorham. "New" DDT inputs to North America: Atmospheric Deposition. Chemosphere, Vol. 14, pg. 1167-1173, 1985.

Ritchie, J. C. and J. R. McHenry. 1990. Application of radioactive fallout Cs-137 for measuring soil erosion and sediment accumulation rates and patterns: A review. *Journal of Environmental Quality 19: 215-233.*

Schwarzenbach, Rene P., Philip M. Gschwend, Dieter M. Imboden. Environmental Organic Chemistry. New York, J. Wiley, 1993.

Tashiro, Shigeki, and Fumio Matsumura. Metabolic Routes of Cis and Trans-Chlordane in Rats. *J. Agric. Food Chem.,* Vol. 25, No. 4, pg. 872, 1977.

Tashiro, Shigeki, and Fumio Matsumura. Metabolism of Trans-Nonachlor and Related Chlordane Components in Rat and Man. *Arch. Of Contam. Toxicol,* Vol. 7, pg. 113, 1978.

U.S. Food and Drug Administration. Action Levels for Poisonous or Deleterious Substances in Human Food and Animal Feed. Industry Activities Staff Booklet, August 2000.

U.S. Tariff Commission. Synthetic Organic Chemicals, Pesticides and Related Products. 1947-1970.

World Health Organization, United Nations, and the International Labor Organization. Environmental Health Criteria 9. DDT and its Derivatives. 1979.

World Health Organization, United Nations, and the International Labor Organization. Environmental Health Criteria 34. Chlordane. 1984.

Appendix I. Sales and Usage Statistics

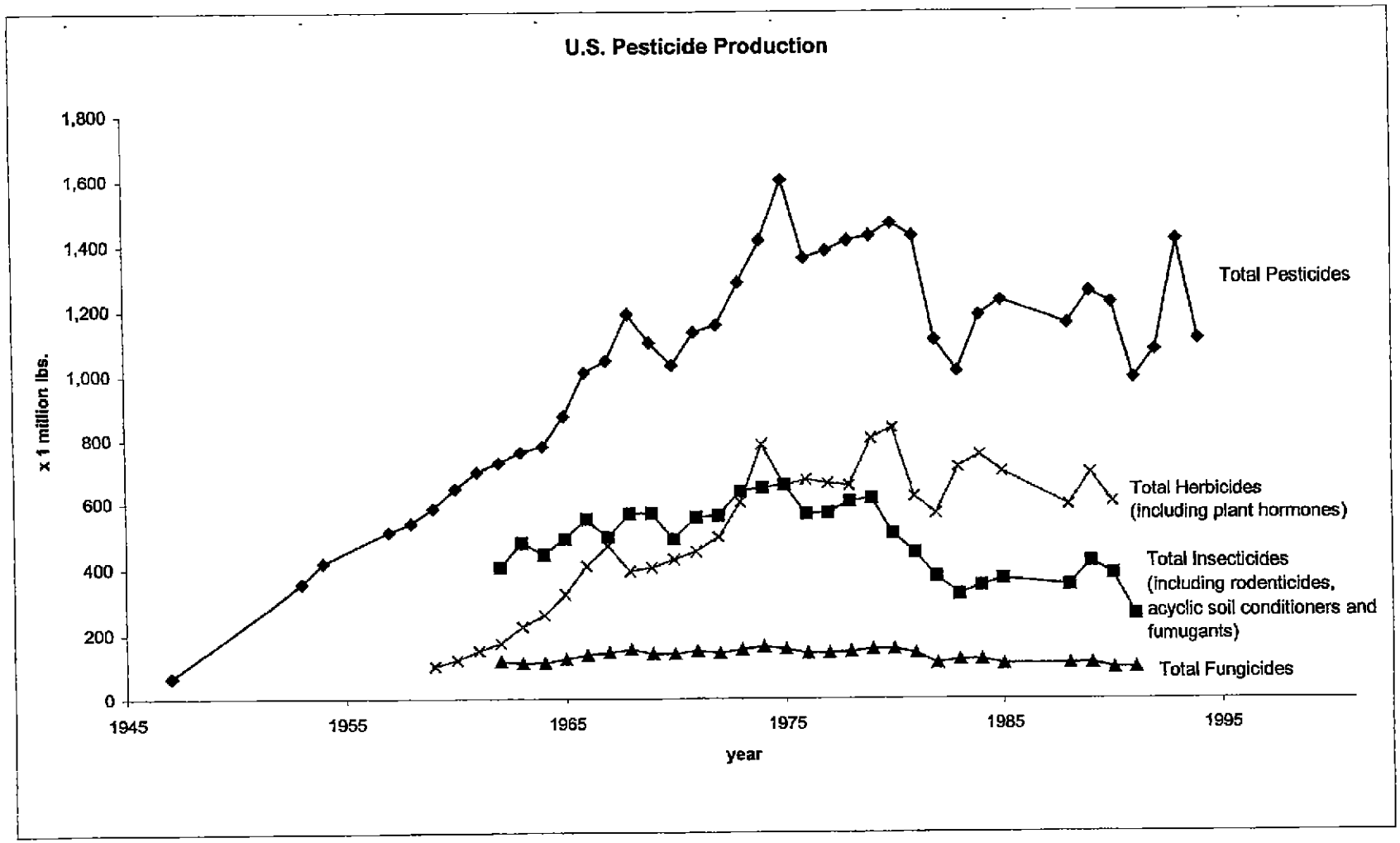


Fig. A1-1. Values from prior years are divided differently and are not included in the plot. These years are reported in the production tables included in this appendix. Values taken from *U.S. Tariff Commission(1947-1994)*.

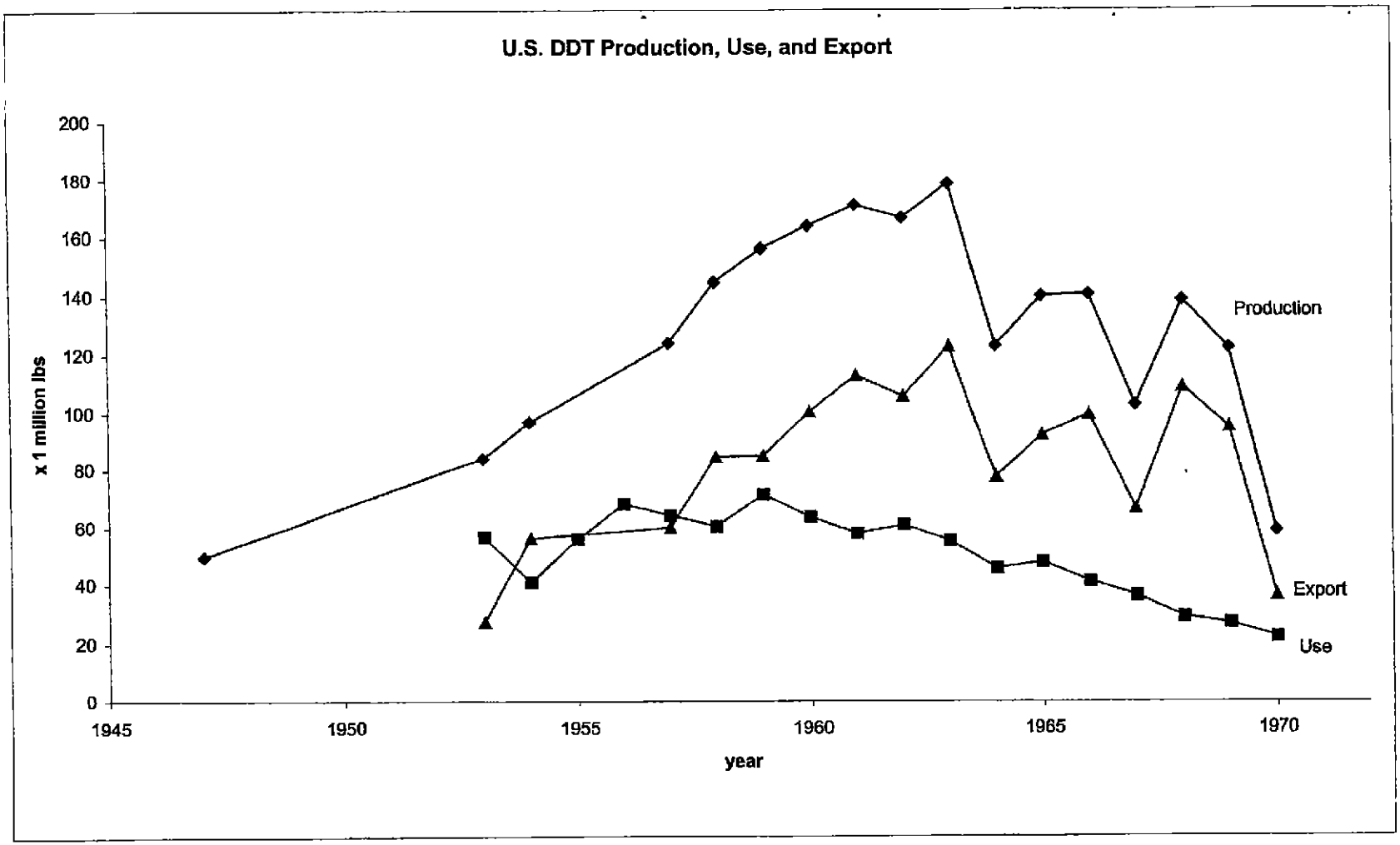


Fig. A1-2. Production values taken from U.S. Tariff Commission(1947-1970). Use values taken from DDT and its Derivatives, WHO, 1979. Export values estimated using the difference between production and use.

U.S. DDT Production, Use, and Export

Table A1-1

Year	Production [1] (10^6 lbs.)	Use [2] (10^6 lbs.)	Export [3] (10^6 lbs.)
1947	50	-	
1953	84	57	28
1954	97	41	56
1955	-	56	
1956	-	68	
1957	125	64	60
1958	145	61	85
1959	157	72	85
1960	164	64	101
1961	171	58	113
1962	167	61	106
1963	179	55	123
1964	124	46	78
1965	141	48	93
1966	141	41	100
1967	103	37	67
1968	139	30	110
1969	123	27	96
1970	59	23	37

[1] Values adapted from U.S. Tariff Commission, 1947-1970.

[2] Values taken from WHO, 1979.

[3] Values estimated by calculating the difference between production and use.

Table A1-2

Total U.S. Production of Pesticides and Related Agricultural Products

Year	10^6 lbs.	Comments
1940	288	Only sales reported (total insecticide)- production not given
1941	2	total cyclic pesticides
1942	3	total cyclic pesticides
1943	5	total cyclic pesticides
1947	68	total cyclic insecticides
1953	356	
1954	419	
1957	512	
1958	539	
1959	585	
1960	648	
1961	700	
1962	730	
1963	763	
1964	783	
1965	877	
1966	1,013	
1967	1,050	
1968	1,192	
1969	1,104	
1970	1,034	
1971	1,136	
1972	1,158	
1973	1,289	
1974	1,417	
1975	1,603	
1976	1,364	
1977	1,388	
1978	1,416	
1979	1,429	
1980	1,468	
1981	1,430	
1982	1,113	
1983	1,017	
1984	1,189	
1985	1,235	
1988	1,164	
1989	1,262	
1990	1,228	
1991	995	
1992	1,082	
1993	1,417	
1994	1,115	

Statistics were taken from *Synthetic Organic Chemicals. U.S. Production and Sales.* U.S. Tariff Commission.

Table A1-3

Total U.S. Production of Fungicides

Year	cyclic (1000 lbs)	acyclic (1000 lbs)	Comments	Total (10^6 lbs.)
1953	44,832	1,690	reported with seed disinfectants	
1954	57,993		reported with seed disinfectants	
1957	62,382	reported with fumigants and seed disinfectants...73,337	cyclic reported with seed disinfectants	
1958	66,737	65,294	acyclic reported with fumigants	
1959	81,016	86,231	acyclic reported with fumigants	
1960	91,796	87,303	acyclic reported with fumigants	
1961	83,130	84,516	acyclic reported with fumigants	
1962	80,651	36,828		117
1963	75,825	35,239		111
1964	80,774	31,929		113
1965	87,378	36,456		124
1966	100,626	36,780		137
1967	103,891	40,521		144
1968	113,178	40,985		154
1969	100,748	39,805		141
1970	95,762	44,397		140
1971	110,036	39,457		149
1972	98,164	44,648		143
1973	110,336	43,628		154
1974	124,562	38,235		163
1975	111,238	44,127		155
1976	109,635	32,627		142
1977	110,624	32,653		143
1978	109,242	38,283		148
1979	126,876	28,031		155
1980	127,846	28,367		156
1981	117,016	25,659		143
1982	87,200	23,306		111
1983	98,828	23,677		123
1984	100,447	22,664		123
1985	96,282	12,756		109
1988	85,389	24,175		110
1989	40,385	9,932		111
1990	38,564	5,149		96
1991	36,504	7,606		97

Statistics taken from *Synthetic Organic Chemicals. U.S. Production and Sales.* U.S. Tariff Commission.

