NBP-89-20

A Review of Major Research Done in Rhode Island on Polychlorinated Biphenyls in Water, Atmosphere, Sediment, & Biota 151pp

Latimer (URI)

Narragansett Bay Estuary Program

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FOREWORD

The United States Congress created the National Estuary Program in 1984, citing its concern for the "health and ecological integrity" of the nation's estuaries and estuarine resources. Narragansett Bay was selected for inclusion in the National Estuary Program in 1984 and designated an "estuary of national significance" in 1988. The Narragansett Bay Project (NBP) was established in 1985. Under the joint sponsorship of the U.S. Environmental Protection Agency and the Rhode Island Department of Environmental Management, the NBP's mandate is to direct a five-year program of research and planning focussed on managing Narragansett Bay and its resources for future generations. The NBP will develop a comprehensive management plan by December, 1990, which will recommend actions to improve and protect the Bay and its natural resources.

The NBP has established the following seven priority issues for Narragansett Bay:

* management of fisheries
* nutrients and potential for eutrophication
* impacts of toxic contaminants
* health and abundance of living resources
* health risk to consumers of contaminated seafood
* land-based impacts on water quality
* recreational uses

The NBP is taking an ecosystem/watershed approach to address these problems and has funded research that will help to improve our understanding of various aspects of these priority problems. The Project is also working to expand and coordinate existing programs among state agencies, governmental institutions, and academic researchers in order to apply research findings to the practical needs of managing the Bay and improving the environmental quality of its watershed.

This report represents the technical results of an investigation performed for the Narragansett Bay Project. The information in this document has been funded wholly or in part by the United States Environmental Protection Agency under assistance agreement #CX812680 to the Rhode Island Department of Environmental Management. It has been subject to the Agency's and the Narragansett Bay Project's peer and administrative review and has been accepted for publication as a technical report by the Management Committee of the Narragansett Bay Project. The results and conclusions contained herein are those of the author(s), and do not necessarily represent the views or recommendations of the NBP. Final recommendations for management actions will be based upon the results of this and other investigations.

EXECUTIVE SUMMARY

The purpose of the present review was to summarize the major data concerning PCB levels in water, sediment, biota, and the atmosphere in Rhode Island. This review includes all of the major data sets ever generated on PCBs in Rhode Island; it covers the period from the mid-seventies to the mid-eighties. The specific objective of the evaluation of these data was to formulate a comprehensive manuscript detailing the major research done on PCBs, particularly as it relates to spatial and temporal trends in PCB sources, transport, and fate in Narragansett Bay.

Generally, most samples showed measurable concentrations of PCBs. Historical records from riverine samples, atmospheric deposition, and marine water analyses suggested that PCB levels in the seventies were significantly greater than those most recently detected; presumably reflecting the regulatory actions of the Federal Government since that time. However, the Blackstone and the Woonasquatucket Rivers continued to show concentrations (in 1985-86) that were at or above the 14 ng/L EPA, fresh-water chronic criteria, indicating potential harm to aquatic life. Historical inputs to Narragansett Bay from selected fluvial sources were compared to recent inputs. PCB values from the surface sediments of Narragansett Bay exhibited a concentration gradient from the highly industrialized Providence River decreasing to lower levels in the less industrialized lower

bay. There was evidence that the levels observed may be detrimental to marine benthic biota, however, the criteria for these distinctions are still developing. Samples of fish and shellfish, while reflecting a concentration gradient controlled by industrial inputs similar to the sediments, had a smaller range in concentrations. The levels observed were considerably lower than the FDA tolerance criterion, with the possible exception of fish samples from the Pawtuxet River (collected in the early 1970s), which had concentrations at or above the 2 ug/kg wet weight limit.

The highest concentrations observed in the rivers were in the Blackstone and Woonasquatucket Rivers. These two rivers exhibited very different chemical characteristics that appeared to be related to the sources of PCBs within them. The sources of PCBs within the Blackstone River were determined to be largely from the Massachusetts section of the river, outside of the sampling area of a study done in 1985. Reduction in the contaminant concentrations in this river will require a interstate effort. The Woonasquatucket river, in marked contrast, exhibited characteristics that suggested that a major point source(s) was causing the elevated PCB concentrations. Regulatory action relating to this source would presumably reduce the levels in this river.

Mass transport calculations indicated that fluvial sources of PCBs made up approximately 70% (on the average) of the total dry weather input, the remainder was from wastewater point sources. During times of the year when river discharge was minimal, however, the relative contribution from the point sources increased and, under some circumstances, they eclipsed the input from the rivers. It was determined that the Blackstone River was the major riverine source of PCBs; it alone comprised over 60% of the fluvial contribution. The single most significant point source was the Fields Point wastewater treatment facility, which contributed over half of the total wastewater PCB flux.

Utilizing PCB concentrations in surface sediments and mass sedimentation rates, an estimated flux of PCBs via sedimentation was calculated. It was concluded from these calculations that the majority of PCBs entering the sediments could not be accounted for by the dry weather fluvial and point sources evaluated. For example, it was estimated that 21.4 kg of Ar 1254 (a PCB formulation), was transported by the rivers and point sources, on an annual basis, under dry weather conditions; however, the sedimentary flux, was determined to be 63.9 kg/yr. Thus, only about 33% of that which was settling to the sediments could be ascribed to the evaluated sources. It was recommended that studies on other potential sources to the system be undertaken, particularly those relating to the flux of PCBs from rivers and point sources under wet weather conditions as these types of sources have been shown to be important for other contaminants. In addition, atmospheric sources of PCBs should be evaluated; calculations based on data from the

1970s suggested that this source could potentially be significant.

PCB sediment quality criteria, based on the effects of contaminated sediments on benthic infauna have been applied to Narragansett Bay sediments. These criteria, derived from another estuary, indicated that Providence River sediments were contaminated to a sufficient degree to cause ecological distress to indigenous benthic fauna. While its application to Narragansett Bay was tenuous, sediment quality criteria research is another area that is in need of development. Its use as a management tool, for such an important fishery is evident, particularly as dredging of the ship channel and the consequent disposal of the spoils, becomes an increasing problem.

TABLE OF CONTENTS

Page No.

Executive summary..i
Table of contents..v
List of tables...vi
List of figures..viii
Introduction...1

I. Freshwater..11
- A. Ponds and Lakes...12
- B. Rivers..14
  1. Pawtuxet River..15
  2. Blackstone River..17
  3. Taunton, Moshassuck, and Wooasquatucket..20
- C. Point sources...22

II. Atmosphere...26

III. Mass inputs...28

IV. Marine water...34
- A. Chemical distribution...34
- B. The role of plankton..41

V. Sediments...46
- A. Freshwater sediments..46
- B. Marine sediments..48a
  1. Surface sediments...48a
  2. Sediment cores..54

VI. Biota..58
- A. Freshwater organisms..58
- B. Marine organisms..60
  1. Fish..60
  2. Mussels (*M. edulis*)...60
  3. Quahogs (*M. mercenaria*).......................................62

Summary and recommendations..65
References...67
Appendix A. Study locations..76
Appendix B. River data...101
Appendix C. Point source data..111
Appendix D. Water column data..116
Appendix E. Sediment data..118
Appendix F. Historical data set evaluation sheets........123

LIST OF TABLES

Table No.		Page No.
1	Concentration of PCBs in fresh-water of Rhode Island. . .	13
2	Point sources evaluated in studies from 1984-1986. . . .	25
3	Removal rates of PCBs and DDT from the atmosphere under dry conditions, Kingston, RI.	27
4	Mass inputs of PCBs to Narragansett Bay from fluvial and point sources.	33
5	Concentration of PCBs in Narragansett Bay water column and surface microlayer.	37
6	Mean PCB concentration in water in various regions of the Narragansett Bay ecosystem.	38
7	Concentration of PCBs and other chlorinated hydrocarbons in freshwater sediments of Rhode Island.	47
8	Concentrations of selected organochlorine compounds in sediment determined by the USGS (ng/gm dry) from 1978-1983.	48
9	PCB concentration in a sediment core taken from Rhodes-on-the-Pawtuxet River site (1983).	49
10	National status and trends program summary of PCBs in surface sediment (ng/gm dry wt.).	51
11	Summary of ERCO sediment analyses of sites near Newport WWTF outfall.	53
12	Mass balance data for PCBs added to MERL tanks during the sludge experiment.	55

Table No. Page No.