Table A1-4

Total U.S. Production of Herbicides
(including plant hormones)

Year	cyclic (1000 lbs)	acyclic (1000 lbs)	Total (10^6 lbs.)
1953	64,349		64
1954	64,013		64
1957	81,438	included with insecticides, rodenticides and soil conditioners...30,765	
1958	75,327	included with rodenticides and soil conditioners...14,722	
1959	82,195	included with rodenticides and soil conditioners...17,844	
1960	101,995	477	102
1961	120,608	345	121
1962	131,690	19,198	151
1963	150,119	24,408	175
1964	186,344	40,042	226
1965	215,307	47,617	263
1966	266,047	57,645	324
1967	366,298	43,149	409
1968	408,959	60,033	469
1969	324,221	69,085	393
1970	330,326	73,458	404
1971	378,256	50,256	429
1972	371,730	79,581	451
1973	386,852	108,967	496
1974	487,697	116,455	604
1975	660,738	127,292	788
1976	511,560	144,485	656
1977	550,145	124,063	674
1978	534,275	129,295	664
1979	527,254	129,890	657
1980	642,397	163,266	806
1981	677,280	161,800	839
1982	486,792	136,559	623
1983	468,521	101,879	570
1984	590,163	126,269	716
1985	631,224	124,620	756
1988	589,261	112,518	702
1989	262,400	53,700	597
1990	260,092	56,578	698
1991	227,278	48,344	608

Statistics were taken from *Synthetic Organic Chemicals. U.S. Production and Sales.* U.S. Tariff Commission.

Table A1-5

Total U.S. Production of Insecticides

Year	cyclic (1000 lbs)	acyclic (1000 lbs)	Comment	Total (10^6 lbs.)
1947	66,058	1,905		
1953	187,873	3,845	acyclic includes soil conditioners	192
1954	235,527	361		236
1957	263,630	not given separately..reported with acyclic herbicides, rodenticides and soil conditioners...30,765	1957-1991 includes rodenticides in cyclic insecticides	
1958	302,806	14,510		317
1959	306	12,538		13
1960	331,694	19,324		351
1961	367,945	22,865		391
1962	372,634	32,855		405
1963	371,128	106,758	1963-1991 include fumigants, rodenticides and soil conidtioners in acyclic insecticides	478
1964	317,580	126,080		444
1965	379,986	110,453		490
1966	410,236	141,776		552
1967	352,969	142,835		496
1968	407,411	161,794		569
1969	394,467	176,055		571
1970	301,045	189,087		490
1971	339,296	218,414		558
1972	369,466	194,109		564
1973	412,713	226,456		639
1974	413,288	236,921		650
1975	424,334	235,267		660
1976	319,066	247,016		566
1977	333,127	236,907		570
1978	338,805	266,584		605
1979	316,493	300,864		617
1980	284,066	222,260		506
1981	218,133	230,187		448
1982	191,593	187,348		379
1983	143,573	180,066		324
1984	152,093	197,533		350
1985	148,706	221,326		370
1988	85,054	267,436		352
1989	59,484	132,904		424
1990	51,968	122,938		386
1991	33,241	86,319		264

All statistics taken from *Synthetic Organic Chemicals. U.S. Production and Sales.* U.S. Tariff Commission.

Appendix II. Radionuclide Data

Table A2-1 Radionuclide Data

Location	Core	Year of Collection	Control Number	Depth (cm)	Cs-137 (pCi/kg)	1σ	Be-7 (pCi/kg)	1σ
Newark Bay	NB13	1985	CN1964A	0-2	178	22	29	169
			CN1964B	2-4	268	22	-15	148
			CN1964C	4-6	262	23		
			CN1964D	6-8	175	19		
			CN1964E	8-12	224	16		
			CN1964F	12-16	275	18		
			CN1964G	16-20	333	25		
			CN1964H	20-24	375	40		
			CN1964I	24-28	396	25		
			CN1964J	28-32	117	11		
			CN1964K	32-36	5	9		
	NB20	1986	CN1998A	0-2	174	82	-13	164
			CN1998B	2-4	313	25	96	208
			CN1998C	4-6	295	26		
			CN1998D	6-8	320	26		
			CN1998E	8-12	285	21		
			CN1998F	12-16	636	38		
			CN1998G	16-20	298	21		
			CN1998H	20-24	319	23		
			CN1998I	24-28	304	20		
			CN1998J	28-32	85	15		
			CN1998K	32-36	41	15		
			CN1998L	36-40	-1	14		
			CN1998M	40-44	10	11		
			CN1998N	44-48	-1	14		
			CN1998O	48-52				
			CN1998P	52-56				
			CN1998Q	56-60				
			CN1998R	64-66	-7	14		
	NB13B	1995	CN2251A	0-2	155	16	951	133
			CN2251B	2-4	125	15	265	161
Newtown Creek	NC3	1987	CN2019A	0-2	326	29	2436	223
	NC6	1990	CN2102A	0-2	322	28	1606	297
	NC7	1992	CN2168A	0-2	315	32	4139	589
	NC9	1996	R1093A	0-2			5068	597
	NC10	1998	R1227A	0-2	250	52	1712	487
			R1227B	2-4	254	55	84	480

Location	Core	Year of Collection	Control Number	Depth (cm)	Cs-137 (pCi/kg)	1σ	Be-7 (pCi/kg)	1σ
Arthur Kill	KIII14	1982	CN1730A	0-2	477	58		
			CN1730B	2-4	449	58		
			CN1730C	4-8	476	33		
			CN1730D	8-12	638	48		
			CN1730E	12-16	462	27		
			CN1730F	16-20	380	29		
			CN1730G	20-24	127	32		
			CN1730H	24-28				
			CN1730I	28-32	15	29		
			CN1730J	32-36				
			CN1730K	36-40				
			CN1730L	40-44				
			CN1730M	44-48				
			CN1730N	48-52	5	29		
			CN1730O	52-56				
			CN1730P	56-60				
			CN1730Q	60-64				
			CN1730R	64-68				
	KIII21	1996	R1091A	0-2	212	27	2090	365
			R1091B	2-4	204	30		
			R1091C	4-6	257	29		
			R1091D	6-8	177	26		
			R1091E	8-12	248	22		
			R1091F	12-16	237	16		
			R1091G	16-20	277	20		
			R1091H	20-24	284	24		
			R1091I	24-28	290	21		
			R1091J	28-32	273	22		
			R1091K	32-36	258	18		
			R1091L	36-40	259	20		
			R1091M	40-44	255	22		
			R1091N	44-48	309	20		
			R1091O	48-52	255	23		
			R1091P	52-56	285	20		
			R1091Q	56-60	288	21		
			R1091R	60-64	329	22		
			R1091S	64-68	292	14		
			R1091T	68-72	280	26		
			R1091U	72-76	327	34		
			R1091V	76-80	334	22		
			R1091W	80-84	316	24		
			R1091X	84-88	352	18		
			R1091Y	88-92	304	21		
			R1091Z	92-96	450	21		
			R1091AA	96-100	309	24		
			R1091BB	100-104	349	25		
			R1091CC	104-108	339	25		
			R1091DD	108-112	307	26		
			R1091EE	112-116	391	26		
			R1091FF	116-120	415	31		
			R1091GG	120-124	409	29		
			R1091HH	124-128	364	24		
			R1091II	128-132	436	30		
			R1091JJ	132-136	511	30		
			R1091KK	136-140	375	25		
			R1091LL	140-144	217	14		
			R1091MM	144-148	111	10		
			R1091NN	148-152	111	14		
			R1091OO	152-156	39	9		
			R1091PP	156-160	26	6		
			R1091QQ	160-164	34	7		
			R1091RR	164.5	24	27		

Location	Core	Year of Collection	Control Number	Depth (cm)	Cs-137 (pCi/kg)	1σ	Be-7 (pCi/kg)	1σ
Kill Van Kull	KVK1	1985	CN1959A	0-2	239	35	992	256
			CN1959B	2-4	201	30	895	208
			CN1959C	4-6	360	35	542	397
			CN1959D	6-8	371	30	38	314
			CN1959E	8-12	349	23		
			CN1959F	12-16	426	27		
			CN1959G	16-20	475	30		
			CN1959H	20-24	382	36		
			CN1959I	24-28	321	22		
			CN1959J	28-32	341	23		
			CN1959K	32-36	386	25		
			CN1959L	36-41	324	21		
	KVK3	1996	R1092A	0-2			1416	326
	KVK4	1998	R1226A	0-2	268	50		
Central Park Lake	CPE	1996	R1077A	0-2	1866	178	2108	1261
			R1077B	2-4	1743	173		
			R1077C	4-6	1994	173		
			R1077D	6-8	2116	192		
			R1077E	8-10	2274	199		
			R1077F	10-12	3406	229		
			R1077G	12-14	3262	230		
			R1077H	14-16	826	87		
			R1077I	16-18	216	54		
			R1077J	18-20	61	63		
			R1077K	20-22	56	39		
			R1077L	22-24	84	69		
			R1077M	24-26	63	46		
			R1077N	26-28	2	62		
			R1077O	28-30	51	27		
			R1077P	30-32	-23	60		
			R1077Q	32-34	102	103		
			R1077R	34-36	31	102		
			R1077S	36-38	95	115		
			R1077T	38-40	-17	110		
			R1077U	40-42	10	115		
			R1077V	42-44	-26	92		
			R1077W	44-47	33	65		
Raritan Bay	RB17	1980	CN1533A	0-2.5	97	19		
			CN1533B	2.5-5	106	15		
			CN1533C	5-7.5	192	17		
			CN1533D	7.5-10	192	25		
			CN1533E	10-12.5	321	38		
			CN1533F	12.5-15	324	25		
			CN1533G	15-18	141	18		
			CN1533H	18-21	43	20		
			CN1533I	21-24	47	25		
			CN1533J	24-27	42	16		
			CN1533K	27-29	112	25		

Location	Core	Year of Collection	Control Number	Depth (cm)	Cs-137 (pCi/kg)	1σ	Be-7 (pCi/kg)	1σ
NY/NJ Harbor Transects	-1.65W	1984	1923A	0-2	674	40	3156	260
			1923B	2-4	724	40	1927	255
			1923C	4-6	755	41	857	252
			1923D	6-8	544	34	385	232
			1923E	8-12	552	25	92	155
			1923F	12-16	524	28		
			1923G	16-20	736	30		
			1923H	20-24	648	27		
			1923I	24-28	612	25		
			1923J	28-32	743	27		
			1923K	32-36	606	29		
			1923L	36-40	680	29		
			1923M	40-44	862	29		
			1923N	44-48	560	25		
			1923O	48-52	529	24		
			1923P	52-56	678	26		
	-0.8W	1984	1924A	0-2	637	37	2810	232
			1924B	2-4	688	38	1520	239
			1924C	4-6	533	36	249	244
			1924D	6-8	663	34	-135	210
			1924E	8-12	455	26		
			1924F	12-16	546	24		
			1924G	16-20	610	24		
			1924H	20-24	737	24		
			1924I	24-28	472	23		
			1924J	28-32	521	26		
			1924K	32-36	611	23		
	2.35W	1984	1926A	0-2	779	40	1860	230
			1926B	2-4	776	28	410	140
			1926C	4-6	704	35	180	170
			1926D	6-8	523	29	90	170
			1926E	8-12	457	19		
			1926F	12-16	481	19		
			1926G	16-20	628	22		
			1926H	20-24	742	25		
			1926I	24-28	806	26		
			1926J	28-32	932	28		
			1926K	32-36	696	24		
	-1.68W	1989	2067A	0-2	378	35	1994	230
			2067B	2-4	363	39	816	278
			2067C	4-8	352	37	293	292
			2067D	6-8	346	44	-47	416
			2067E	8-12	490	31		
			2067F	12-16	454	28		
			2067G	16-20	492	32		
			2067H	20-24	471	32		
			2067I	24-28	456	30		
	2.34W	1992	2068A	0-2	331	30	1160	200
			2068B	2-4	326	34	450	260
			2068C	4-6	320	29	100	220
			2068D	6-8	359	55		
			2068E	8-12	389	44		
			2068F	12-16	331	38		
			2068G	16-20	443	43		
			2068H	20-24	437	44		

Location	Core	Year of Collection	Control Number	Depth (cm)	Cs-137 (pCi/kg)	1σ	Be-7 (pCi/kg)	1σ
	2.73E	1989	2069A	0-2	451	39	1860	240
			2069B	2-4	500	37	1420	230
			2069C	4-6	520	41	1510	285
			2069D	6-8	646	50	-70	220
	6.3W	1989	2072A	0-2	379	26	396	121
			2072B	2-4	414	26	93	106
			2072C	4-6	336	24	-14	116
			2072D	6-8	395	24		
			2072E	8-12	445	34		
			2072F	12-16	548	53		
	9.7W	1989	2073A	0-2	338	27	865	153
			2073B	2-4	312	23	147	124
			2073C	4-6	442	31	-93	152
			2073D	6-8	415	28		
			2073E	8-12	329	22		
	2.4W	1992	2167A	0-2	397	36	2132	585
			2167B	2-4	325	25	943	302
			2167C	4-6	439	32	282	460
			2167D	6-8	463	38	663	641
			2167E	8-12	460	31		
			2167F	12-16	494	37		
			2167G	16-20	424	34		
			2167H	20-24	470	36		
			2167I	24-28	543	28		
			2167J	28-32	428	27		
			2167K	32-36	427	29		
			2167L	36-40	485	36		
			2167M	40-43	395	35		
	-1.69W	1994	R1042A	0-2	414	56	1826	527
			R1042B	2-4	454	54	474	445
			R1042C	4-6	487	53	74	424
			R1042D	6-8	452	63	976	562
	2.33W	1994	R1041A	0-2	417	60	2261	572
			R1041B	2-4	396	55	1721	487
			R1041C	4-6	442	57	1939	527
			R1041D	6-8	454	44	1976	388
	2.76E	1994	R1040A	0-2	399	45	2551	396
			R1040B	2-4	413	52	2080	428
			R1040C	4-6	493	68	1642	537
			R1040D	6-8	445	52	985	409
			R1040E	8-12	478	48	44	307
			R1040F	12-16	426	38	229	243
			R1040G	16-20	408	46	304	306
	6.31W	1994	R1039A	0-2	231	26	604	208
			R1039B	2-4	169	35	109	281
			R1039C	4-6	311	34	151	252
			R1039D	6-8	324	41	-130	296
	9.71W	1994	R1038A	0-2	276	40	1442	380
			R1038B	2-4	417	63	2307	603
			R1038C	4-6	453	55	849	443
			R1038D	6-8	365	40	300	303
	-1.7C	1998	R1225A	0-2	341	50	1577	445
			R1225B	2-4	294	50	488	432
	2.77E	1998	R1223A	0-2	251	50	2166	504
			R1223B	2-4	245	49	1288	472

Location	Core	Year of Collection	Control Number	Depth (cm)	Cs-137 (pCi/kg)	1σ	Be-7 (pCi/kg)	1σ
	2.34W	1998	R1224A	0-2	288	53	1825	491
			R1224B	2-4	346	53	217	432
	6.4W	1998	R1222A	0-2	201	43	1208	371
			R1222B	2-4	247	47	1120	385
	9.72W	1998	R1108A	0-2	218	40	550	319
			R1108B	2-4	261	47	-302	347
Hudson tidal mainstem	88.6	1986	CN1984A	0-2	293	22	310	137
			CN1984B	2-4	336	24	-29	138
			CN1984C	4-6	348	21	-7	112
			CN1984D	6-8	419	25		
			CN1984E	8-12	387	21		
			CN1984F	12-16	427	24		
			CN1984G	16-20	618	33		
			CN1984H	20-24	1013	52		
			CN1984I	24-28	1352	70		
			CN1984J	28-32	1731	89		
			CN1984K	32-36	2500	127		
			CN1984L	36-40	1603	82		
			CN1984M	40-44	1548	79		
			CN1984N	44-48	1576	81		
			CN1984O	48-52	740	39		
			CN1984P	52-56	188	13		
			CN1984Q	56-59	44	10		
	88.6f	1995	R1066A	0-2	208	17	968	164
			R1066B	2-4	211	14	66	96
			R1066C	4-6	230	20	14	199
			R1066D	6-8	260	22	-8	187
	88.6h	1998	R1214A	0-2	1666	105	556	447
			R1214B	2-4	162	28	467	325
	91.8	1977	CN1329A	0-2	730	31		
			CN1329B	2-4	995	67		
			CN1329C	4-8	1600	90		
			CN1329D	8-12	1690	95		
			CN1329E	12-16	1620	81		
			CN1329F	16-20	1660	83		
			CN1329G	20-24	2050	102		
			CN1329H	24-28	2380	119		
			CN1329I	24-28	896	45		
			CN1329J	28-32	51	9		
			CN1329K	32-36	9	10		
			CN1329L	36-40				
			CN1329M	40-44				
			CN1329N	44-48				
			CN1329O	48-52				
	120.2	1998	R1213A	0-2	423	65	2129	708
			R1213B	2-4	445	62	67	608
			R1213C	4-6	367	46	-67	1085
			R1213D	6-8	450	50	457	1142
			R1213E	8-12	589	78	2675	1724
			R1213F	12-16	429	70	-32	1620
			R1213G	16-20	45	42	739	1241
			R1213H	20-24	30	33		

Location	Core	Year of Collection	Control Number	Depth (cm)	Cs-137 (pCi/kg)	1σ	Be-7 (pCi/kg)	1σ
Upper NY/NJ Harbor	mp-1.7W	1979	CN1472A	0-2				
			CN1472B	2-4				
			CN1472C	4-6				
			CN1472D	6-8				
			CN1472E	8-10				
			CN1472F	10-12				
			CN1472G	12-16				
			CN1472H	16-20				
			CN1472I	20-24				
			CN1472J	24-28				
			CN1472K	28-32				
			CN1472L	32-36				
			CN1472M	36-40				
			CN1472N	40-46				
	mp -1.69	1994	R1042A	0-2	414	56	1826	527
			R1042B	2-4	454	54	474	445
			R1042C	4-6	487	53	74	424
			R1042D	6-8	452	63	976	562
Upper Hudson River	188.5	1983	CN1852A	0-2	945	40	440	190
			CN1852B	2-4	1560	62		
			CN1852C	4-8	3740	140		
			CN1852D	8-12	6250	230		
			CN1852E	12-16	6210	230		
			CN1852F	16-20	6230	240		
			CN1852G	20-24	10500	400		
			CN1852H	24-28	18600	690		
			CN1852I	28-32	6100	230		
			CN1852J	32-36	1020	55		
			CN1852K	36-40	32	6		
			CN1852L	40-44	7	5		
			CN1852M	44-47	24	5		
	188.6	1991	CN2113A	0-2	938	229	1874	272
			CN2113B	2-4	905	174	775	165
			CN2113C	4-6	928	218		
			CN2113D	6-8	1561	270		
			CN2113E	8-12	1074	131		
			CN2113F	12-16	1473	150		
			CN2113G	16-20	1786	206		
			CN2113H	20-24	2467	265		
			CN2113I	24-28	4870	397		
			CN2113J	28-32	5153	418		
			CN2113K	32-26	4209	391		
			CN2113L	36-40	6493	492		
			CN2113M	40-44	11448	702		
			CN2113N	44-48	4693	372		
			CN2113N	48-52	1381	167		
			CN2113O	52-56	74	72		
			CN2113P	56-60	167	87		
			CN2113Q	60-64	-65	61		
			CN2113R	64-68	-80	59		

Location	Core	Year of Collection	Control Number	Depth (cm)	Cs-137 (pCi/kg)	1σ	Be-7 (pCi/kg)	1σ
	163.6V	1997	R1129A	0-2	324	34	527	484
			R1129B	2-4	364	36	645	499
			R1129C	4-6	474	50	3268	1242
			R1129D	6-8	534	56	76	1370
			R1129E	8-12	567	45		
			R1129F	12-16	514	54		
			R1129G	16-18	601	59		
			R1129H	20-24	740	69		
			R1129I	24-28	1069	89		
			R1129J	28-32	1512	95		
			R1129K	32-36	1928	116		
			R1129L	36-40	1810	100		
			R1129M	40-44	2759	157		
			R1129N	44-48	3615	200		
			R1129O	48-52	4943	269		
			R1129P	52-56	5597	306		
			R1129Q	56-60	4619	249		
			R1129R	60-64	2468	141		
			R1129S	64-68	1290	87		
			R1129T	68-72	891	67		
			R1129U	72-76	750	71		
			R1129V	76-80	1075	94		
			R1129W	80-84	1131	79		
			R1129X	84-88	661	73		
			R1129Y	88-92	513	55		
			R1129Z	92-96	103	35		
			R1129AA	96-100	3	27		
			R1129BB	100-104	10	32		
			R1129CC	104-108	0	33		
			R1129DD	108-112	-10	44		
			R1129EE	112-116	-29	45		
			R1129FF	116-119	2	45		

Location	Core	Year of Collection	Control Number	Depth (cm)	Cs-137 (pCi/kg)	1σ	Be-7 (pCi/kg)	1σ
Mohawk River	MOH 10V	1996	R1100A	0-2	263	54	-418	2435
			R1100B	2-4	305	40	1725	1133
			R1100C	4-6	157	41	2731	2101
			R1100D	6-8	178	23	-1948	1041
			R1100E	8-12	197	31		
			R1100F	12-16	175	31		
			R1100G	16-20	274	30		
			R1100H	20-24	443	28		
			R1100H	20-24	448	37		
			R1100I	24-28	600	66		
			R1100J	28-32	248	41		
			R1100K	32-26	349	41		
			R1100L	36-40	408	54		
			R1100M	40-44	403	48		
			R1100N	44-48	440	45		
			R1100O	48-52	588	49		
			R1100P	52-56	634	59		
			R1100Q	56-60	813	55		
			R1100R	60-64	1481	89		
			R1100S	64-68	2563	155		
			R1100T	68-72	567	56		
			R1100U	72-76	40	40		
			R1100V	76-80	-41	37		
			R1100W	80-84	-27	35		
			R1100X	84-88	-23	35		
			R1100Y	88-92	-14	35		
			R1100Z	92-96	-16	41		
			R1100AA	96-100	7	38		
			R1100AB	100-104	-11	38		
			R1100AC	104-108	-60	39		
			R1100AD	108-112	-51	36		
			R1100Q	56-60	818	67		
	MOH 12	1997	R1147A	0-2	215	32	624	325

Appendix III. Sediment DDT and Chlordane Tracer Data

DDT and Chlordane Tracer Data for the Upper Hudson Basin

(Concentrations are in ppb)

Table A3-1

Core	Control Number	Depth Interval (cm)	Approximate Year [1]	pp'-DDD (AXYS)	γ-chlordane (AXYS) [2,3]
188.5	CN1852H	24-28	1964	18	1.7
188.6	CN2113M	40-44	1964	7.8	1.1
MOH 10V	R1100S	64-68	1964	12	ND (0.71)
163.6V	R1129L	36-40	1970	1.2	0.75
MOH 10V	R1100A	0-2	1996	1.3	NDR (0.18)
163.6V	R1129B	2-4	1997	0.95	0.36
MOH12	R1147	0-2	1997	1.7	ND (0.19)

DDT and Chlordane Tracer Data for the Central Park Lake

(Concentrations are in ppb)

Table A3-2

Core	Control Number	Section	Approximate Year [1]	pp'-DDD (AXYS) [4]	γ-chlordane (AXYS) [2]
CPE	R1077A, B	0-4	1995	2300	21
CPE	R1077D	6-8	1981	1600	17
CPE	R1077G	12-14	1968	3100	25
CPE	R1077J	18-20	1954	42	ND(0.38)
CPE	R1077M	24-26	1940	21	0.23
CPE	R1077P	30-32	1922	8.1	ND (0.22)
CPE	R1077S	36-38	1913	6.6	ND (0.03)

[1] Approximate years were determined based on ^{137}Cs and ^{7}Be data.

[2] ND: non detect. Number in parentheses is detection limit.

[3] Flagged NDR by AXYS. Did not meet quantification standards.

[4] Samples dated 1940 and earlier pre-date the use of DDT as a pesticide and most likely reflect a small amount of mixing with the contaminated sediments above.

DDT and Chlordane Tracer Data for the Tidal Hudson River

(Concentrations are in ppb)

Table A3-3

Core	Control Number	Depth Interval (cm)	Approximate Year [1]	pp'-DDD (AXYS)	pp'-DDD (Bopp)	γ-chlordane (AXYS)	γ-chlordane (Bopp)
88.6	CN1984A	0-2	1986		6.18		0.85
	CN1984B	2-4	1984		3.49		0.66
	CN1984C	4-6	1983		5		0.58
	CN1984D	6-8	1981		7.12		1.59
	CN1984E	8-12	1979		7.1		0.92
	CN1984F	12-16	1976				1.26
	CN1984G	16-20	1975				1.51
	CN1984H	20-24	1974		13.86		1.82
	CN1984I	24-28	1973		13.23		1.38
	CN1984J	28-32	1968		16.77		0.83
	CN1984K	32-36	1964		19.13		1.4
	CN1984Q	56-59	1954		17.52		2.21
88.6f	R1068A	0-2	1995	1.5		0.15	
88.6h	R1214A	0-2	1998	0.8		0.086	
91.8	CN1329A	0-2	1975		15.19		<5
	CN1329B	2-4	1974		21.64		<6
	CN1329C	4-8	1973		27.9		<6
	CN1329D	8-12	1971		27.9		<5
	CN1329E	12-16	1969		24.46		<5
	CN1329F	16-20	1967		23.5		<5
	CN1329G	20-24	1965	13		1	
	CN1329H	24-28	1963		28.87		<3
	CN1329H	24-28	1963		26.54		<2
	CN1329I	28-32	1959		20.02		<4
	CN1329J	32-36	1954		14.2		<2
	CN1329K	36-40	1950		0.25		<1
	CN1329L	40-44	1945				<1
	CN1329M	44-48	1941		0.054		<1
	CN1329N	48-52	1936				
120.2	R1213A	0-2	1998	0.79		0.18	

[1] Approximate years were determined based on ^{137}Cs and ^{7}Be data.

DDT and Chlordane Tracer Data for Raritan Bay

(Concentrations are in ppb)

Table A3-4

Core	Control Number	Depth Interval (cm)	[1]Approximate Year	pp'-DDD (Bopp)	γ-chlordane (Bopp)
RB17	CN1533A	0-2.5	1980	9.4	5.6
	CN1533B	2.5-5	1977	9.8	3.4
	CN1533C	5-7.5	1973	16	4.6
	CN1533D	7.5-10	1970	17	4.1
	CN1533E	10-12.5	1966	31	7.1
	CN1533F	12.5-15	1963	43	7.3
	CN1533G	15-18	1961	31	4.6
	CN1533H	18-21	1958	30	3.2
	CN1533I	21-24	1956	62	<3
	CN1533J	24-27	1953	62	<3
	CN1533K	27-29	1951	25	<3

[1] Approximate years were determined based on ^{137}Cs and ^{7}Be data.