13 Mass budget for PCBs in Narragansett Bay under dry weather conditions. 56

14 Concentration of PCBs and other chlorinated hydrocarbons in freshwater fish of RI. 59

15 National status and trends program summary of PCBs in fish and shellfish (ng/gm dry wt.). 61

16 Approximate concentration of PCBs (as Ar 1254 and 1260) in mussels and transplanted mussels from Narragansett Bay; concentrations in ng/gm dry wt. 63

17 PCB concentrations in quahogs from Narragansett Bay in 1985 and 1986; concentrations are in ng/gm dry wt. . . . 64

LIST OF FIGURES

Figure No.		Page No.
1	Concentration of PCBs in the Pawtuxet and Blackstone rivers from 1978 to 1986	16
2	Concentration of PCBs in the Blackstone River 1985	19
3	Discharge-concentration relationships for the Blackstone and Woonasquatucket rivers (1985-1986)	21
4	Concentration of PCBs in selected rivers (1985-1986)	23
5	Concentration of PCBs in selected point sources (1984-1986)	24
6	Estimated PCB input rates to Narragansett Bay from the Blackstone and Pawtuxet rivers (1978-1986)	29
7	Relative PCB inputs from rivers evaluated in the 1985-86 surveys	30
8	Relative PCB inputs from point sources evaluated in the 1985-86 surveys	31
9	Relative inputs of PCBs from point sources and rivers for the October, 1985 and April, 1986 surveys	35
10	Concentration of CB138 in the water column of Narragansett Bay (1985-1986)	40
11	Ar 1254 concentration versus Chl-a for surface waters of Narragansett Bay (1985-1986)	44
12	Ar 1254 concentration versus Chl-a for surface waters of Narragansett Bay (all stations) by date	45
13	Concentration of Ar1254 in surface sediments of Narragansett Bay	50
14	Concentration of PCBs in cores collected in the 1970s	57

INTRODUCTION

Polychlorinated biphenyls (PCBs) were first identified as an environmental contaminant in 1966 by Swedish investigators (Jensen, 1966). Upon further investigation, these compounds were found to be widespread in the environment; they have been detected in remote areas, great distances from where they have been used (Tanabe et al., 1983; Atlas and Giam,1981).

PCBs are a class of compounds known to have physical and chemical properties that make them useful for industrial applications. These properties, however, also make them problematic in terms of environmental contamination; they are resistant to degradation and therefore persistent in the environment. PCBs are stable to hydrolysis and oxidation reactions, resist photodegradation and have low water solubilities (Mabey et al., 1982) They also have dielectric characteristics that make them very good resistors of electrical current and, furthermore, they exhibit fire retardent and pesticidal properties.

PCBs are extremely lipophilic, they accumulate in the fatty tissues of animals, making them, not only persistent in the abiotic environment, but cumulative in the food webs. Precisely because of these properties and the experiences with PCBs, the National Academy of Sciences has recommended that widespread use of compounds that are both persistent and lipophilic should be considered suspect and alternative substances developed (NAS, 1979).

The principal industrial uses of PCBs were: dielectric fluids (i.e., electrical transformers and capacitors: produced from before 1957 through 1977), plasticizers (e.g., rubber, adhesives, textiles, sealants, surface coatings: produced from before 1957 through 1971), carbonless copy paper (production ending in 1971), hydraulic systems/lubricants (e.g., die casting, steel production: produced from before 1957 through 1971), fire retardents (production ended in 1971), heat transfer applications (production from 1962-1972), miscellaneous industrial fluids (e.g., gas turbines, vacume pumps: produced from before 1957 through 1971), incorporation into pesticide formulations (productions ended in 1971) and as an industrial lubricant additive (1969 only) (Anon., 1979; Hutzinger et al., 1974).

PCBs have been produced in large quantities by the Monsanto Co. in the United States, under the trade name Aroclor, from the 1950s through 1977, when sales were restricted. They are usually formulated into mixtures of individual compounds with a prescribed chlorine content. These materials are designated by a 4 digit number, the first two digits indicate the biphenyl skeleton and the last two digits indicate the percentage, by weight, of chlorine in the mixture. For example, Ar 1254 has 54% chlorine by weight and would have a certain distribution of individual chlorobiphenyl (CB) molecules that together, yield the appropriate chlorine content (e.g., for Ar 1254, mainly penta, hexa, and hepta chlorinated constituents. One exception to these rules of nomenclature is Ar 1016; this formulation is chemically similar to Ar 1242). These formulations have been produced since 1930, but accurate production and sales records can only be determined from 1957 onward. U.S. PCB production in the period from 1930 to 1977 has been estimated to be somewhere between 5.0-6.8 x 10^8 kg and domestic sales throughout this period have been estimated to be 4.5-5.9 x 10^8 kg (Durfee et al., 1976). From Monsanto records, the total domestic sales of PCBs in the period from 1957 through 1977 was 3.92 x 10^8 kg (Anon., 1979). Thus, the bulk of the production and sales of these compounds were in the period from 1957 through 1977. Of this amount, 70% has been sold for closed system uses (e.g., electrical capacitors and transformers) while the remaining 30% were sold for open uses such as lubricants, hydraulic fluids, carbonless carbon paper, plasticizers, in heat transfer systems and even as petroleum additives (Anon., 1979). The production of PCBs in the U.S. was voluntarily stopped in 1977 and, subsequently, banned, legislatively, in 1979. Approximately 65% of the total PCBs produced in the period from 1957-1977 were Ar 1242 formulations (as well as the chemically similar Ar 1016); their primary use was in capacitors, synthetic rubber, carbonless carbon paper, and as wax extenders. Ar 1254 made up 16% of the total PCB production and was mainly used in transformers, whereas Ar 1260 made up 11% of the production and was used in transformers, hydraulic fluids, synthetic resins, and as dedusting agents (Durfee et al., 1976).

Even though applications of PCBs may have been within closed systems, improper handling, storage and disposal has been a cause of much environmental contamination. For example, it has been estimated that as much as 3.00×10^5 kg of PCBs contaminated the Hudson River from the General Electric Company through improper handling, storage, and disposal of capacitors during the period from 1950-1977 (Brown et al., 1985; NAS, 1979). Initially, a dam near the point of entry contained the contaminated sediments but in 1973 it was removed and an estimated 650,000 m^3 of contaminated sediment were released; the effects of which have been observed hundreds of miles downstream in elevated levels of PCBs in sediments and in aquatic organisms. As of 1978, an estimated 2.2×10^5 kg of PCBs still remained in the river system (Brown et al., 1985). The PCB content of fish, invertebrates, vertebrates, and water, however, was declining. The partitioning of PCB mixtures between water and sediment was important in the observed composition in the sediments and water (Bush, et al., 1985; Bopp, et al., 1981). The decrease in the concentration of PCBs in the sediments was due to dilution and burial (Bopp, et al., 1981). Desorption of PCB residues from the sediment affected the levels observed in the water column and therefore in the indigenous fish (Brown et al., 1985). Striped bass apparently still have levels that exceed the 2 ppm limit set by the FDA (White et al., 1985). Mussels, used to indicate areas of contamination, showed higher levels in the New York bight than in non-urban areas (Farrington et al., 1983) and may reflect the selective uptake of congeners (Stainken and Rollwagen, 1979).

The estuary around the Acushnet River and New Bedford Harbor in Massachusetts can be considered one of the most highly contaminated marine areas for PCBs. Water concentrations have been shown to approach 1,000 ng/L in this locality (Weaver, 1984).

Public health. Studies have also been done to assess the toxicology of PCBs. Hutzinger and colleagues (1974) have reviewed the research and reported that chronic exposure to these compounds in humans causes fatty degeneration of the liver, a dermal condition known as chloracne, and low birth weight in newborns. In cases of acute exposure, these compounds have been found to cause yellow atrophy of the liver (Hutzinger et al., 1974) as well as elevated hepatic enzymes indicative of liver damage (Schecter, 1987). Various toxicity effects have been observed: (in lower animals) death of salmon eggs and chicken eggs, reproductive failure in mink, mixed function oxidase enzyme induction in mice and catfish (Ankley et al., 1986), hepatocarcinogenicity, neoplasmic changes in rat liver, liver injury in rabbits, fetopathy and gastric mucusal hyperplasia in primates (Hutzinger et al., 1974). Therefore, these compounds could have a significant effect on human health and their input rates and distribution in Narragansett Bay are in need of a thorough study.

Ecological effects. Studies of the uptake of compounds have indicated that three principal modes of entry into the organism are possible: ingestion of residues in food, integumental adsorption, or inhalation (i.e., for aqueous species: partitioning from the water through the gills).

Integumental adsorption is probably of minor importance, at least for fish (Robinson, 1976). The compound residues in the organism can be influenced by the level of contamination in the medium in which it lives as well as the level in the food eaten. An investigation on the demersal fish *Leiostomus xanthurus* indicated that both dietary uptake (primarily) and accumulation of PCBs directly from contaminated sediment were responsible for the body burdens detected (Rubinstein *et al*., 1984). Thomann and Connolly (1984) showed that 99% of the PCB body burden of lake trout was due to food chain exposure and not through adsorption processes. In addition, researchers have concluded that diet was the main factor in the PCB contamination of striped bass in the Hudson River (White *et al*., 1985; O'Connor and Pizza, 1987). Significant correlations have been determined between daily dietary doses of pesticides (e.g., DDT) and the body burdens in various vertebrates (Robinson, 1976). Although correlations do not directly imply causation, by controlling some variables, explicit relationships have been derived between the concentration of a pesticide in a particular tissue and the dietary intake of the pesticide (Robinson, 1976). In contrast, Sodergren (1987) showed that the uptake pattern of lipophilic compounds was similar in solvent filled membranes, to those of fish, copepods, and plankton; indicating that uptake of these types of compounds was due to passive partitioning from the water. The uptake and distribution of certain PCBs by fish have been related to structural characteristics of the chemical with respect to steric effects and metabolic activity (Shaw and Connell, 1984; Boon and Duinker, 1985a,b).