DDT and Chlordane Tracer Data for the Arthur Kill

(Concentrations are in ppb)

Table A3-5

Core	Control Number	Depth Interval (cm)	Approximate Year [1]	p,p'-DDD (AXYS)	p,p'-DDD (Bopp)	γ-chlordane (AXYS) [2]	γ-chlordane (Bopp) [3]
Kill14	1730A	0-2	1982		250		57
	1730B	2-4	1978		560		110
	1730C	4-8	1972		520		120
	1730D	8-12	1963		530		130
	1730E	12-16	1960		510		I (56)
	1730F	16-20	1957		530		I (24)
	1730G	20-24	1954		560		I (15)
	1730H	24-28	1951		360		I (3)
	1730I	28-32	1948		400		I
	1730J	32-36	1945		1500		I
	1730K	36-40	1941	1900	2240	ND (0.97)	I
	1730L	40-44	1938		36		*<3.4*
	1730M	44-48	1935		42		*<3.6*
	1730N	48-52	1932		64		*<4.6*
	1730O	52-56	1929		12		*<1*
	1730P	56-60	1926	12		ND(1.5)	
	1730R	64-68	1920	0.41		ND(1.5)	<1
Kill21	R1091A	0-2	1996	520		15	
	R1091O	48-52	1983	280		22	
	R1091Z	92-96	1971	100		27	
	R1091JJ	132-136	1963	1000		70	
	R1091LL	140-144	1960	2600		23	

[1] Approximate years were determined based on ^{137}Cs and ^{7}Be data.

[2] ND: non detect. Number in parentheses is detection limit.

[3] Chromatograms with major interfering peaks are designated "I". Estimated values are in parentheses.

DDT and Chlordane Tracer Data for the Kill Van Kull

(Concentrations are in ppb)

Table A3-6

Core	Control Number	Depth Interval (cm)	Approximate Year [1]	pp'-DDD (AXYS)	pp'-DDD (Bopp)	γ-chlordane (AXYS)	γ-chlordane (Bopp)
KVK1	1959A	0-2	1985		396		79
	1959B	2-4	1985		322		40
	1959C	4-6	1985		267		33
	1959D	6-8			278		37
	1959E	8-12			289		41
	1959F	12-16			247		37
	1959G	16-20			645		83
	1959H	20-24			1406		217
	1959I	24-28			1885		274
	1959J	28-32			370		52
	1959K	32-36			382		58
	1959L	36-41			388		61
	1959L2	36-41b			420		65
KVK3	R1092A	0-2	1996	140		15	
KVK4	R1226A	0-2	1998	110		14	

DDT and Chlordane Tracer Data for Newark Bay

(Concentrations are in ppb)

Table A3-7

Core	Control Number	Depth Interval (cm)	Approximate Year [1]	pp'-DDD (AXYS)	pp'-DDD (Bopp)	γ-chlordane (AXYS)	γ-chlordane (Bopp)
NB13	CN1964A	0-2	1985		55		15
	CN1964B	2-4	1984		78		39
	CN1964C	4-6	1983		146		34
	CN1964D	6-8	1981		130		36
	CN1964E	8-12	1978		83		33
	CN1964F	12-16	1974		65		32
	CN1964G	16-20	1970		65		36
	CN1964H	20-24	1966		77		49
	CN1964I	24-28	1962	71	84	30	35
	CN1964J	28-32	1958		139		<6
	CN1964K	32-36	1954		223		<6
NB20	1998K	32-36	1958	190	290	14	
	1998L	36-40	1955		340		
	1998M	40-44	1952		480		
	1998N	44-48	1948		490		
	1998O	48-52	1945		410		
	1998P	52-56	1942		210		
	1998Q	56-60	1938		2		
NB13B	CN2551A	0-2	1995	26		3.6	

DDT and Tracer Data for Newtown Creek

(Concentrations are in ppb)

Table A3-8

Core	Control Number	Depth Interval (cm)	Approximate Year [1]	pp'-DDD (AXYS)	γ-chlordane (AXYS)
NC3	CN2019A	0-2	1987	62	28
NC6	CN2102A	0-2	1990	18	6.4
NC9	R1093A	0-2	1996	36	11
NC10	R1227A	0-2	1998	37	13

[1] Approximate years were determined based on ^{137}Cs and ^{7}Be data.

DDT and Chlordane Tracer Data for the Upper Harbor

(Concentrations are in ppb)

Table A3-9

Core	Control Number	Depth Interval (cm)	Approximate Year [1]	pp'-DDD (AXYS)	pp'-DDD (Bopp)	γ-chlordane (AXYS)	γ-chlordane (Bopp)
mp-1.7W	1472A	0-2	1978		55		31
	1472B	2-4	1977		70		33
	1472C	4-6	1975		92		45
	1472D	6-8	1974		105		49
	1472E	8-10	1973		110		42
	1472F	10-12	1971		138		48
	1472G	12-16	1969		108		37
	1472H	16-20	1967		100		36
	1472I	20-24	1964	97	106	25	34 [2]
	1472J	24-28	1961		114		32
	1472K	28-32	1959		69		23
	1472L	32-36	1957		54		15
	1472M	36-40	1955		37		13
	1472N	40-46	1953		<1		<1
mp-1.65W	1923A	0-2	1984		35		15
	1923B	2-4	1984		35		15
	1923C	4-6	1983		42		17
	1923D	6-8	1983		41		19
	1923E	8-12	1982		42		21
	1923F	12-16	1982		49		21
	1923G	16-20	1981		44		21
	1923H	20-24	1980				
	1923I	24-28	1980		47		21
	1923J	28-32	1979		43		23
	1923K	32-36	1978		49		26
	1923L	36-40	1978		55		34
	1923M	40-44	1977		48		26
	1923N	44-48	1976		49		30
	1923O	48-52	1976		63		33
	1923P	52-56	1975		65		34
mp -1.69	R1042A	0-2	1994	16			3
mp -1.7C	R1225A	0-2	1998	7			2

[1] Approximate years were determined based on ^{137}Cs and ^{7}Be data.

[2] Due to a calculation error, this has previously been reported incorrectly as 39 ppb.

Appendix IV. DDT and Chlordane Sediment Data

Table A4-1

Comparison of Bopp and AXYS Analyses

(Concentrations are in ppb)

Core	Control Number	Depth Interval (cm)	[1] γ- chlordane (AXYS)	[2] γ-chlordane (Bopp)	[1] α- chlordane (AXYS)	[2] α-chlordane (Bopp)	pp'-DDT (AXYS)	pp'-DDT (Bopp)	op'-DDD (AXYS)	op'-DDD (Bopp)	pp'-DDD (AXYS)	pp'-DDD (Bopp)
Kill14	1730K	36-40	ND (0.97)	I	ND(1.2)	I	170	1040	810	1150	1900	2240
Kill14	1730R	64-68	ND(1.5)	<1	ND (2.1)	<1	ND (0.19)	<0.2	ND (0.17)	<0.4	0.41	<0.4
NB13	CN1964I	24-28	30	35.10	18	32.60						
NB13	CN1964I	24-28					4.9	3.13	28	31.78	71	84.15
NB20	1998K	32-36					2.4	6.6			190	290
mp-1.7W	1472I	20-24	25	34	16	26						
mp-1.7W	1472I	20-24					2.9	3.6	35	39	97	106

[1] ND: non detect. Number in parentheses is detection limit.

[2] Chromatograms with major interfering peaks are designated "I".

Chlordane in the Upper Hudson Basin

Table A4-2

(Concentrations are in ppb)

Core	Control Number	Depth Interval (cm)	Approximate Year [1]	γ-chlordane (AXYS) [2,3]	α-chlordane (AXYS) [2,3]	transnonachlor (AXYS) [2,3]	cisnonachlor (AXYS) [3]	oxychlordane (AXYS) [3]	Heptachlor epoxide (AXYS) [3]	Σ chlordane	γ/α	trans non/ (α+γ)	P/M [4]
188.5	CN1852H	24-28	mid 60s	1.7	1.5	0.54	ND (0.64)	ND (.22)		3.74	1.13	0.17	>4
MOH 10V	R1100S	64-68	mid 60s	ND (0.71)	ND (0.81)	ND (0.89)	ND (1.1)	ND (1.3)	ND (.19)				
MOH 10V	R1100A	0-2	1996	.18 (NDR)	0.19	ND (.15)	ND (.13)		ND (.07)	0.37	0.95		
MOH12	R1147	0-2	1997	ND (0.19)	ND (0.22)	ND (0.24)	ND (0.3)	ND (.28)	ND (.08)				
										Average	1.18	0.19	
										1σ	0.28	0.07	

DDT in the Upper Hudson Basin

Table A4-3

(Concentrations are in ppb)

Core	Control Number	Depth Interval (cm)	Approximate Year [1]	o,p'-DDT (AXYS) [2,3]	p,p'-DDT (AXYS) [2,3]	o,p'-DDD (AXYS) [2,3]	p,p'-DDD (AXYS)	o,p'-DDE (AXYS) [3]	p,p'-DDE (AXYS)	Σ DDT	pp'-DDT/ pp'-DDD	pp'-DDE/ pp'-DDD	op-DDT/ pp'-DDT	pp'-DDT/ pp'-DDE	op-DDD/ pp-DDD	op-DDE/ pp-DDE
188.5	CN1852H	24-28	1964	.19 (NDR)	.63 (NDR)	5.7	18	2.2	16	42.72	0.04	0.89	0.30	0.04	0.32	0.14
MOH 10V	R1100S	64-68	1964	ND (0.94)	ND (1.1)	2.2 (NDR)	12	0.88	16	30.08	<.09	1.25		<.01	0.18	0.08
MOH 10V	R1100A	0-2	1996	0.13	0.63	0.34	1.3	0.08	2.3	4.85	0.48	1.77	0.21	0.27	0.26	0.03
MDH12	R1147	0-2	1997	ND (.89)	1.2 (NDR)	ND (.28)	1.7	ND (.18)	2.3	4	0.71	1.35	<.74	0.52	0.16	<.08
										Average [5]	0.35	2.15	0.48	0.13	0.25	0.09
										1σ [5]	0.20	2.54	0.31	0.12	0.07	0.06

[1] Approximate years were determined based on ^{137}Cs and ^{7}Be data.

[2] Flagged NDR by AXYS. Did not meet quantification standards.

[3] ND: non detect. Number in parentheses is detection limit.

[4] Ratio of (α+γ + transnon+cisnon) to (Oxy + heptachlor epox.).

[5] Left out > or < in calculating ratios.

Chlordane in the Tidal Hudson River

Table A4-4

(Concentrations are in ppb)

Core	Control Number	Depth Interval (cm)	Approximate Year [1]	γ-chlordane (AXYS)	[2] α-chlordane (AXYS)	transnonachlor (AXYS) [2,3]	cisnonachlor (AXYS) [2,3]	Oxychlordane (AXYS) [2,3]	Heptachlor Epoxide (AXYS) [2,3]	γ-chlordane (Bopp)	α-chlordane (Bopp)
88.6		0-2	1986							0.85	
		4-6	1983							0.58	
		8-12	1979							0.92	
		16-20	1975							1.51	
		24-28	1973							1.38	
		32-36	1964							1.4	
	CN1329B	2-4	1974							<6	
	CN1329D	8-12	1971							<5	
	CN1329F	16-20	1967							<5	
	CN1329H	24-28	1963							<3	
	CN1329I	28-32	1959							<4	
	CN1329K	36-40	1950							<1	
	CN1329M	44-48	1941							<1	

[1] Approximate years were determined based on ^{137}Cs and ^{7}Be data.

[2] ND; non detect. Number in parentheses is detection limit.

[3] Flagged NDR by AXYS. Did not meet quantification standards.

DDT in theTidal Hudson

(Concentrations are in ppb)

Table A4-5

Core	Control Number	Depth Interval (cm)	Approximate Year [1]	o,p'-DDT (AXYS) [2]	p,p'-DDT (AXYS)	o,p'-DDD (AXYS)	p,p'-DDD (AXYS)	o,p'-DDE (AXYS)	p,p'-DDE (AXYS) [3]	p,p'-DDT (Bopp)	p,p'-DDD (Bopp)	Σ DDT	pp'-DDT/ pp'-DDD	pp'-DDE/ pp'-DDD	op-DDT/ pp'-DDT	pp'-DDT/ pp'-DDE	op-DDD/ pp-DDD	pp-DDE/ op-DDE
88.6		0-2	1986								6.18							
		4-6	1983								5							
		8-12	1979								7.1							
		16-20	1975															
		24-28	1973								13.23							
		32-36	1964								19.13							
	CN1329B	2-4	1974															
	CN1329D	8-12	1971															
	CN1329F	16-20	1967															
												Average	0.33	2.48		0.17	0.27	
												1σ	0.08	1.87		0.10	0.10	

[1] Approximate years were determined based on ^{137}Cs and ^{7}Be data.

[2] ND: non detect. Number in parentheses is detection limit.

[3] Flagged NDR by AXYS. Did not meet quantification standards

Chlordane in the Upper Harbor

(Concentrations are in ppb)

Table A4-6

Core	Control Number	Depth Interval (cm)	Approximate Year [1]	γ-chlordane (AXYS)	α-chlordane (AXYS)	transnonachlor (AXYS)	cisnonachlor (AXYS)	Oxychlordane [2] (AXYS)	Heptachlor Epoxide [2,3] (AXYS)	γ-chlordane (Bopp)	α-chlordane (Bopp)	Σ chlordane	P/M [4]	γ-chlordane/ α-chlordane	transnon/ (γ+α)
mp-1.7W	1472A	0-2	1978							31	34			0.93	
	1472C	4-6	1975							45	48			0.94	
	1472E	8-10	1973							42	42			1.00	
	1472G	12-18	1969							37	34			1.07	
	1472I	20-24	1964	25	16	6.7	3.2	ND (1)	ND (7.6)	34	26	50.9	>6	1.29	0.16
	1472K	28-32	1959							23	14			1.65	
	1472M	36-40	1955							13	6			2.06	
	1923B	2-4	1984							15	15			0.95	
	1923D	6-8	1983							19	22			0.84	
	1923F	12-16	1982							21	24			0.88	
	1923H	20-24	1980							23	27			0.85	
	1923J	28-32	1979							34	37			0.91	
	1923L	36-40	1978							30	42			0.71	
	1923N	44-48	1976							34	39			0.87	
	1923P	52-56	1975												
mp -1.69	R1042A	0-2	1994	3.2	3.1	1.4	0.96	ND (.37)	ND (.36)			8.66	>12	1.03	0.22
mp -1.7C	R1225A	0-2	1998	1.9	1.5	1	0.41	ND (.003)	.069 (NDR)			4.81	>67	1.27	0.29
												Average		1.04	0.23
												1σ		0.30	0.07

[1] Approximate years were determined based on ^{137}Cs and ^{7}Be data.