In filter feeding animals the relationship of the sediment concentrations to the body loadings appears to be greater. Nimmo and coworkers (1971) found that PCBs were taken up by Fiddler crabs and shrimp either by ingesting particles or by direct adsorption from the water. In another study, uptake of petroleum hydrocarbons by the filter feeding bivalve, Mytilis edulis in contaminated sediment was apparent over a 24 hour time frame (DiSalvo et al., 1975). Pruell and coworkers (1986) found uptake of both polycyclic aromatic hydrocarbons (PAHs) and PCBs by M. edulis after exposure to contaminated sediment. Their experiments suggested that the uptake was from the dissolved phase. Evidence for dissolved phase partitioning has been presented for other invertebrates (Boon and Duinker, 1986). In experiments with both filter feeding and deposit feeding invertebrates, contaminants associated with the sediment pore waters were thought to be the major source of the body burdens observed (Roesijadi et al., 1978). This seems to be a reasonable hypothesis since pore waters have been shown to be very high in colloidal organic matter and associated hydrophobic contaminants (Brownawell, 1986; Brownawell and Farrington, 1986).

Equilibrium partitioning of PCBs from the water column is thought to be the major mechanism for uptake of hydrophobic contaminants by aquatic plankton. Evidence for partitioning has been derived from the predictive ability of physical-chemical parameters such as K_{OW} and aqueous solubility to estimate the bioconcentration factors (BCFs) in alga, and zooplankton (Mailhot, 1987; Pavlou and Dexter, 1979; Clayton et al., 1977). PCBs have been detected in plankton from various regions of the world ocean. Large concentrations of PCBs have been observed in plankton in the North Atlantic and yet food chain magnification could not be proved among pelagic gilled fish (Harvey et al., 1974). In an elegant study, Oliver and Niimi (1988) have shown, in the lentic environment, that, differential uptake of PCB congeners from the water phase at the lower trophic levels (plankton and shrimp) was occurring and they also demonstrated food chain accumulation and bioconcentration at the upper trophic levels (fish).

Thus, research has shown that dietary uptake as well as adsorption phenomena are active mechanisms in the accumulation of organic pollutants by both aquatic plant and animal organisms. PAHs, PCBs, pesticides, and petroleum hydrocarbons have been observed to accumulate in benthic species in amounts higher than sediment loadings and this accumulation appears to increase while the organisms are in the contaminated areas. PCBs levels in plankton and in other lower trophic level organisms are related to their partitioning from the aqueous phase. In gill breathing fish the body burdens seem to be due to water partitioning and dietary uptake, although the specific dietary preferences of the animal play a role in the relative magnitude of the two uptake mechanisms.

Analytical considerations. The measurement of PCBs in environmental samples is not without its difficulty and an adequate understanding of the pitfalls and nuances of the analysis is necessary for the best analytical results. Experience in the extraction and quantification of organic and, especially halogenated organic compounds in a variety of samples matrices is one of the best ways to ensure quality data. Most analyses involve the extraction of the samples with organic solvents followed by some type of cleanup step. This cleanup step is usually based on the differences in affinity of the varied classes of organics dissolved in the organic solvent to different adsorbents or coatings in adsorption or partition chromatography. Thin-layer or column adsorption chromatography are most frequently used, with florisil or silica-gel, the major adsorbents. Once the sample is fractionated, concentration and injection into gas-chromatographic (gc) instrumentation is the method of choice for detection, using a halogen selective detector. Typically this is an electron capture detector.

In the early years of PCB analysis, gas chromatographic separations were achieved using packed columns. This led to relatively poor separation of the numerous individual isomers and congeners in the Aroclor mixtures and less sensitive detection. When PCBs were first observed in the environment, and up until quite recently, they were generally characterized by matching a few broad humps from the chromatograms to those of the specific technical mixtures of Aroclor. This was sufficient to understand if an area had PCBs present and to what degree; however, for an understanding of toxicological and ecosystem dynamics, the distribution of the individual congeners is particularly important. Recently, glass and most recently, fused silica capillary gc columns have led to a significant advancement in the detection of these compounds. For the present considerations and due to the fact that an historical context is sought, PCB data will generally be presented in the form of "the most similar to" a particular Aroclor equivalent. It should be realized that increasingly, with the advent of the more efficient columns and most recently, gc-ms detection, that PCB data will, in the future, and indeed, at the present time, involve congener specific detection or at least chlorinated cluster detection. These types of data will eventually eclipse the older Aroclor based concentration results.

Competency in the analyses of PCBs should be demonstrated by suitable QC/QA programs in each laboratory and would be required for confidence in the analytical results. Any program should include an evaluation of sources of contamination and blank determinations. Precision and accuracy measurements, by comparison with analyses of relevant reference materials available from various agencies such as the NBS and EPA, are essential for the highest quality data.

The following review will serve as a summary of the data that have accumulated on PCBs in Rhode Island since the early seventies when the first research was done. Various sources were used in this compilation, some were from the open scientific literature while others were unpublished data or data that were in the process of being published, and still others were from government monitoring studies. The locations of most of the sampling sites for the various studies can be found in Appendix A. Included in this appendix are maps that were in the various source publications. In many cases latitude and longitude coordinates are also presented but in some cases this was not done due to insufficient information from the sources themselves.

DISCUSSION

I. PCBs in freshwater

PCB data for the freshwaters in RI mainly come from U.S. Geological Survey (USGS) river monitoring programs (U.S. Geological Survey, 1986; 1985; 1984; 1983; 1982; 1981; 1980; 1979) or projects funded by the Rhode Island Department of Environmental Management (RIDEM) or the EPA such as the recent URI studies (Quinn *et al.*, 1988, 1987a, 1987b, 1985). Because there is no consistent fiscal structure to continue river monitoring studies such as these, the data tend to be spotty and historical trends are obscured by the paucity of data and analytical uncertainties. However, some data are available that may be useful.

A. Ponds and Lakes

Most of the original work was done by scientists under the aegis of Prof. Charlie Olney (1972) at URI and was funded by the Rhode Island Water Resources Research Program. In 1972 water samples from many freshwater ponds and rivers were collected and analyzed (Table 1). Unfortunately, the water samples were not filtered to derive any information on the relative importance of dissolved and particulate species. In addition, the analytical methods at the time only allowed detection to about 50 ng/l, not sensitive enough from a biogeochemical standpoint. It was found, in this study, that no PCBs were present above the 50 ng/L detection limit in any of the lakes and ponds of the state with the possible exception of the Pawtuxet River where many unexplained peaks were observed in the halogenated fraction of the sample extracts.

Table 1. Concentration of PCBs in freshwater of Rhode Island.

Location	PCBs type	PCBs ng/l	PESTICIDES (ng/L) DDE	PESTICIDES (ng/L) DDD
1). Slatersville Res.	ND	ND	ND	ND
2). Nichols Pond	ND	ND	ND	ND
3). Keech Pond	ND	ND	ND	ND
4). Waterman Reservoir	ND	ND	ND	ND
5). Woonasquatucket Res.	ND	ND	ND	ND
6). Olney Pond	ND	ND	ND	ND
7). Scituate Reservoir				
a. Bridge 251; Rt 116	ND	ND	ND	ND
b. Stream from Bard. Res.	ND	ND	ND	ND
c. Str. from Westcon. Rv.	ND	ND	ND	ND
8). Str. from Flat Riv Res.	ND	ND	ND	ND
9). Pawtuxet River and tributaries*				
a. At mouth	Sample contained many unidentified peaks			
b. Elmwood A..	Sample contained many unidentified peaks			
c. Print Wks Pd.	Sample contained many unidentified peaks			
10). Alton Jones Pond	ND	ND	ND	ND
11). Belleville Pond	ND	ND	ND	ND
12). Annaquatuc. Riv.; Rt 1	ND	ND	ND	ND
13). Bissells Cove	NC	NC	NC	NC
14). Indian Lake	ND	ND	ND	ND
15). Card Pond	ND	ND	ND	ND
16). Yawgoog Pond	ND	ND	ND	ND
17). Ell Pond	ND	ND	ND	ND
18). Moscow Brook	ND	ND	ND	ND
19). Locustville Pond	ND	ND	ND	ND
20). Yawgoo Pond	ND	ND	ND	ND
21). Hundred Acre Pond	NC	NC	NC	NC
22). Thirty Acre Pond				
a. North end	ND	ND	ND	ND
b. Below turf dr. pipe	ND	ND	ND	ND
23). Larkins Pond	NC	NC	NC	NC
24). Wordens Pond	NC	NC	NC	NC
25). Tuckers Pond	ND	ND	ND	ND
26). Wood River Pond	ND	ND	ND	ND
27). Brickyard Pond	ND	ND	ND	ND
28). One Hundred Acre Cove	ND	ND	ND	ND
29). Easton Pond				
a. West	ND	ND	ND	ND
b. East	ND	ND	ND	ND
30). Jamestown Reservoir	ND	ND	ND	ND
31). Pond off Rt 3, Cov.	NC	NC	NC	NC
32). Melville Pond	ND	ND	ND	ND

ND = <50 ng/L; NC = not collected

* See tables of river data for more recent information.

Source: Olney, 1972.

B. Rivers

In order to facilitate a more scientific basis for the wasteload allocation of industrial and municipal permits in the various rivers in the state, the RIDEM in cooperation with the USEPA had contracted with URI-GSO to design and complete studies of the Pawtuxet (PR), Pawcatuck, and Blackstone (BR) Rivers. Since the latter part of 1984 the Organic Geochemistry Laboratory at GSO has developed and enhanced methods for the accurate detection of PCBs and other selected organochlorine compounds in environmental samples. Raw data for all the water quality stations analyzed in these studies are given in Appendix B. In addition to this detailed work on these rivers, the Narragansett Bay Project recently funded the study of these rivers (excluding the Pawcatuck) and including the Moshassuck (MR), Woonasquatucket (WR), and the Taunton (TR) with an emphasis on their impact on the bay ecosystem. These data are also found in Appendix B. It should be noted that whereas some samples from the Blackstone River and other studies showed a soluble component of the total PCB concentration, generally, most of the PCBs were detected in the particulate fraction of the samples. This was especially prevalent in the saline water samples and may reflect the flocculation of soluble PCBs that are present in freshwater as the salinity increases. The Pawcatuck River, while not evaluated in detail in the present review, had the highest proportion of soluble PCBs and this was most likely due to the presence of high amounts of dissolved and colloidal organic matter (which gave the river its tea colored water). A brief review of the major findings for the most important rivers is following.