[2] ND: non detect. Number in parentheses is detection limit.

[3] Flagged NDR by AXYS. Did not meet quantification standards.

[4] Ratio of (α + γ + transnon+cisnon) to (Oxy + heptachlor apox.).

DDT in the Upper Harbor

(Concentrations are in ppb)

Table A4-7

Core	Control Number	Depth Interval (cm)	Approximate Year [1]	o,p'-DDT (AXYS) [2]	p,p'-DDT (AXYS)	o,p'-DDD (AXYS)	p,p'-DDD (AXYS)	o,p'-DDE (AXYS)	p,p'-DDE (AXYS)	p,p'-DDT (Bopp)	p,p'-DDD (Bopp)	o,p'-DDD (Bopp)	Σ DDT	pp'-DDT/ pp'-DDD	pp'-DDE/ pp'-DDD	op-DDT/ pp'-DDT	pp'-DDT/ pp'-DDE	opDDD/ pp-DDD	op-DDE/ pp-DDE
mp-1.7W	1472A	0-2	1978							4.9	55	17		0.09				0.31	
	1472C	4-6	1975							2.6	92	27		0.03				0.30	
	1472E	8-10	1973							2.9	110	33		0.03				0.30	
	1472G	12-16	1969							7.1	108	38		0.07				0.33	
	1472I	20-24	1964	ND (.09)	2.9	35	97	9.9	66	3.6	106	39	210.8	0.03	0.66	<.03	0.04	0.37	0.15
	1472K	28-32	1959							3.0	89	23		0.04				0.33	
	1472M	36-40	1955							<1	37	13						0.35	
mp-165W	1923A	0-2	1984							2.2	35	11		0.06				0.33	
	1923C	4-6	1983							27.9	42	15		0.67				0.36	
	1923E	8-12	1982							1.7	42	13		0.04				0.30	
	1923G	16-20	1981							4.6	44	14		0.10				0.32	
	1923I	24-28	1980							3.1	47	17		0.07				0.35	
	1923K	32-36	1978							2.3	49	14		0.05				0.30	
	1923M	40-44	1977							3.8	48	15		0.08				0.32	
	1923O	48-52	1976							3.8	63	20		0.06				0.32	
mp -1.69	R1042A	0-2	1994	4.8	3.2	5.2	16	2.1	12				43.3	0.20	0.75	1.5	0.27	0.33	0.18
mp -1.7C	R1225A	0-2	1998	0.22	0.74	2.1	7	1.5	8.4				19.96	0.11	1.20	0.30	0.09	0.30	0.18
													Average	0.09	0.88	0.90	0.13	0.32	0.17
													1σ	0.12	0.28	0.85	0.12	0.03	0.02

[1] Approximate years were determined based on ^{137}Cs and ^{7}Be data.

[2] ND: non detect. Number in parentheses is detection limit.

Table A4-8

Chlordane In Newtown Creek
(Concentrations are in ppb)

Core	Control Number	Depth Interval (cm)	Approximate Year [1]	γ-chlordane (AXYS)	α-chlordane (AXYS)	transnonachlor (AXYS) [2]	cisnonachlor (AXYS)	oxychlordane (AXYS) [3]	Heptachlor Epoxide (AXYS) [3]	γ-chlordane (Bopp)	Σ chlordane	γ/α	transnon/ (α+γ)	P/M [4]
NC6	CN2102A	0-2	1990	6.4	6.8	4.2	1.8	ND (.56)	ND (.4)		19.2	0.94	0.32	>20.00
NC10	R1227A	0-2	1998	13	12	8.5	2.6	0.64	0.26		37	1.08	0.34	40.11
											Average	1.01	0.30	
											1σ	0.07	0.05	

Table A4-9

DDT In Newtown Creek
(Concentrations are in ppb)

Core	Control Number	Depth Interval (cm)	Approximate Year [1]	o,p'-DDT (AXYS) [3]	p,p'-DDT (AXYS)	o,p'-DDD (AXYS)	p,p'-DDD (AXYS)	o,p'-DDE (AXYS)	p,p'-DDE (AXYS)	p,p'-DDD (Bopp)	pp'-DDT/ pp'-DDD	Σ DDT	pp'-DDE/ pp'-DDD	op-DDT/ pp'-DDT	pp'-DDT/ pp'-DDE	opDDD/ pp-DDD	op-DDE/ pp-DDE
NC6	CN2102A	0-2	1990	ND (.81)	3.7	8.4	18	2.5	20		0.21	51	1.11	<.25	0.19	0.36	0.13
NC10	R1227A	0-2	1998	1.7	4.5	6.9	37	1.4	17		0.12	72	0.45	0.38	0.26	0.27	0.08
												Average	0.72		0.27	0.33	0.11
												1σ	0.35		0.09	0.05	0.02

[1] Approximate years were determined based on ^{137}Cs and ^{7}Be data
[2] Flagged NDR by AXYS. Did not meet quantification standards.
[3] ND non detect. Number in parentheses is detection limit.
[4] Ratio of (α + γ + transnon+cisnon) to (Oxy + heptachlor epox.).

Chlordane in the Kill Van Kull

(Concentrations are in ppb)

Table A4-10

Core	Control Number	Depth Interval (cm)	[1] Approximate Year	γ- chlordane (AXYS)	α- chlordane (AXYS)	transnonachlor (AXYS)	cisnonachlor [2] (AXYS)	Oxychlordane [2,3] (AXYS)	Heptachlor Epoxide [2] (AXYS)	γ-chlordane (Bopp)	α-chlordane (Bopp)	Σ chlordane	γ/α	Trans nonachor/ (α+γ)	[4] P/M
KVK1	1959A	0-2	1985							79	50		1.58		
	1959C	4-6	1984							33	35		0.94		
	1959E	8-12								41	44		0.93		
	1959G	16-20								83	77		1.08		
	1959I	24-28								274	195		1.41		
	1959K	32-36								58	51		1.14		
	1959L2	36-41b								65	55		1.18		
KVK3	R1092A	0-2	1986	15	9.8	4.4	2 NDR	ND (0.3)	ND (0.24)			29	1.53	0.18	>54
												Average	1.19	0.20	
												1σ	0.23	0.02	

[1] Approximate years were determined based on ^{137}Cs and ^{7}Be data.
[2] Flagged NDR by AXYS Did not meet quantification standards
[3] ND: non detect. Number in parentheses is detection limit.
[4] Ratio of (α + γ + transnon+cisnon) to (Oxy + heptachlor epox.).

DDT in the Kill Van Kull

(Concentrations are in ppb)

Table A4-11

Core	Control Number	Depth Interval (cm)	Approximate Year [1]	o,p'-DDT (AXYS)	p,p'-DDT (AXYS)	o,p'-DDD (AXYS)	p,p'-DDD (AXYS)	o,p'-DDE (AXYS)	p,p'-DDT (Bopp)	p,p'-DDD (Bopp)	p,p'-DDE (AXYS)	pp'-DDT/ pp'-DDD	Σ DDT	pp'-DDE/ pp'-DDD	op-DDT/ pp'-DDT	pp'-DDT/ pp'-DDE	opDDD/ pp-DDD	op-DDE/ pp-DDE
KVK1	1959A	0-2	1985						445	396		1.12						
	1959C	4-6	1984						591	267		2.21						
	1959E	8-12							232	289		0.80						
	1959G	16-20							314	645		0.49						
	1959I	24-28							1322	1885		0.70						
	1959K	32-36							311	382		0.81						
	1959L2	36-41b							221	420		0.53						
KVK3	R1092A	0-2	1996	11	93	53	140	8.2			68	0.66	373	0.49	0.12	1.37	0.38	0.12
													Average	0.43	0.20	0.69	0.31	0.17
													1σ	0.08	0.12	0.67	0.10	0.08

[1] Approximate years were determined based on ^{137}Cs and ^{7}Be data.

Table A4-12

Chlordane in the Arthur Kill

(Concentrations are in ppb)

Core	Control Number	Depth Interval (cm)	[1] Approximate Year	[2] γ- chlordane (AXYS)	[3] α- chlordane (AXYS)	[2,3] transnonachlor (AXYS)	[2] cis nonachlor (AXYS)	[2,3] Oxychlordane (AXYS)	[2,3] Heptachlor Epoxide (AXYS)	[4] γ-chlordane (Bopp)	[4] α-chlordane (Bopp)	Σ chlordane	γ/α	Trans nonachlor/ (α+γ)	[6] P/M
Kill14	1730A	0-2	1982							57	65		0.88		
	1730C	4-8	1972							120	120		1.00		
	1730E	12-16	1960							I (56)	I (56)				
	1730G	20-24	1954							I (15)	I (15)				
	1730I	28-32	1948							I	I				
	1730K	36-40	1941	ND (0.97)	ND(1.2)	ND(1.2)	ND(1.9)	ND (.68)	ND	I	I				
	1730M	44-48	1935							<3.6	<1.3				
	1730O	52-56	1929							<1	<1				
	1730R	64-68	1920	ND(1.5)	ND (2.1)	ND(2.1)	ND(3.2)	ND (2.6)	NQ	<1	<1				
Kill21	R1091AL	140-144	1954	23	17	5.1	2.6	NQ	5.6 (NDR)			48	1.35	0.13	>9
	CN1091Z	92-98	1972	27	24	9.6 (NDR)	10	ND (2.6)	ND (2.2)			71	1.13	0.19	>15
	R1091A	0-2	1998	15	18	8.9	3.6	.99 (NDR)	ND (.57)			44	0.94	0.29	>28
												Average	1.16	0.21	
												1σ	0.22	0.06	

[1] Approximate years were determined based on ^{137}Cs and ^{7}Be data.

[2] ND: non detect. Number in parentheses is detection limit.

[3] Flagged NDR by AXYS. Did not meet quantification standards.

[4] Chromatograms with major interfering peaks are designated "I". Estimated values are in parentheses.

[6] Ratio of (α + γ + transnon+cisnon) to (Oxy + heptachlor epox.).

Table A4-13

DDT in the Arthur Kill

(Concentrations are in ppb)

Core	Control Number	Depth Interval (cm)	Approximate Year [1]	o,p'-DDT (AXYS) [2]	p,p'-DDT (AXYS) [2]	o,p'-DDD (AXYS)	p,p'-DDD (AXYS)	o,p'-DDE (AXYS)	p,p'-DDE (AXYS)	p,p'-DDD (Bopp)	p,p'-DDT (Bopp)	op'-DDD (Bopp)	pp'-DDT/ pp'-DDD	Σ DDT	pp'-DDE/ pp'-DDD	op-DDT/ pp'-DDT	pp'-DDT/ pp'-DDE	opDDD/ pp-DDD	o,p-DDE/ p,p-DDE
Kill14	1730A	0-2	1982							250	98	104	0.39					0.42	
	1730C	4-8	1972							520	36	200	0.07					0.38	
	1730E	12-16	1980							510	190	320	0.37					0.63	
	1730G	20-24	1954							580	15	320	0.03					0.57	
	1730I	28-32	1948							400	200	240	0.50					0.60	
	1730K	36-40	1941	ND (.52)	170	610	1900	830	2100	2240	1040	1150	0.46	5810	1.11		0.08	0.51	0.40
	1730M	44-48	1935							42	<0.2	16						0.38	
	1730O	52-56	1929							12	<0.2	5.3						0.44	
	1730R	64-68	1920	ND (.17)	ND (.19)	0.41	0.41	0.6	0.9	<0.4	<0.2	<0.4		2.32	2.20		0.21		0.67
Kill21	R1091AL	140-144	1954	15	1700	450	2600	350	700				0.65	5815	0.27	0.01	2.43	0.17	0.50
	CN1091Z	92-96	1972	24	46	52	100	99	230				0.46	551	2.30	0.52	0.20	0.52	0.43
	R1091A	0-2	1996	29	650	140	520	67	170				1.25	1576	0.33	0.04	3.82	0.27	0.39
												Average	0.63		1.08	0.12	1.44	0.43	0.42
												1σ	0.65		0.78	0.23	1.41	0.12	0.08

[1] Approximate years were determined based on ^{137}Cs and ^{7}Be data.

[2] ND: non detect. Number in parentheses is detection limit.