The Pawtuxet River. The trends in concentration of PCBs for the Pawtuxet River from 1978-1986 are shown in Figure 1A. The results were quite startling in that over an eight year period the concentration seems to have dropped from a maximum of 4.3 ug/L to about 5 ng/L. A logarithmic ordinate was necessary to adequately view the data. The drop in concentration may have been even more precipitous because the values determined by the USGS for the 1982 through 1984 water years were below their detection limit of 100 ng/L and the river may have been at the levels typically found by our lab in 1984 and following. One can only speculate as to the cause of the drop as well as what the levels were before 1978. Is it a coincidence that the maximum in observed concentrations coincides with the termination of PCB production? Whatever the cause of the trend, it appeared that the discharge dynamics of the river were not significant because the water discharges during the 1978 and 1979 water years were very similar to the period from 1985 and 1986 despite the tremendous concentration differences. Information from sediment cores will help in the interpretation of these data.

Since the concentration of a constituent within a river will depend on the amount of flow in the river due to the effects of dilution and sediment transport, discharge-

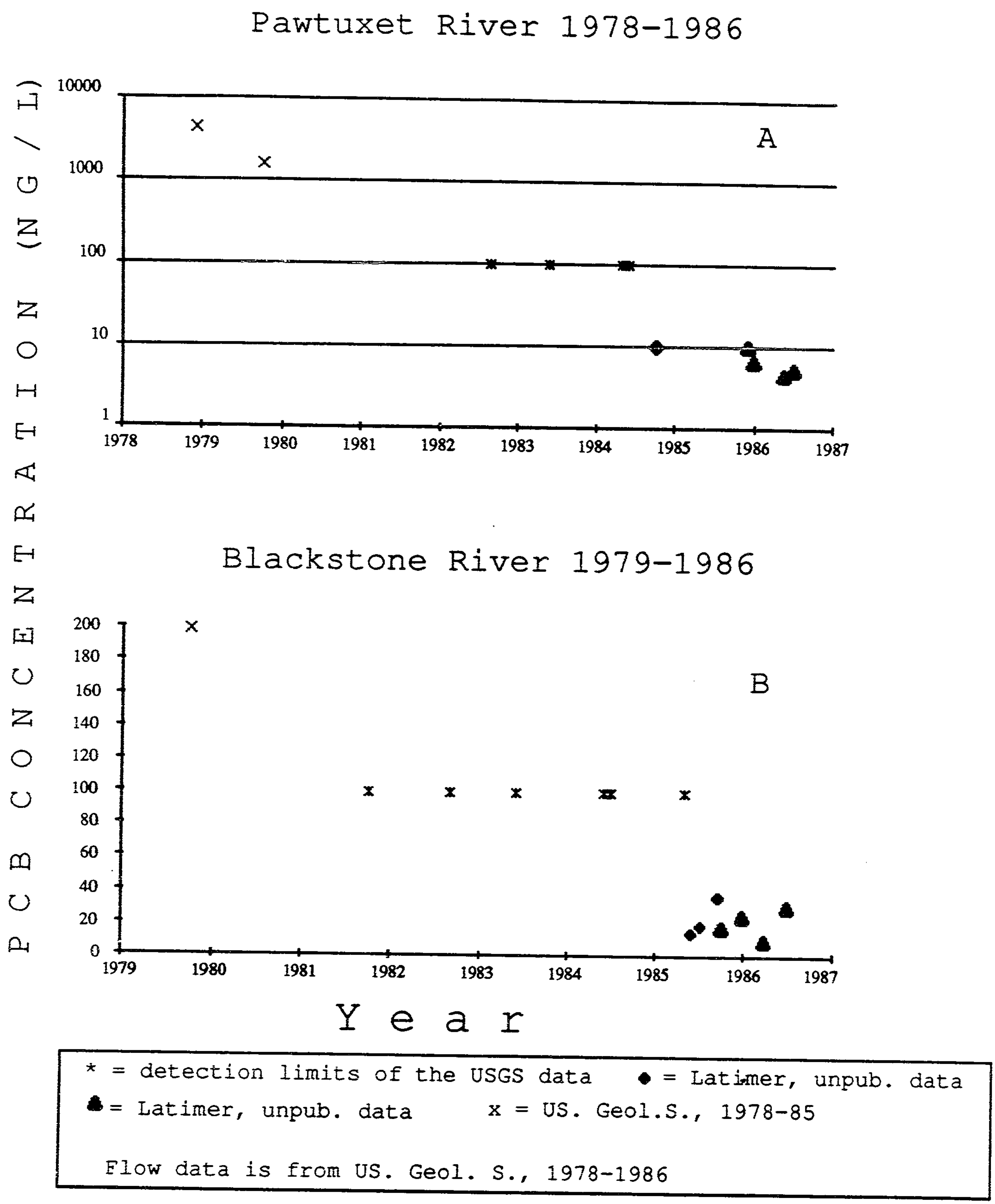


Figure 1. Concentration data of PCBs in the Pawtuxet and Blackstone rivers from 1978 to 1986.

concentration relationships can help in the interpretation of trends over time. For a constituent associated with particles within the river, a negative slope in a flow versus concentration graph would indicate dilution of point source discharges by the river water. Implicit in this assertion is the assumption that levels of the contaminant in the river water are at a lower concentration than in the point source effluents. Erosion of contaminated bottom sediment would cause a positive slope in this type of graph. A positive slope would also be present if the source waters for the river (i.e., headwaters, groundwater) had higher concentrations than the ambient water. Discharge/concentration data for the period from 1985 through 1986 for the Pawtuxet River indicated no clear trends in the data. It should be kept in mind that this type of interpretation rarely leads to a "classical" sediment scouring or point source controlled system, rather, in practice, a combination of these factors is operating.

The Blackstone River. Historical PCB concentrations in this river indicated a significant decrease in the PCB levels from 1979 (200 ng/L) to the present (~10-35 ng/L) (Figure 1B). Although the decrease was not nearly as drastic as was observed for the Pawtuxet River, the data still suggested a major change in the PCB signal that was reflective of the regulatory actions of the late seventies. Data indicated that causes other than flow differences must account for the discrepancies in concentrations over the period, since the flow regime of the river in 1979 was similar to the regime of the more recent period.

Present PCB levels in the Blackstone River were at or exceeded the chronic toxicity level of 14 ng/L as set by the EPA and the causes of the relatively high concentrations will have to be addressed with respect to future usage of the river.

A study of the distribution of these compounds within the Blackstone River system itself revealed that the sources were not from the wastewater treatment facilities (WWTF) nor the industries that discharged along the Rhode Island section of the river (Quinn et al., 1987b). Sampling locations for this study are shown in the map in Appendix A. Results of the analysis of water samples indicated that the headwaters started out relatively contaminated and a general decrease in concentration with distance downstream was observed (Figure 2). This led to the hypothesis that the Massachusetts section of the river was controlling the PCB distribution throughout its Rhode Island journey. Mathematical modeling of suspended solids and other pollutants using a one dimensional steady state model also indicated that the water quality of the Blackstone in Rhode Island was controlled primarily by the Massachusetts contribution (Wright, 1988). A detailed discussion of other aspects of the behavior of PCBs in this system can be obtained from Latimer (1989a).