Chlordane in Newark Bay

(Concentrations are in ppb)

Table A4-14

Core	Control Number	Depth Interval (cm)	Approximate Year [1]	γ- chlordane (AXYS)	α- chlordane (AXYS)	transnonachlor (AXYS)	cisnonachlor (AXYS)	Oxychlordane [2] (AXYS)	Heptachlor Epoxide [2] (AXYS)	γ-chlordane (Bopp)	α-chlordane (Bopp)	Σ chlordane	γ/α	transnon/ (γ+α)	P/M [3]
NB13	CN1964A	0-2	1984.5							14.57	19.74		0.74		
	CN1964C	4-6	1983							34.09	37.71		0.90		
	CN1964E	8-12	1978							33.08	35.74		0.93		
	CN1964G	16-20	1970							36.05	37.31		0.97		
	CN1964I	24-28	1962	30	18	8.8	5.8	ND (.61)	ND (15)	35.10	32.60	62.60	1.08	0.18	>4.01
	CN1964K	32-36	1954												
NB20	1998K	32-36	1956	14	5.2	2.4	1.8	ND (1.4)	ND (6.2)			23.2	2.69	0 13	>3.05
	1998M	40-44	1951.5												
	1998O	48-52	1945												
	1998Q	56-60	1938												
NB13B	CN2551	0-2	1995	3.8	3.5	1.9	1.8	ND (.54)	ND (.36)			10.6	1.03	0.27	>11.78
												Average	1.10	0.19	
												1σ	0.54	0.07	

[1] Approximate years were determined based on ^{137}Cs and ^{7}Be data.

[2] ND: non detect. Number in parentheses is detection limit.

[3] Ratio of (α + γ + transnon+cisnon) to (Oxy + heptachlor epox.).

DDT in Newark Bay

(Concentrations in ppb)

Table A4-15

Core	Control Number	Depth Interval (cm)	Approximate Year [1]	o,p'-DDT (AXYS) [2,3,4]	p,p'-DDT (AXYS)	o,p'-DDD (AXYS)	p,p'-DDD (AXYS)	o,p'-DDE (AXYS)	p,p'-DDE (AXYS)	p,p'-DDT (Bopp)	p,p'-DDD (Bopp)	o,p'-DDD (Bopp)	pp'-DDT/ pp'-DDD (257)	Σ DDT	pp'-DDE/ pp'-DDD	op-DDT/ pp'-DDT	pp'-DDT/ pp'-DDE	opDDD/ pp-DDD	op-DDE/ pp-DDE
NB13	CN1964A	0-2	1985							4.46	54.80	20.95	0.08					0.38	
	CN1964C	4-8	1983							83.59	146.14	60.17	0.57					0.41	
	CN1964E	8-12	1978							10.90	83.00	32.36	0.13					0.39	
	CN1964G	18-20	1970							4.70	55.23	23.32	0.07					0.36	
	CN1964I	24-28	1962	ND (0.1)	4.8	28	71	28	110	3.13	84.15	31.78	0.04	239.90	1.55	<.02	0.04	0.38	0.24
	CN1964K	32-36	1954							10.66	223.00	125.10	0.05					0.56	
NB20	1998K	32-36	1958	ND (0.1)	2.4	120	190	410	1100	8.8	290		0.02	1822.40	5.79	<.04	0.02	0.63	0.37
	1998M	40-44	1951.5							100	480		0.21						
	1998O	48-52	1945							36	410		0.09						
	1998Q	56-60	1938							<1	1.5		<0.67						
NB13B	CN2551A	0-2	1995	.38 (NDR)	2.8	10	28	8.7	34					81.88	1.31	0.14	0.03	0.38	0.26
												Average	0.16		2.88		0.03	0.43	0.29
												1σ	0.17		2.52		0.01	0.08	0.07

[1] Approximate years were determined based on ^{137}Cs and ^{7}Be data

[2] ND: non detect. Number in parentheses is detection limit.

[3] Flagged NDR by AXYS. Did not meet quantification standards.

[4] Flagged NDR by AXYS. Did not meet quantification standards

Chlordane in Raritan Bay

Table A4-16

(Concentrations in ppb)

Core	Control Number	Depth interval (cm)	[1]Approximate Year	γ-chlordane (Bopp)	α-chlordane (Bopp)	γ/α
RB17	CN1533A	0-2.5	1980	5.6	4.1	1.37
	CN1533B	2.5-5	1977	3.4	4	0.85
	CN1533C	5-7.5	1973	4.6	4.6	1.00
	CN1533D	7.5-10	1970	4.1	3.3	1.24
	CN1533E	10-12.5	1966	7.1	4.8	1.48
	CN1533F	12.5-15	1963	7.3	4.7	1.55
	CN1533G	15-18	1961	4.6	2.6	1.77
	CN1533H	18-21	1958	3.2	2.5	1.28
	CN1533I	21-24	1956	<3	<3	
	CN1533J	24-27	1953	<3	<3	
	CN1533K	27-29	1951	<3	<3	
					Average	**1.32**
					1σ	**0.30**

[1] Approximate years were determined based on ^{137}Cs and ^{7}Be data.

Chlordane in the Central Park Lake

(Concentrations are in ppb)

Table A4-17

Core	Control Number	Section	Approximate Year [1]	γ-chlordane[2] (AXYS)	α-chlordane[2,3] (AXYS)	transnonachlor[2] (AXYS)	cisnonachlor[2,3] (AXYS)	Oxychlordane[2] (AXYS)	Heptachlor Epoxide[2] (AXYS)	Σ chlordane	γ/α	Trans nonachlor/ (α+γ)	P/M[3]
CPE	R1077A, B	0-4	1995	21	18	8	4.5	ND(.04)	ND(8.5)	52	1.17	0.21	>6
CPE	R1077G	12-14	1968	12	4 (NDR)	1.7	2.1 (NDR)	ND(1.1)	ND(1.0)	14			>12
CPE	R1077M	24-26	1940	0.23	ND(.21)	ND(.22)	ND(.35)	ND(.29)	ND(.18)	0.23			
CPE	R1077S	36-38	1913	ND(.03)	ND(.04)	ND(.04)	ND(.05)	ND(.24)					
										Average	1.11	0.22	
										1σ	0.073657	0.02	

[1] Approximate years were determined based on ^{137}Cs and ^{7}Be data.

[2] ND: non detect. Number in parentheses is detection limit.

[3] Ratio of (α +γ + transnon+cisnon) to (Oxy + heptachlor epox.).

DDT in the Central Park lake

(Concentrations are in ppb)

Table A4-18

Core	Control Number	Depth Interval (cm)	Approximate Year [1,4]	o,p'-DDT (AXYS) [2]	p,p'-DDT (AXYS) [2,3]	o,p'-DDD (AXYS)	p,p'-DDD (AXYS)	o,p'-DDE (AXYS)	p,p'-DDE (AXYS)	pp'-DDT/ pp'-DDD	Σ DDT	pp'-DDE/ pp'-DDD	op-DDT/ pp'-DDT	pp'-DDT/ pp'-DDE	opDDD/ pp-DDD	o,p-DDE/ p,p-DDE
CPE	R1077A, B	0-4	1995	ND(.09)	38	580	2300	28	500	0.02	3448	0.22		0.08	0.25	0.06
	R1077G	12-14	1968	ND(.16)	ND(1.6)	520	3100	120	1100		4840	0.35			0.17	0.11
	R1077M	24-26	1940	ND(.27)	ND(.39)	3.5	21	0.91	9		34	0.43			0.17	0.10
	R1077S	36-38	1913	ND(.12)	1.2	0.85	6.6	0.28	2.3	0.18	11	0.35		0.52	0.13	0.12
											Average	**0.35**		**0.24**	**0.19**	**0.09**
											1σ	**0.10**		**0.24**	**0.05**	**0.02**

[1] Approximate years were determined based on ^{137}Cs and ^{7}Be data.

[2] ND: non detect. Number in parentheses is detection limit.

[3] Flagged NDR by AXYS. Did not meet quantification standards.

[4] Samples dated 1940 and earlier pre-date the use of DDT as a pesticide and most likely reflect a small amount of mixing with the highly contaminated sediments above.

Appendix V. DDT and Chlordane Fish Data

Chlordane in American Eels From the NY/NJ Harbor

(Concentrations are in ppm-wet wt.)

Table A5-1

LOCATION	γ-chlordane [3]	α-chlordane [3]	Trans nonachlor [3]	Cis nonachlor [3]	Oxychlordane [3]	Heptachlor Epoxide [3]	γ/α	transnon/ α+γ+oxy	P/M [4]	Σ chlordane
BORDON AVENUE BRIDGE [1]	0.02	0.09	0.13	0.06	0.04	0.03	0.22	0.87	7.50	0.37
CHEESEQUOKO CREEK [1]	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-	-	-	
CHEESEQUOKO CREEK [1]	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-	-	-	
END OF NEWTON CREEK [1]	0.02	0.07	0.08	0.05	0.03	-0.01	0.29	0.67	7.33	0.25
END OF NEWTON CREEK [1]	0.02	0.09	0.12	0.06	0.03	-0.01	0.22	0.86	9.67	0.32
MORSES CREEK [2]	0.01	0.05	0.06	0.03	0.02	-0.01	0.20	0.75	7.50	0.17
MORSES CREEK [2]	-0.01	0.02	0.04	0.03	0.03	-0.01	<.5	>1	<3.33	0.12
WEST COAST NEAR DOUBLE TOWERS [1]	0.01	0.03	0.03	0.03	0.02	-0.01	0.33	0.50	5.00	0.12
WEST COAST NEAR DOUBLE TOWERS [1]	-0.01	0.01	0.02	0.01	-0.01	-0.01	<1	>1		0.04
WEST COAST NEAR DOUBLE TOWERS [2]	0.02	0.05	0.07	0.04	-0.01	-0.01	0.40	1.00	18.00	0.18
WINHOLE CREEK NEAR JFK AIRPORT [1]	0.01	0.04	0.04	0.02	0.01	0.01	0.25	0.67	11.00	0.13
WINHOLE CREEK NEAR JFK AIRPORT [1]	-0.01	0.01	0.02	0.02	0.02	0.01	<1	>1	<3	0.08

All samples were standard fillets.

FDA action limit-300ppb

[1] samples taken in 1993.

[2] samples taken in 1994.

[3] Negative numbers are non-detects. Number reported is detection limit.

[4] Oxychlordane was the only metabolite used in P/M calculation.

DDT in American Eels From the NY/NJ Harbor

Concentrations in ppm (wet wt.)

Table A5-2

LOCATION	p,p'-DDE	[1] o,p'-DDE	[1] p,p'-DDD	[1] o,p'-DDD	[1] p,p'-DDT	[1] o,p'-DDT	p,p'-DDT/ p,p'-DDE
BORDON AVENUE BRIDGE	0.16	-0.01	0.4	-0.01	0.04	-0.01	0.25
CHEESEQUOKO CREEK	0.01	-0.01	-0.01	-0.01	-0.01	-0.01	<1
CHEESEQUOKO CREEK	0.01	-0.01	0.01	-0.01	-0.01	-0.01	<1
END OF NEWTON CREEK	0.21	0.01	0.36	0.01	0.05	-0.01	0.24
MORSES CREEK	0.74	-0.01	0.86	0.01	0.08	-0.01	0.11
MORSES CREEK	1.9	-0.01	3.3	0.07	0.23	-0.01	0.12
MORSES CREEK	1.4	0.03	5.1	0.13	0.14	-0.01	0.10
WEST COAST NEAR DOUBLE TOWERS	0.09	-0.01	0.05	-0.01	-0.01	-0.01	<.11
WEST COAST NEAR DOUBLE TOWERS	0.16	-0.01	0.1	-0.01	0.01	-0.01	0.06
WINHOLE CREEK NEAR JFK AIRPORT	0.03	-0.01	0.01	-0.01	-0.01	-0.01	<.33
WINHOLE CREEK NEAR JFK AIRPORT	0.05	-0.01	0.02	-0.01	-0.01	-0.01	<.2
WINHOLE CREEK NEAR JFK AIRPORT	0.06	-0.01	0.04	-0.01	-0.01	-0.01	<.17

All analysis done on standard fillets.
All samples collected between 1993 and 1994.
[1] Negative numbers are non-detects. Number reported is the detection limit.

Table A5-3

Chlordane In American Lobster Hepatopancreas From the NY/NJ Harbor

(Concentrations are in ppm-wet wt.)

LOCATION	γ- chlordane [1]	α-chlordane [1]	Trans nonachlor [1]	Cis nonachlor [1]	Oxychlordane [1]	Heptachlor Epoxide [1]	γ/α	transnon/ (α+oxy)	P/M [2]	Σ chlordane
DUE SOUTH OF THE FARMS	-0.01	0.01	0 02	0.02	0.06	0 01	<1	0.29	0.71	0 12
DUE SOUTH OF THE FARMS	-0 01	0 02	0 04	0.03	0.06	0.02	<.5	0 40	0.90	0.19
DUE SOUTH OF THE FARMS	-0 01	0.03	0.04	0.03	0 06	0.01	< 33	0.44	1 43	0.17
DUE SOUTH OF THE FARMS	-0.01	0.01	0 04	0 03	0.07	0 02	<1	0.50	0.86	0.17
.78MI SOUTH OF SWINBURNE ISLAND	-0.01	0.01	0 03	0.02	0.03	0.01	<1	0.75	1 50	0 1
G&D WRECK	-0.01	-0.01	-0.01	-0 01	-0.01	-0 01				

All data from DEC database

[1] Negative numbers are non-detects. Numbers reported are detection limits.

[2] These calculations were done without g-chlordane.

FDA action limit-300 ppb

All samples taken in 1993.

Table A5-4

Chlordane In Blue Crab Hepatopancreas From the NY/NJ Harbor

(Concentrations are in ppm-wet wt.)

LOCATION	γ- chlordane [1]	α-chlordane [1]	Trans nonachlor [1]	Cis nonachlor [1]	Oxychlordane [1]	Heptachlor Epoxide [1]	γ/α	transnon/ (α+oxy)	P/M [2]	Σ chlordane
MOUTH OF HACKENSACK RIVER BUOY 5	0 01	0.05	0.06	0.05	0 14	0.08	0.2	0.32	0.80	0.38
NEWARK BAY BUOY B-10	-0 01	0.02	0 05	0.05	0.1	0.03	<.5	0.42	0.92	0.25
WALLABOUT CHANNEL	-0.01	0.02	0 04	0.03	0 07	0.02	<.5	0.44	1 06	0.18
NEWARK BAY BUOY B-10	0.01	0.05	0.09	0.06	0.11	0 05	0 2	0.56	1.25	0 36
WALLABOUT CHANNEL	-0.01	0 02	0.06	0 04	0.07	0.02	<.5	0.67	1.33	0.21
WALLABOUT CHANNEL	-0.01	0.02	0.09	0.06	0.1	0.02	<.5	0.75	1.42	0.29
.02MI EAST OF NORTHERN TIP OF SANDY HOOK	-0.01	0 04	0.1	0.07	0.09	0 04	<.25	0.77	1.82	0 34
END OF MORRIS CANAL BASIN	-0 01	0.02	0.09	0 06	0 07	0 03	<.5	1.00	1.70	0.27
MORRIS CANAL BASIN NEAR WARREN STREET	-0.01	0.02	0.11	0.09	0 09	0 03	<.5	1.00	1.83	0.34
MORRIS CANAL BASIN NEAR WARREN STREET	-0.01	0.01	0 08	0.05	0 04	0.03	<1	1.60	2.00	0.21

All data from DEC database.

[1] Negative numbers are non-detects. Numbers reported are detection limits.

[2] These calculations were done without g-chlordane

FDA action limit-300 ppb

All samples taken in 1993

Table A5-5

DDT in American Lobster Hepatopancreas From the NY/NJ Harbor

Concentrations in ppm (wet wt.)

LOCATION	pp'-DDE	[1] op'-DDE	[1] pp'-DDD	[1] op'-DDD	[1] pp'-DDT	DDT/DDE
.78MI. SOUTH OF SWINBURNE ISLAND	0.27	-0.01	0.03	-0.01	-0.01	<.04
DUE SOUTH OF THE FARMS	0.71	-0.01	0.05	-0.01	-0.01	<.01
DUE SOUTH OF THE FARMS	0.76	-0.01	0.02	-0.01	-0.01	<.01
DUE SOUTH OF THE FARMS	1.1	-0.01	0.08	-0.01	0.02	0.02
DUE SOUTH OF THE FARMS	0.92	-0.01	0.06	-0.01	0.01	0.01
G&D WRECK	0.03	-0.01	-0.01	-0.01	-0.01	<.33

All samples collected in 1993.

[1] negative numbers are non-detects. Number reported is detection limit.

[2] Sum of DDT compounds with non-detects as zero.

Table A5-6

DDT in Blue Crab Hepatopancreas From the NY/NJ Harbor

Concentrations in ppm (wet wt.)

LOCATION	pp'-DDE	[1] op'-DDE	[1] pp'-DDD	[1] op'-DDD	[1] pp'-DDT	DDT/DDE
.02MI EAST OF NORTHERN TIP OF SANDY HOOK	0.25	-0.01	0.13	-0.01	0.01	0.04
.02MI EAST OF NORTHERN TIP OF SANDY HOOK	1.1	-0.01	0.95	-0.01	0.13	0.12
1.24MI. SOUTH OF CONEY ISLAND BEACH	0.03	-0.01	0.02	-0.01	-0.01	<.33
BRIDGE OFF OF PARK AVENUE	0.28	-0.01	0.15	-0.01	0.01	0.04
CARNASIE CHANNEL	0.06	-0.01	0.04	-0.01	-0.01	<.17
CARNASIE CHANNEL	0.03	-0.01	0.02	-0.01	-0.01	<.33
END OF MORRIS CANAL BASIN	0.33	-0.01	0.29	-0.01	0.01	0.03
MORRIS CANAL BASIN NEAR WARREN STREET	0.14	-0.01	0.08	-0.01	-0.01	< 07
MORRIS CANAL BASIN NEAR WARREN STREET	0.38	-0.01	0.19	-0.01	0.01	0.03
NEWARK BAY BUOY 22	0.75	-0.01	0.4	-0.01	0.02	0.03
NEWARK BAY BUOY 0-10	0.19	-0.01	0.12	-0.01	0.01	0.05
WALLABOUT CHANNEL	0.39	-0.01	0.14	-0.01	0.01	0.03
WALLABOUT CHANNEL	0.19	-0.01	0.09	-0.01	0.01	0.05

All samples collected in 1993.

[1] negative numbers are non-detects. Number reported is detection limit.

Table A5-7

Chlordane in Striped Bass in NY/NJ Harbor Complex
(Concentrations are in ppm-wet wt.)

LOCATION	γ-chlordane[3]	α-chlordane[3]	Transnonachlor[3]	Cis nonachlor[3]	Oxychlordane[3]	Heptachlor Epoxide[3]	γ/α	transnon/ α + oxy	P/M[4]	Σ chlordane
.25MILE NORTHWEST BREEZY POINT[1]	0.02	0.07	0.06	0.03	0.02	-0.01	0.29	0 67	8	0.2
.25MILE NORTHWEST BREEZY POINT[1]	-0.01	0.03	0.07	0.03	0.02	-0.01	<.33	1.40	6.5	0.15
.25MILE NORTHWEST BREEZY POINT[1]	-0.01	0.02	0.02	0.01	-0.01	-0.01	<.5	>.67	>5	0.05
.47MI. NE OF ELLIS ISLAND 1	0.01	0.04	0.06	0.03	0.01	-0.1	0.25	1.20	13	0.15
.48MI. WEST OF NORTON POINT[1]	0 01	0.05	0.07	0.04	0.01	-0.01	0 20	1.17	16	0 18
.5MILE EAST OF LONG BRANCH, NJ[1]	-0.01	0.01	0.01	-0.01	-0.01	-0.01	<1	>.5		0.02
1.5MI. S OF US MILITARY RES. @ ROCKAWAY BEACH[1]	0.01	0.04	0.09	0.04	0.02	-0.01	0.25	1.50	8.5	0.2
2 MILES SOUTH OF WEST END OF CONEY ISLAND[2]	-0.01	0.012	0.011	-0.01	-0.01	-0.01	<.83	>.5		0.023
200YDS. SOUTHEAST OF BREEZY POINT[1]	-0.01	0.01	0.01	-0.01	-0.01	-0.01	<1	>.5		0.02
200YDS. SOUTHEAST OF BREEZY POINT[1]	-0.01	0.01	0.02	0.01	-0.01	-0.01	<1	>1	>4	0.04
CONEY ISLAND[1]	-0.01	0.01	0.02	-0.01	-0.01	-0.01	<1	>1		0.03
EAST OF BERGEN'S POINT AT BUOY H9[1]	0.01	0.02	0.02	0.01	0.01	-0.01	0.50	0.67	5	0.07
EAST OF BERGEN'S POINT AT BUOY H9[1]	0.01	0.04	0.05	0.03	0.01	-0.01	0.25	1.00	12	0.14
EAST OF BERGEN'S POINT AT BUOY H9[1]	-0.01	0.02	0.02	0.01	-0.01	-0.01	<.5	> 67	>5	0.05
EAST OF BERGEN'S POINT AT BUOY H9[1]	-0.01	0.01	0.02	-0.01	-0.01	-0.01	<.1	>1		0.03

Table A5-7

Chlordane in Striped Bass in NY/NJ Harbor Complex

(Concentrations are in ppm-wet wt.)

LOCATION	γ-chlordane[3]	α-chlordane[3]	Transnonachlor[3]	Cis nonachlor[3]	Oxychlordane[3]	Heptachlor Epoxide[3]	γ/α	transnon/ α + oxy	P/M[4]	Σ chlordane
East River[2]	-0.01	0.01	0.01	-0.01	-0.01	-0.01	<1	>.50		0.02
East River[2]	-0.01	0.022	0.029	-0.01	-0.01	-0.01	<.45	>.91		0.051
ELLIS ISLAND BUOY 31[1]	-0.01	0.01	0.01	0.01	-0.01	-0.01	<1	>.50	>3	0.03
GOVERNORS ISLAND NEW YORK CITY[2]	-0.01	0.024	0.03	0.013	-0.01	-0.01	<.42	>.88	>6.7	0.067
Jamaica Bay[2]	-0.01	0.018	0.017	-0.01	-0.01	-0.01	<.56	>.61		0.035
Jamaica Bay[2]	-0.01	0.014	0.017	0.011	-0.01	-0.01	<.71	>.71	>4.2	0.042
Jamaica Bay[2]	-0.01	0.015	0.026	0.014	-0.01	-0.01	<.67	>1.04	>5.5	0.055
JAMAICA BAY EAST OF MARINE PARKWAY BRIDGE[1]	-0.01	0.02	0.03	0.01	0.01	-0.01	<.5	1.00	6	0.07
JAMAICA BAY EAST OF MARINE PARKWAY BRIDGE[1]	-0.01	0.016	0.019	-0.01	-0.01	-0.01	<.63	>.73		0.035
JERSEY FLATS[1]	-0.01	0.01	0.01	0.01	-0.01	-0.01	<1	>.5	>3	0.03
JERSEY FLATS[1]	-0.01	0.02	0.02	0.01	-0.01	-0.01	<.5	>.67	>5	0.05
Kill Van Kull[2]	-0.01	0.014	0.011	0.011	-0.01	-0.01	<.71	>.46	>3.6	0.036
Kill Van Kull[2]	-0.01	0.014	0.016	-0.01	-0.01	-0.01	<.71	>.67		0.03
MANHATTAN BRIDGE[1]	-0.01	0.04	0.04	0.02	0.01	0.01	<.25	0.80	10	0.12
MARINE PARKWAY BRIDGE[1]	-0.01	0.02	0.03	0.01	0.01	-0.01	<.5	1.00	6	0.07
MARINE PARKWAY BRIDGE[1]	-0.01	0.01	0.01	-0.01	-0.01	-0.01	<1	>.5		0.02

Table A5-7

Chlordane in Striped Bass In NY/NJ Harbor Complex

(Concentrations are in ppm-wet wt.)

LOCATION	γ-chlordane[3]	α-chlordane[3]	Transnonachlor[3]	Cis nonachlor[3]	Oxychlordane[3]	Heptachlor Epoxide[3]	γ/α	transnon/ α + oxy	P/M[4]	Σ chlordane
MILL BASIN BRIDGE[1]	-0.01	0.01	0.02	-0.01	-0.01	-0.01	<1	>1		0.03
MILL ROCK ISLAND[1]	-0.01	0.04	0.04	0.03	-0.01	-0.01	<.25	>.8	>11	0.11
MORRIS CANAL BASIN- CENTER OF INLET NEAR WARREN ST.[1]	-0.01	0.02	0.02	-0.01	-0.01	-0.01	<.5	>.67		0.04
MOUTH OF HACKENSACK RIVER BUOY 5[1]	-0.01	0.02	0.02	-0.01	-0.01	-0.01	<.5	>.67		0.03
RARITAN BAY AT BUOY 13[1]	-0.01	0.02	0.02	0.01	-0.01	-0.01	<1	>.67	>5	0.05
ROBBINS REEF[1]	-0.01	0.01	0.02	0.01	-0.01	-0.01	<1	>1	>4	0.04
SE END CROSS BAY BR[1]	0.01	0.02	0.02	0.01	0.01	-0.01	0.50	0.67	5	0.07
SOUTH OF ROOSEVELT ISLAND FOUNTAIN[1]	-0.01	0.03	0.05	0.03	0.01	-0.01	<.33	1.25	11	0.12
UNITED NATIONS BLD.[1]	0.02	0.07	0.06	0.04	0.01	-0.01	0.29	0.75	17	0.2
UNITED NATIONS BLD.[1]	-0.01	0.02	0.03	0.02	0.01	0.01	<.5	1.00	7	0.09
UPPER BAY[1]	-0.01	0.01	0.02	0.01	-0.01	-0.01	<1	>1	>4	0.04
WEST OF RITZ TOWER[1]	-0.01	0.01	0.01	-0.01	-0.01	-0.01	<1	>.5		0.02

FDA action limit-300ppb
All analysis done on standard fillets.

[1] Sampled in 1993.

[2] Sampled in 1998.

[3] Negative numbers are non detects. Number reported is detection limit.

4 Oxychlordane was the only metabolite used in P/M calculation.

Table A5-8

DDT in Striped Bass From the NY/NJ Harbor

Concentrations are in ppm (wet wt.)