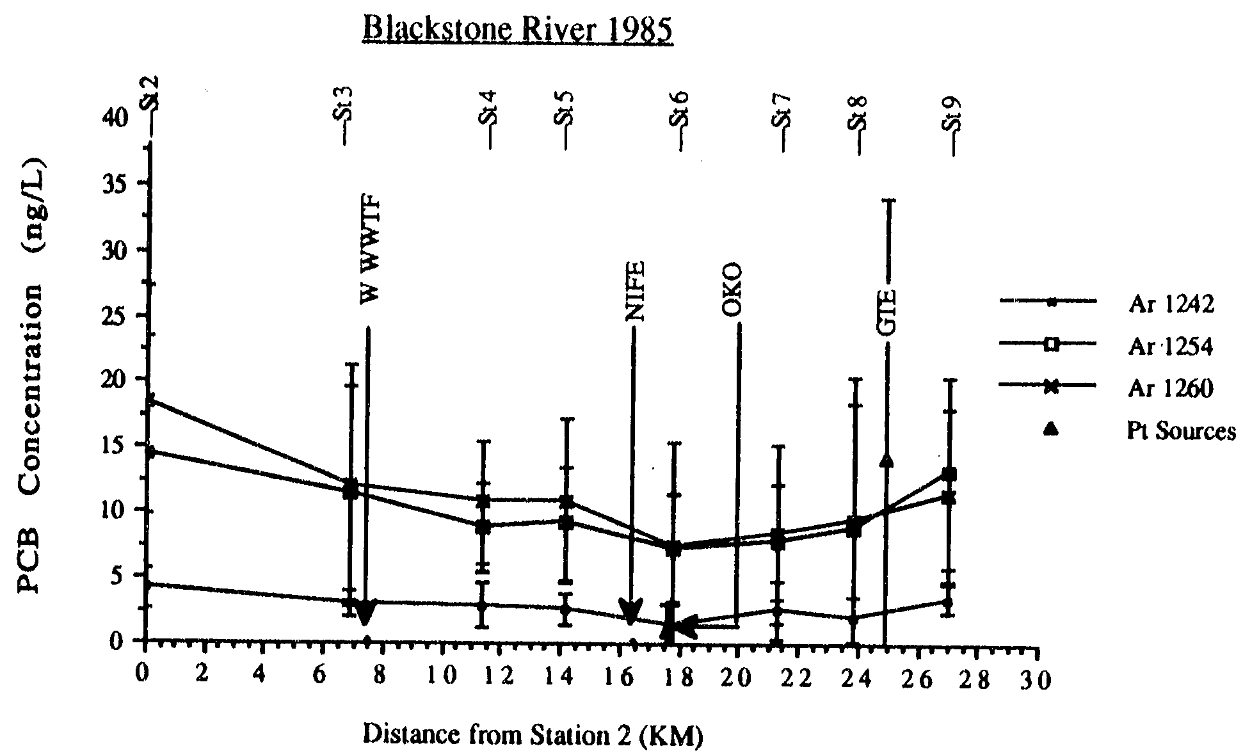


Figure 2. Mean concentration of PCBs in the Blackstone River, 1985. Error bars represent one standard deviation from the means calculated (n=3 for most data). The line is a linear interpolation between data points. See Appendix A, Figure A-I-7 for sample locations. Source: Latimer, 1989a.

The discharge-concentration relationship for the Blackstone River indicated a system that was subject to significant PCB contamination due to sediment resuspension during times of higher flow (Figure 3A). One relationship seemed to be operating in the discharge range of less than 1,000 million liters per day (MLD). Whereas the discharge-concentration relationship during periods of exceptionally high flows (e.g., 2,000-4,000 MLD) gave a different relationship (Figure 3A).

The Pawcatuck River will not be included in the discussion since it does not affect the Narragansett Bay system directly although it does influence Rhode Island Sound. Results of a detailed survey of this river during 1984 and 1985 can be found in Appendix B (Quinn *et al*., 1987a).

The Taunton, Moshassuck and Woonasquatucket Rivers. The only available PCB information on these rivers was from the samples taken during the bay wide cruises of 1985-86 (Latimer, 1989a; 1989b). Concentration data can be found in the appendices (Appendix B). From these data, discharge-concentration relationships have been derived. The levels for the Taunton and Moshassuck Rivers were quite variable, so no inferences were drawn from these results. The data for the Woonasquatucket River were remarkably consistent with a system that was point source controlled (Figure 3B). The graph illustrates that during periods of higher river discharges, the PCB levels were at a minimum. An

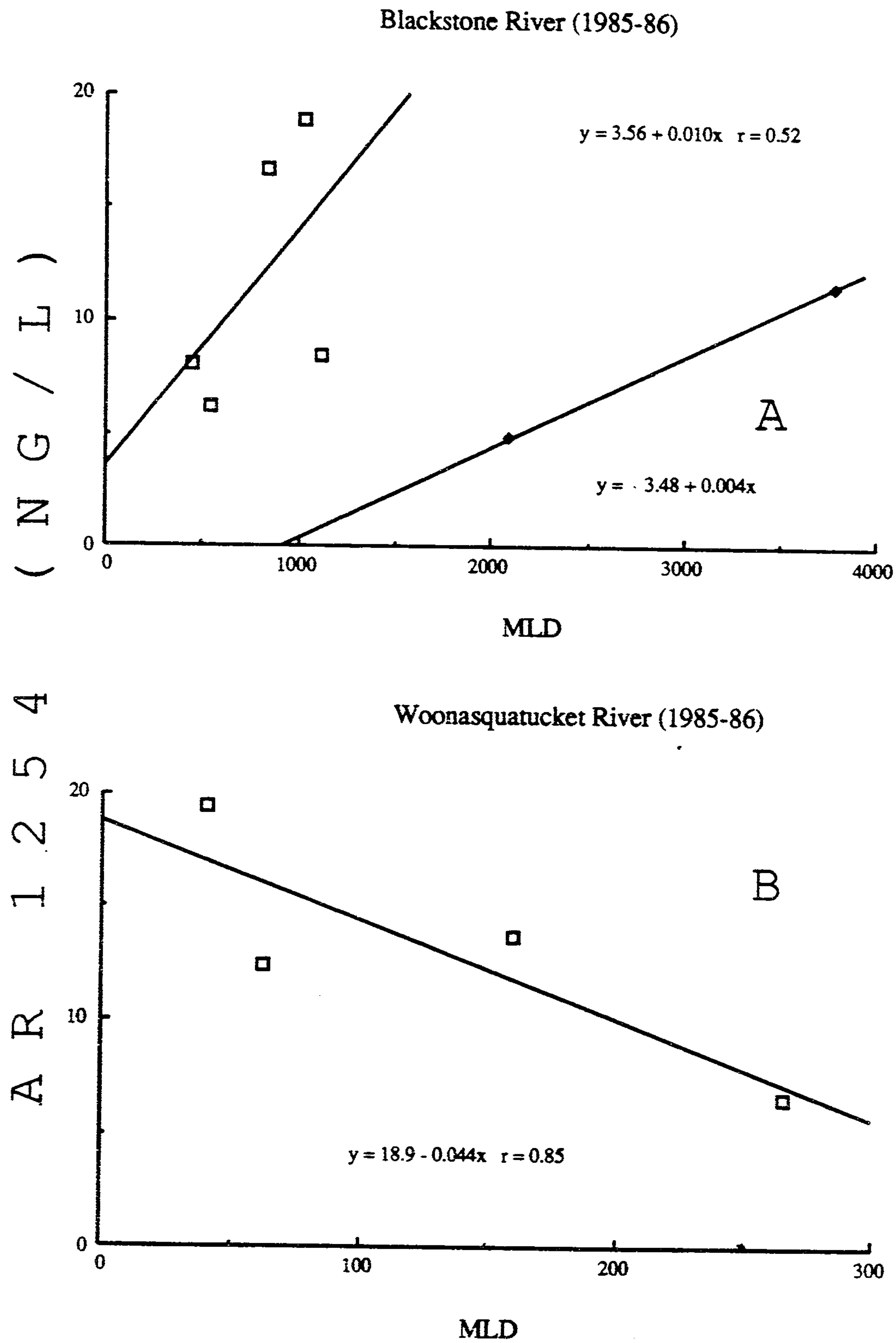


Figure 3. Discharge-concentration relationships for the Blackstone and Woonasquatucket rivers (1985-86). Flow data are from U.S. Geological Survey, 1985-86 and were not corrected for ungauged flow between gauge location and sampling station location.

investigation of the point source effluents along the river would be extremely enlightening; and, if the PCB source could be isolated, it appears that concentrations could be brought under control. This is especially important since the Woonasquatucket River showed the highest average concentration of PCBs of all the rivers evaluated (Figure 4). It was significantly higher than the chronic fresh-water criteria set by federal and state authorities.

C. Point sources

Available data on the PCB content of industrial and municipal effluents are extremely sparse since these constituents are not typically determined for compliance with state and federal permit regulations. The data have been derived from the the various studies (Latimer, 1989a; Quinn et al., 1987a; Quinn et al.,1987b; Quinn et al., 1985). Complete data sets organized by river basin in the case of the URI-GSO river studies and by cruise date in the case of the bay wide data are presented in Appendix B. Figure 5 depicts the PCB data, generated since 1984 in our laboratory, for all the industrial and municipal effluents that impact on Narragansett Bay or its tributaries. Table 2 lists the complete names of the point sources as well as the bodies of water into which they discharge. For the sake of clarity, facilities that showed no detectable PCB levels were not included in the figure; they included: Woonsocket WWTF, S. A. B. Nife (an industrial effluent), and American Hoechst (an industrial effluent). Concentration ranges for those

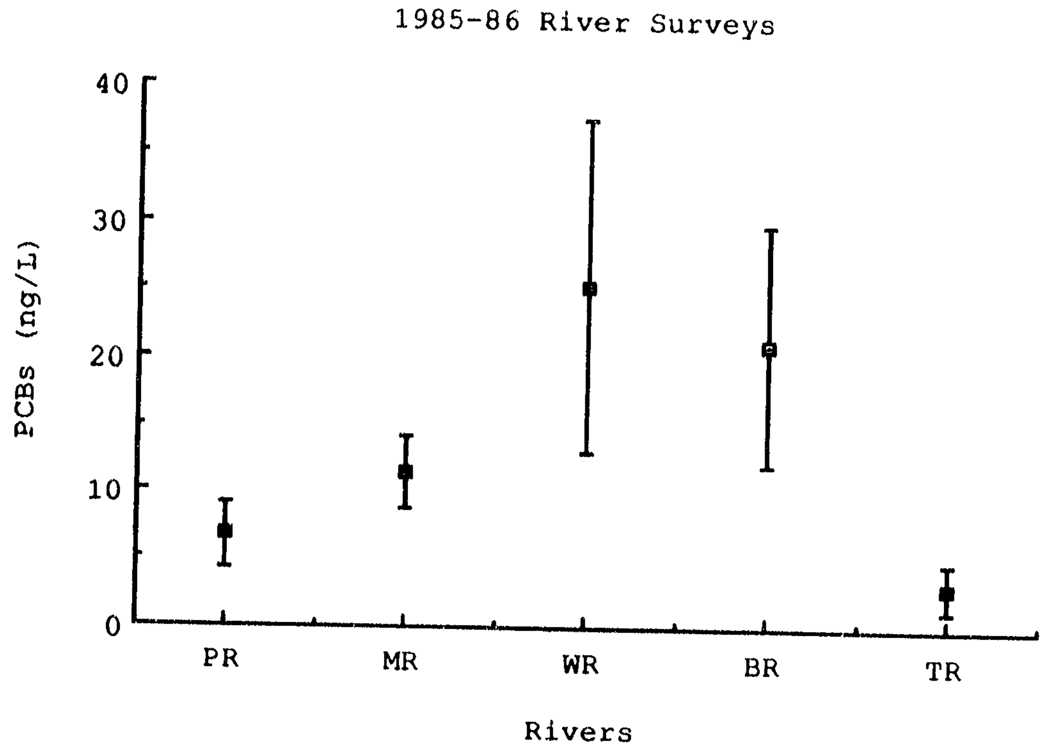


Figure 4. Mean concentration of PCBs in selected rivers (1985-86). Error bars represent one standard deviation from the mean (n=4 for each data point). Source: Latimer, unpublished data. PR = Pawtuxet River, MR = Moshassuck River, WR = Woonasquatucket River, BR = Blackstone River, TR = Taunton River. See Appendix A, Figure A-II-3 for river locations.

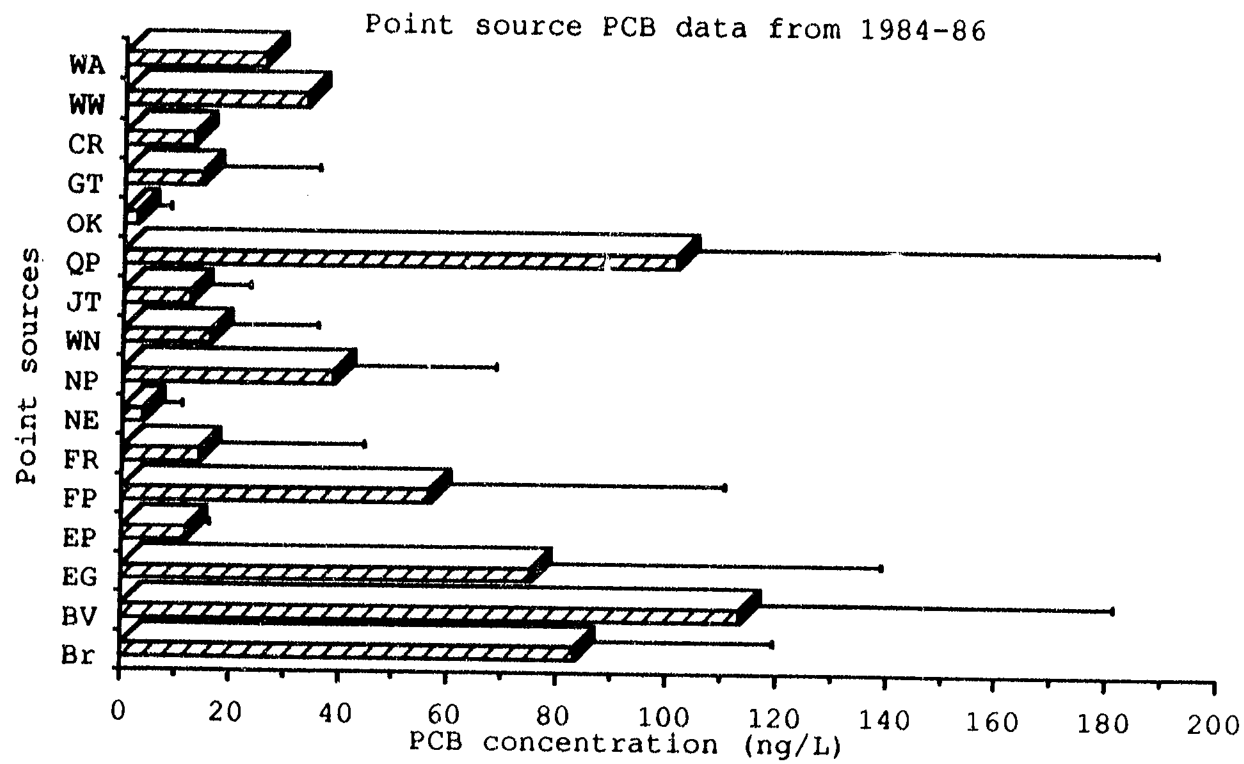


Figure 5. Mean concentration of PCBs in selected point sources (1984-1986). Error bars represent one standard deviation from the mean (n was usually 3, 4 for each point source, no error bar indicates (n=1)). Source: Latimer, unpublished data. See Table 2 for abbreviation explanation. See Appendix A, Figures A-I-3, A-I-7, and A-II-3 for sample locations.

Table 2. Point sources evaluated in studies from 1984-1986.

Code	Name	Type	Receiving water	Yr. of sample collection
WA	Warwick	WWTF	Pawtuxet R.	1984
WW	W.Warwick	"	"	1984
CR	Cranston	"	"	1984
GT	G.T.E. Corning	Industry	Blackstone R.	1985
OK	Okonite	"	"	1985
QP	Quonset Point	WWTF	Narra. Bay	1985-86
JT	Jamestown	"	"	"
WN	Warren	"	"	"
NP	Newport	"	"	"
NE	Narragansett Electric	Industry	"	"
FR	Fall River	WWTF	"	"
FP	Fields Point	"	"	"
EP	East Providence	"	"	"
EG	East Greenwich	"	"	"
BV	Blackstone Valley	"	"	"
BR	Bristol	"	"	"
*WP	Woonsocket	WWTF	Blackstone R.	1985
*NF	Nife	Industry	"	"
*AH	American Hoechst	"	Pawtuxet R.	1984

*Those effluents that showed no detectable PCB concentrations.

Sources: Quinn et al., 1985; 1987b; 1988.

municipalities and industries that had detectable PCB levels were from 4 to 113 ng/L. The Blackstone Valley (BV), Quonset Point (QP), Bristol (Br) and East Greenwich (EG) WWTFs showed the highest concentrations.

II. PCBs from atmospheric contributions

The only local studies concerning atmospheric sources of PCBs to the bay were done in the mid-seventies. Using a site at the Kingston Campus of URI, Christensen and coworkers (1979) and Bidleman and Christensen (1979) have reported atmospheric fluxes of Ar 1016/1242 and Ar 1254 of 113 ± 76 and 246 ± 51 $ng/m^2/d$, respectively (Table 3). These fluxes translated into a yearly areal wide input of 29.5 ± 6.10 kg/yr (Ar 1254) from dry deposition in period from 1973-75 (area excludes the Sakonnet Passage). This study, however, took place during the time when PCBs were still being produced, in fact; the peak of US production was in 1970 with 1973 also being a major year for production. Levels in both the Blackstone and the Pawtuxet Rivers, the only other direct measurements during, or just subsequent to the period of major PCB production, show extremely high values compared to recent data. Therefore, it would not be advisable to utilize these data as representing the present day atmospheric deposition and, in actuality, the fluxes reported by Christensen were probably near the maximum yearly levels. A comparison of atmospheric fluxes at the present time with those of the previous studies would be sound.

Table 3. Removal rates of PCBs and DDT from the atmosphere under dry conditions, Kingston, RI.

Date	Ar 1016/1242			Ar 1254			p,p'-DDT		
	F	C	V_d	F	C	V_d	F	C	V_d
Sept. 1973	<29	8.3	<0.004	298	8.7	0.04	96	0.54	0.21
Feb. 1974	176	2.0	0.10	245	1.7	0.17	107	0.03	4.1
May 1975	135	1.4	0.11	196	1.9	0.12	43	0.10	0.50
arith. mean			0.071			0.11			1.6
geo. mean						0.093			

F = deposition flux, ng/m^2/day
C = aerial concentration, ng/m^3
V_d = deposition velocity, cm/s
source: Christensen et al., 1979 and Bidleman and Christensen, 1979.

III. Mass inputs of PCBs to Narragansett Bay

The only recent complete data set suitable for the mass transport of PCBs from fluvial and point sources has been obtained from Latimer (1989b). It must be kept in mind, however, that in an historical framework, all the evidence indicates that previous inputs to the bay were significantly greater than at the present time. Estimated mass loadings rates of PCBs from the Blackstone and Pawtuxet Rivers back to 1978 are presented in Figure 6. In the late seventies the Pawtuxet River dominated with an estimated yearly input rate of about 500 kg/yr compared to a Blackstone River input rate of about 40 kg/yr. However, in the early eighties the Blackstone River exceeded the Pawtuxet in its transport of PCBs. Thus, it can be seen that there has been a considerable drop in the rate of PCB transport from the two river systems in this period.