FEATURE	LOCATION	pp-DDE	[4] op-DDE	[4] pp-DDD	[4] op-DDD	[4] pp-DDT	[4] op-DDT	pp-DDT/pp-DDE
RARITAN BAY	[1] TWO MILES WEST OLD ORCHARD LIGHT HOUSE	0.049	-0.01	0.022	-0.01	-0.01	-0.01	-0.20
RARITAN BAY	[1] TWO MILES WEST OLD ORCHARD LIGHT HOUSE	0.025	-0.01	-0.01	-0.01	-0.01	-0.01	-0.40
RARITAN BAY	[1] OLD ORCHARD LIGHT HOUSE	0.025	-0.01	0.01	-0.01	-0.01	-0.01	-0.38
NY-NJ HARBOR	[2] WEST OF RITZ TOWER	0.48	0.08	0.19	0.05	-0.01	-0.01	-0.02
NY-NJ HARBOR	[2] UNITED NATIONS BLD.	0.23	-0.01	0.08	-0.01	0.03	-0.01	0.13
NY-NJ HARBOR	[2] UNITED NATIONS BLD.	0.15	0.01	-0.01	-0.01	0.02	-0.01	0.13
NY-NJ HARBOR	[1] STATUE OF LIBERTY	0.088	-0.01	0.027	-0.01	-0.01	-0.01	-0.12
NY-NJ HARBOR	[2] SOUTH OF WILLIAMSBURGH FIXED BRIDGE	0.04	-0.01	-0.01	-0.01	-0.01	-0.01	-0.25
NY-NJ HARBOR	[2] SOUTH OF ROOSEVELT ISLAND FOUNTAIN	0.1	0.01	-0.01	-0.01	0.01	-0.01	0.10
NY-NJ HARBOR	[1] ROBBINS REEF	0.19	0.02	0.1	-0.01	0.02	-0.01	0.11
NY-NJ HARBOR	[1] ROBBINS REEF	0.06	-0.01	0.03	-0.01	0.01	-0.01	0.17
NY-NJ HARBOR	[2] RARITAN BAY AT BUOY 13	0.09	0.01	0.05	0.01	0.01	-0.01	0.13
NY-NJ HARBOR	[2] NY/KING CO BORDER NEAR SUBSTATION; W OF WALL BAY	0.03	-0.01	0.02	-0.01	-0.01	-0.01	-0.33
NY-NJ HARBOR	[2] MOUTH OF HACKENSACK RIVER BUOY 5	0.09	0.02	0.06	0.02	-0.01	-0.01	-0.11
NY-NJ HARBOR	[2] MORRIS CANAL BASIN- CENTER OF INLET NEAR WARREN ST.	0.08	-0.01	0.05	0.03	-0.01	-0.01	-0.13
NY-NJ HARBOR	[2] MORRIS CANAL BASIN- CENTER OF INLET NEAR WARREN ST.	0.09	-0.01	0.03	-0.01	-0.01	-0.01	-0.33
NY-NJ HARBOR	[2] MILL ROCK ISLAND	0.13	-0.01	0.09	-0.01	0.02	-0.01	0.11
NY-NJ HARBOR	[2] MARINE PARKWAY BRIDGE	0.06	-0.01	0.03	-0.01	-0.01	-0.01	-0.17
NY-NJ HARBOR	[2] MARINE PARKWAY BRIDGE	0.03	-0.01	0.01	-0.01	-0.01	-0.01	-0.33
NY-NJ HARBOR	[2] MANHATTAN BRIDGE	0.14	-0.01	0.09	-0.01	0.02	-0.01	0.14
NY-NJ HARBOR	[2] JERSEY FLATS	0.08	-0.01	0.05	-0.01	0.01	-0.01	0.13
NY-NJ HARBOR	[2] JAMAICA BAY EAST OF MARINE PARKWAY BRIDGE	0.11	-0.01	0.09	0.02	0.01	-0.01	0.09

Table A5-8

DDT in Striped Bass From the NY/NJ Harbor

Concentrations are in ppm (wet wt.)

NY-NJ HARBOR	[3] JAMAICA BAY EAST OF MARINE PARKWAY BRIDGE	0.09	-0.01	0.05	0.01	0.01	-0.01	0.11
NY-NJ HARBOR	[3] JAMAICA BAY EAST OF MARINE PARKWAY BRIDGE	0.09	-0.01	0.04	0.01	-0.01	-0.01	-0.11
NY-NJ HARBOR	[3] JAMAICA BAY EAST OF MARINE PARKWAY BRIDGE	0.05	-0.01	0.02	-0.01	-0.01	-0.01	-0.20
NY-NJ HARBOR	[1] JAMAICA BAY EAST OF MARINE PARKWAY BRIDGE	0.025	-0.01	-0.01	-0.01	-0.01	-0.01	-0.40
NY-NJ HARBOR	[1]JAMAICA BAY 2 MILES EAST OF MARINE PARKWAY BRIDGE	0.07	-0.01	0.025	-0.01	-0.01	-0.01	-0.14
NY-NJ HARBOR	[3] ELLIS ISLAND BUOY 31	0.04	-0.01	0.02	-0.01	-0.01	-0.01	-0.25
NY-NJ HARBOR	[3] ELLIS ISLAND BUOY 31	0.03	-0.01	0.01	-0.01	-0.01	-0.01	-0.33
NY-NJ HARBOR	[3] EAST OF BERGEN'S POINT AT BUOY H9	0.07	0.04	0.02	0.01	0.01	-0.01	0.15
NY-NJ HARBOR	[2] EAST OF BERGEN'S POINT AT BUOY H9	0.16	0.04	0.12	-0.01	0.02	-0.01	0.11
NY-NJ HARBOR	[2] EAST OF BERGEN'S POINT AT BUOY H9	0.15	0.03	0.12	0.04	0.01	-0.01	0.07
NY-NJ HARBOR	[2] EAST OF BERGEN'S POINT AT BUOY H9	0.12	0.02	0.1	-0.01	0.01	-0.01	0.08
NY-NJ HARBOR	[2] EAST OF BERGEN'S POINT AT BUOY H9	0.07	0.02	0.05	0.02	-0.01	-0.01	-0.14
NY-NJ HARBOR	[2] EAST END OF QUEENS MIDTOWN TUNNEL NEAR WEST BANK	0.07	-0.01	0.01	-0.01	0.01	-0.01	0.14
NY-NJ HARBOR	2 DUE SOUTH OF LONG BEACH, NY	0.04	-0.01	0.02	-0.01	-0.01	-0.01	-0.25
NY-NJ HARBOR	[2] CONEY ISLAND	0.05	-0.01	0.03	-0.01	-0.01	-0.01	-0.20
NY-NJ HARBOR	[1]BETWEEN HALLETS POINT & WARDS ISLAND	0.06	-0.01	-0.01	-0.01	-0.01	-0.01	-0.17
NY-NJ HARBOR	[1] BAY RIDGE CHANNEL	0.027	-0.01	-0.01	-0.01	-0.01	-0.01	-0.37
NY-NJ HARBOR	[1]200YDS. SOUTHEAST OF BREEZY POINT	0.04	-0.01	0.02	-0.01	-0.01	-0.01	-0.25
NY-NJ HARBOR	[2] 200YDS. SOUTHEAST OF BREEZY POINT	0.04	-0.01	0.02	-0.01	-0.01	-0.01	-0.25
NY-NJ HARBOR	[1] 2 MILES SOUTH OF WEST END OF CONEY ISLAND	0.066	-0.01	0.019	-0.01	-0.01	-0.01	-0.15
NY-NJ HARBOR	[1] 2 MILES SOUTH OF WEST END OF CONEY ISLAND	0.049	-0.01	0.022	-0.01	-0.01	-0.01	-0.20
NY-NJ HARBOR	[1] 2 MILES SOUTH OF WEST END OF CONEY ISLAND	0.039	-0.01	0.018	-0.01	-0.01	-0.01	-0.26

Table A5-8

DDT in Striped Bass From the NY/NJ Harbor

Concentrations are in ppm (wet wt.)

NY-NJ HARBOR	[1] 2 MILES SOUTH OF WEST END OF CONEY ISLAND	0.023	-0.01	0.01	-0.01	-0.01	-0.01	-0.43
NY-NJ HARBOR	[2] 1.5MI. S OF US MILITARY RES. @ ROCKAWAY BEACH	0.1	-0.01	0.03	-0.01	0.01	-0.01	0.10
NY-NJ HARBOR	[3] 72MI. SW OF GOWANUS BAY IN BAY RIDGE CHANNEL	0.03	-0.01	0.02	-0.01	-0.01	-0.01	-0.33
NY-NJ HARBOR	[3] .5MI E OF SANDY HOOK, NJ	0.04	-0.01	0.01	-0.01	-0.01	-0.01	-0.25
NY-NJ HARBOR	[3] .47MI. NE OF ELLIS ISLAND	0.03	-0.01	0.12	0.03	0.03	-0.01	1.00
NY-NJ HARBOR	[3] .25MILE NORTHWEST BREEZY POINT	0.24	-0.01	0.14	-0.01	0.01	-0.01	0.04
NY-NJ HARBOR	[3] .25MILE NORTHWEST BREEZY POINT	0.09	-0.01	0.03	-0.01	0.01	-0.01	0.13
NY-NJ HARBOR	[2] .25MILE NORTHWEST BREEZY POINT	0.03	-0.01	0.01	-0.01	-0.01	-0.01	-0.33
NEWARK BAY	[1] BAYONNE BRIDGE	0.093	-0.01	0.045	-0.01	-0.01	-0.01	-0.12
KILL VAN KULL	[1] GENERAL	0.11	-0.01	0.071	-0.01	-0.01	-0.01	-0.09
KILL VAN KULL	[1] GENERAL	0.062	-0.01	0.011	-0.01	-0.01	-0.01	-0.10
KILL VAN KULL	[1] GENERAL	0.049	-0.01	0.022	-0.01	-0.01	-0.01	-0.20
KILL VAN KULL	[1] GENERAL	0.035	-0.01	0.01	-0.01	-0.01	-0.01	-0.29
JAMAICA BAY	[1] GENERAL	0.085	-0.01	0.027	-0.01	-0.01	-0.01	-0.12
JAMAICA BAY	[1] GENERAL	0.062	-0.01	0.032	-0.01	-0.01	-0.01	-0.18
JAMAICA BAY	[1] GENERAL	0.058	-0.01	0.02	-0.01	-0.01	-0.01	-0.17
JAMAICA BAY	[1] GENERAL	0.041	-0.01	0.018	-0.01	-0.01	-0.01	-0.24
JAMAICA BAY	[1] 1 MILE EAST OF MARINE PARKWAY BRIDGE	0.032	-0.01	0.015	-0.01	-0.01	-0.01	-0.31
JAMAICA BAY	[1] 1 MILE EAST OF MARINE PARKWAY BRIDGE	0.03	-0.01	-0.01	-0.01	-0.01	-0.01	-0.33
JAMAICA BAY	[1] 1 MILE EAST OF MARINE PARKWAY BRIDGE	0.027	-0.01	-0.01	-0.01	-0.01	-0.01	-0.37
HUDSON RIVER	[1] TAPPAN ZEE BRIDGE	0.38	-0.01	0.12	0.027	0.44	-0.01	1.16
HUDSON RIVER	[1] TAPPAN ZEE BRIDGE	0.17	-0.01	0.042	0.012	0.031	-0.01	0.18
HUDSON RIVER	[1] TAPPAN ZEE BRIDGE	0.077	-0.01	0.028	-0.01	-0.01	-0.01	-0.13
HUDSON RIVER	[1] TAPPAN ZEE BRIDGE	0.068	-0.01	0.04	-0.01	-0.01	-0.01	-0.15

Table A5-8

DDT in Striped Bass From the NY/NJ Harbor

Concentrations are in ppm (wet wt.)

HUDSON RIVER	[1] TAPPAN ZEE BRIDGE	0.049	-0.01	-0.01	-0.01	-0.01	-0.01	-0.20
HUDSON RIVER	[1] PIER 40 MANHATTAN	0.053	-0.01	0.021	-0.01	-0.01	-0.01	-0.19
HUDSON RIVER	[3] 1 MI. BELOW GW BR	0.0823	-0.01	0.014	0.0058	0.005	-0.01	0.06
HUDSON RIVER	[3] 1 MI. BELOW GW BR	0.14	-0.01	0.061	0.017	-0.01	-0.01	-0.07
HUDSON RIVER	[2] 1 MI. BELOW GW BR	0.089	-0.01	0.02	-0.01	-0.01	-0.01	-0.11
HUDSON RIVER	[3] 1 MI. BELOW GW BR	0.051	-0.01	0.02	-0.01	-0.01	-0.01	-0.20
HUDSON RIVER	[3] 1 MI. BELOW GW BR	0.025	-0.01	-0.01	-0.01	-0.01	-0.01	-0.40
GOVERNORS ISLAN	[1] GOVERNORS ISLAND NEW YORK CITY	0.13	-0.01	0.063	-0.01	-0.01	-0.01	-0.06
GOVERNORS ISLAN	[1] GOVERNORS ISLAND NEW YORK CITY	0.048	-0.01	0.021	-0.01	-0.01	-0.01	-0.21
GOVERNORS ISLAN	[1] GOVERNORS ISLAND NEW YORK CITY	0.023	-0.01	0.01	-0.01	-0.01	-0.01	-0.43
EAST RIVER	[1] BETWEEN 41ST AND 42ND STREETS	0.19	-0.01	0.097	-0.01	0.024	-0.01	0.13
EAST RIVER	[3] BETWEEN 41ST AND 42ND STREETS	0.089	-0.01	0.039	-0.01	-0.01	-0.01	-0.11
EAST RIVER	[1] BETWEEN 41ST AND 42ND STREETS	0.056	-0.01	0.029	-0.01	-0.01	-0.01	-0.16
EAST RIVER	[3] BETWEEN 41ST AND 42ND STREETS	0.048	-0.01	0.023	-0.01	-0.01	-0.01	-0.21
EAST RIVER	[1] BETWEEN 41ST AND 42ND STREETS	0.031	-0.01	0.018	-0.01	-0.01	-0.01	-0.32
EAST RIVER	[1] BETWEEN 41ST AND 42ND STREETS	0.026	-0.01	-0.01	-0.01	-0.01	-0.01	-0.35

All analysis done on standard fillets.

[1] Samples collected in 1990

[2] Samples collected in 1993.

[3] Samples collected in 1997.

[4] Negative numbers are non-detects. Number reported is detection limit.