PCB fluxes from wastewater sources and fluvial transport have been reported under dry weather conditions (Latimer, 1989b). The Blackstone River was determined to be the dominant source of PCBs of the fluvial samples studied, comprising over 50% of the total riverine inputs (Figure 7). The total daily flux of Ar 1254 was estimated to be 32 gm/d from the combined rivers under dry weather conditions. The wastewater transport was comprised largely of the flux from the Fields Point WWTF (Figure 8). It alone discharged over half of the total contributions from all the WWTFs. Based on the four sampling events in 1985-86, it was estimated that an

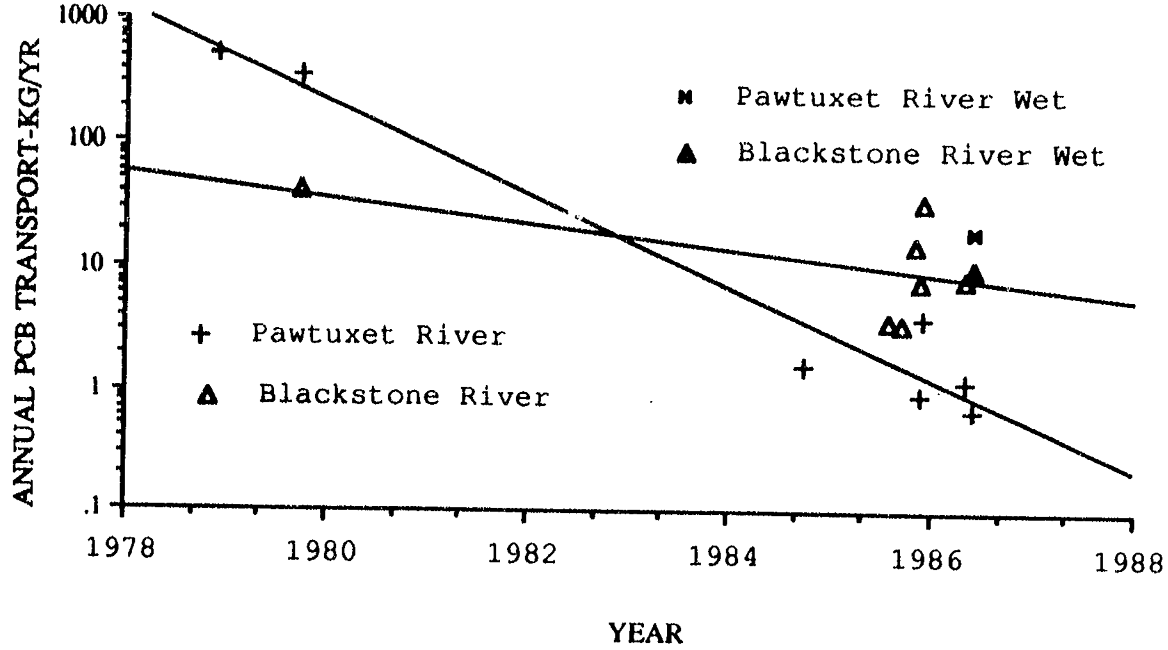
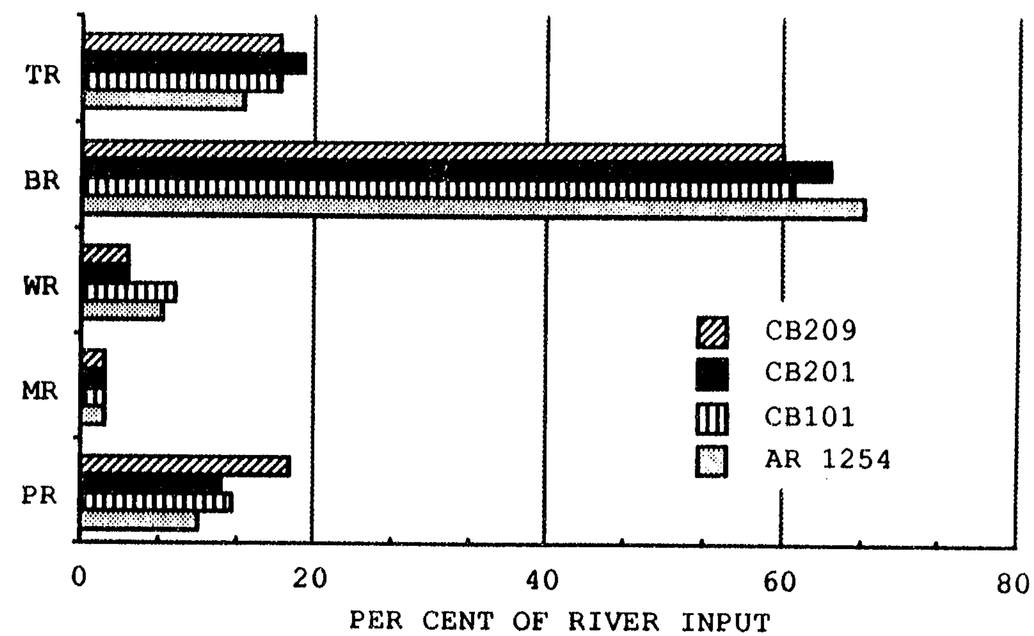
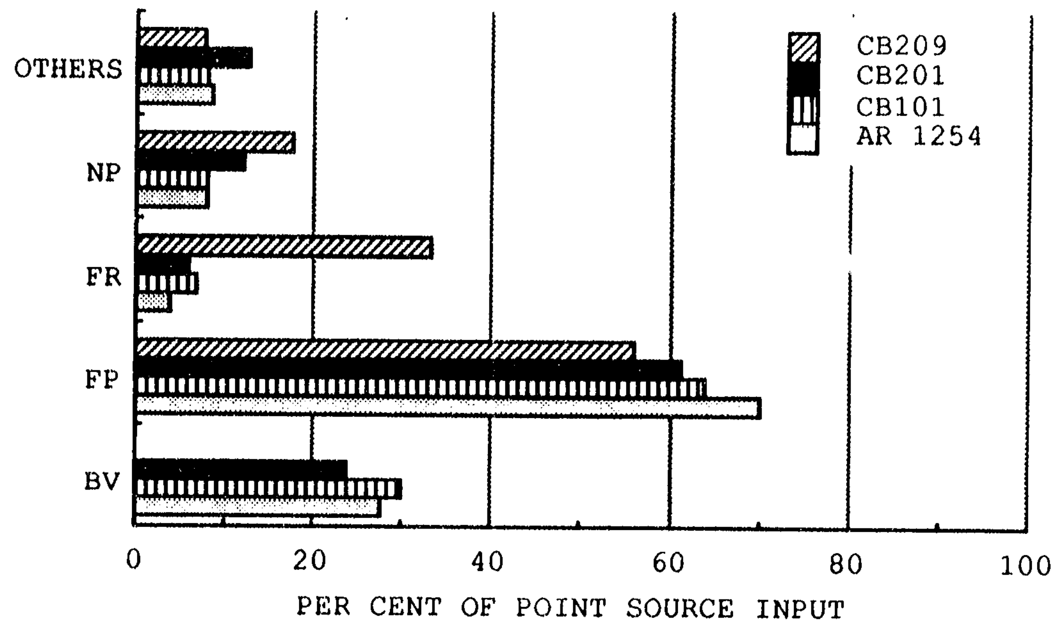


Figure 6. Estimated PCB input rates to Narragansett Bay from the Blackstone and Pawtuxet rivers (1978-1986). Source: Latimer, 1989a; flow data from U.S. Geol. Survey, 1978-87; concentration data for 1979-1980 were from U.S. Geol. Survey, 1979-80. Line represents a linear best fit of the data.



MEAN TOTAL (GM/D): AR 1254 = 31.8 ± 24.0 CB101 = 2.91 ± 1.97
CB201 = 2.09 ± 1.82 CB209 = 0.53 ± 0.53

Figure 7. Relative PCB inputs from the rivers evaluated in the 1985-86 surveys. PR = Pawtuxet River, MR = Moshassuck River, WR = Woonasquatucket River, TR = Taunton River, CB 209 = 2,2',3,3',4,4',5,5',6,6'-decachlorobiphenyl, CB 201 = 2,2',3,3',4',5,5',6-octachlorobiphenyl, CB 101 = 2,2',3,4,5,5'-pentachlorobiphenyl. Source: Latimer, 1989b.



MEAN TOTALS (GM/D): AR 1254 = 16.1 ± 11.3 CB101 = 1.76 ± 1.24

CB201 = 0.31 ± 0.25 CB209 = 0.02 ± 0.03

Figure 8. Relative PCB inputs from point sources evaluated in the 1985-86 surveys. See Figure 7 legend for congener designations, NP = Newport WWTF, FR = Fall River WWTF, FP = Fields Point WWTF, BV = Blackstone Valley WWTF.

average of 16 gm/d of Ar 1254 were transported from the WWTFs under dry weather conditions. One point of interest is that the effluents of the point sources showed, in many cases, and specifically for the Fields Point plant, irregular PCB concentrations. For example, in some samples, PCBs were present, whereas in others at the same facility but at different times, they were not detected at all. This indicates that the point sources would need to be more extensively studied to accurately investigate their impact on the bay as a whole. This is particularly true for the Fields Point plant as well as others with substantial discharges.

The annualized mass inputs of these compounds from the evaluated rivers and point sources to Narragansett Bay are presented in Table 4. Due to constraints on resources, not all of the freshwater inflow to the bay was gauged nor analyzed for PCBs; therefore, certain approximations were made to obtain as complete an estimate of the sources as possible. In the case of the fluvial inputs, the Blackstone River dominated with about 50% of the total. The Woonasquatucket River, which showed the highest PCB concentrations, was of little concern to the overall bay with respect to mass inputs, due to its relatively minor discharges (i.e., <5% of the riverine flux). On the average, it can be seen from Table 4 that the rivers made up most of the inputs to the bay; they comprised about 70% of the total inputs of particulate bound Ar 1254 annually (i.e., 15.5 kg) whereas approximately 5.9 kg can be ascribed to the point

Table 4. Annual inputs of PCBs from fluvial and municipal sources to Narragansett Bay*. Values in parenthesis represent area ratios between the total drainage area and the area served by the USGS gauge for each river.

	Mean Flow MLD	Ar 1254 KG	CB101 GM	CB209 GM
RIVERS				
Measured				
gauged				
Pawtuxet (601/521)	786[1]	1.20	137	39.9
Moshassuck (61.4/60.4)	74.7[1]	0.24	19.4	2.48
Woonasquatucket (134.4/98.9)	174[1]	0.67	68.8	6.54
Blackstone (1222/1077)	2210[1]	7.98	658	115
Taunton (1446/668)	1660[1]	1.52	180	30.9
Total measured:	4905[1]	11.6	1060	195
Estimated				
gauged				
Three mile[4] (218.3/218.3)	436[2]	1.22	119	14.3
Segregansett[4] (27.5/27.5)	57[2]	0.16	15.6	1.87
Ten mile[4] (143.5/138.6)	355[2]	1.00	97.2	11.7
Hunt[4] (59.3/59.3)	113[2]	0.32	30.9	3.71
ungauged[5]	1112[3]	1.22	122	16.2
Total estimated:	2073	3.92	385	47.8
OVERALL FLUVIAL TOTAL:	6978	15.5	1440	243
WASTEWATER EFFLUENTS:	511	5.88	642	7.3
TOTAL INPUTS:		21.4	2080	250

[1]Means over sampling periods

[2]USGS mean flows for periods ranging from 1-44 years.

[3]Areas used in calculation were from Pilson, personal communication. *All areas exclude Sakonnet Passage. Estimated using the % of total drainage area that was ungauged: total area ungauged (Palmer River, smaller rivers, coastal drainage areas, and islands) is 695.2 km^2*. The river discharges from ungauged area = flow of gauged + estimated areas (5866 MLD) x (total area ungauged, 695.2 km^2/ area gauged(+ estimated), 3668 km^2) = 1112 MLD.

[4]The average concentration of evaluated RI rivers was used to calculate transport from unstudied rivers: 7.68 ng Ar 1254/L, 0.75 ng CB101/L, 0.09 ng CB209/L.

[5]The average PCB concentration of the Pawcatuck River was used for the calculation of transport from ungauged areas, since they are generally more rural than the gauged rivers (i.e., 3 ng Ar 1254/L, Quinn et al., 1987a). Since individual CBs were not determined in the Pawcatuck River study, an Ar 1254 concentration ratio between the Pawcatuck River and all of the evaluated rivers (3/7.68 = 0.4) was used to estimate the CB concentration in the ungauged areas: CB101, 0.3 ng/L; CB209, 0.04 ng/L.

sources surveyed. Therefore, a total of 21.4 kg (Ar 1254) may be entering the bay from fluvial and wastewater sources. The average picture, however, was not the whole situation. The input breakdown for the October 1985 and April 1986 sampling dates showed that during some parts of the year (when river flow was minimized) the point sources made up as much as 60% of the total input of these constituents (Figure 9, Oct. 1985). There was a seasonal cycle to the input of PCBs from rivers that would be related to their discharge characteristics (Latimer, 1989b). While there was some variation in the flows of the municipalities (13% rsd of the mean), the rivers show a considerably higher variation (72% rsd), thus the point source inputs were concentration variable whereas the rivers were variable, due mainly to discharge variation.

Other, important yet not well known, sources of PCBs to the bay include atmospheric deposition (wet and dry), CSO discharges, as well as PCB inputs under wet weather conditions. There was evidence that the wet weather transport may be considerable (Latimer, unpublished data, see Figure 6).

IV. PCBs in marine waters

A. Chemical distribution

There have been very few data sets concerning the levels of PCBs in the water column of the bay. The only data available, prior to 1985, were from a study by Duce and

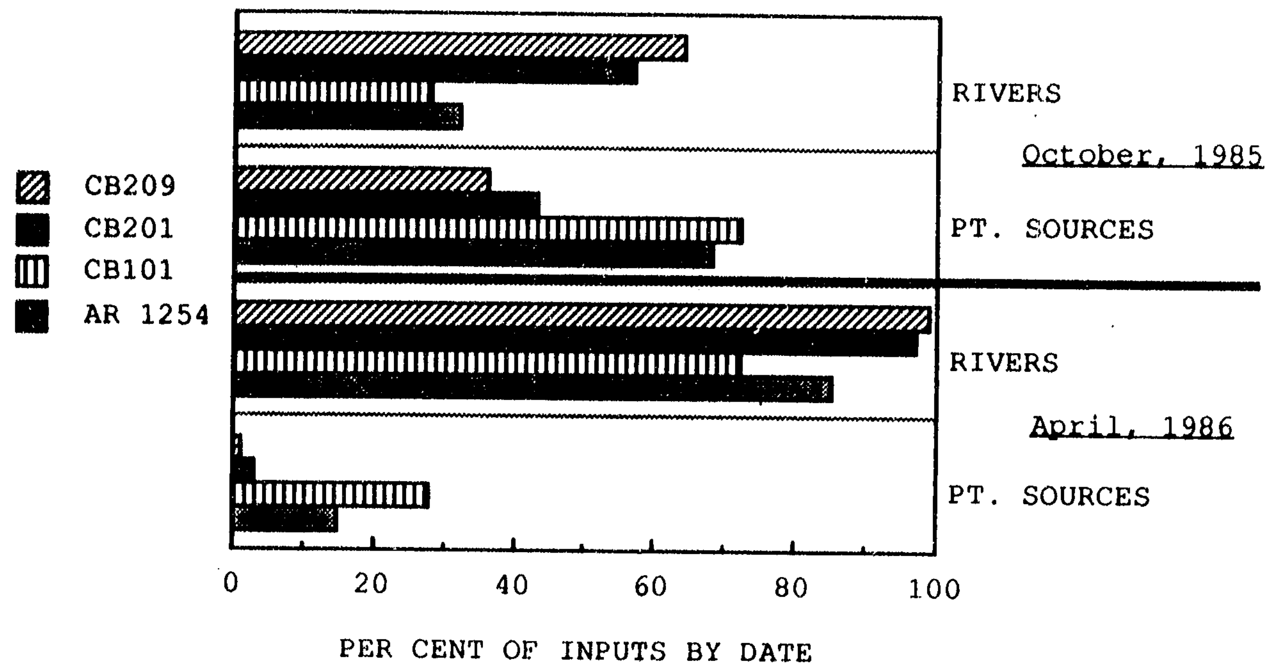


Figure 9. Relative inputs of PCBs from point sources and rivers for the October, 1985 and April, 1986 surveys. See legend on Figure 7 for congener designations. Source: Latimer, 1989b.

colleagues (1972). The study was concerned with microlayer and bulk water PCB measurements and these data are summarized in Table 5. The results indicated that the sea surface microlayer was enriched in PCBs compared to the bulk water; an enrichment factor of 28 was observed. It is plausible that these kinds of enrichments were common, although no other data are forthcoming. However, the data for the bulk water were extremely high and leads one to consider the cause. It is possible that sample contamination had occurred in sample 1 giving an anomalously high concentration; however, the level in sample 2 was significantly lower. Another hypothesis is plausible in the light of the extremely high concentrations previously determined by the USGS for some of RI rivers (as noted previously) - i.e., that the entire marine environment experienced elevated PCB contamination in the 1970s due to the widespread use of the Aroclor products. These assertions can be tested, in principle, by an evaluation of PCBs in sediment cores.

The levels determined in the water column during the bay-wide sampling events of 1985-86 are presented in Table 6 (Appendix D has the complete data). Point source concentrations can be seen to have been considerably higher than marine samples. River concentrations, in contrast, were at, or, only slightly elevated above the water column values. When dilution of the sources was taken into account, the data suggested that another source of PCBs, presumably from the resuspension of bottom deposits, may account for the water

Table 5. Concentration of PCBs in Narragansett Bay water column and surface microlayer, before 1972.

	Ar 1254 (ng/L)	
	Sample 1	Sample 2
Sample Type	41°30'20"N 71°23'30"W	41°34'30"N 71°23' W
Surface microlayer (16 mesh)	4200	450
Subsurface (z = 20 cm)	150	<50

Source: Duce *et al.*, 1972 Samples taken near mouth of Bay. Surface microlayer depths represent layers from 100-150 um thickness but values could be actually from layers that are only 5 monomolecular layers (~0.01 um).

Table 6. Mean PCB* concentration in water in various regions of the Narragansett Bay ecosystem.

	Water[1] ng L^{-1}
Freshwater	
Pawtuxet River	4.39 ± 0.94
Moshassuck River	7.94 ± 4.55
Woonasquatucket River	13.1 ± 5.29
Blackstone River	10.4 ± 5.01
Taunton River	2.56 ± 0.75
Point Sources	
Fields Point	56.4 ± 52.2
Blackstone Valley	50.7 ± 19.2
All others	29.1 ± 29.3
Marine Water	
Surface (<1 m)	
Fox Point	4.45 ± 4.02
Conimicut Pt.	3.04 ± 1.35
West Passage	0.76 ± 3.42
East Passage	1.69 ± 1.07
Bottom (>5 m)	
Fox Point	2.40 ± 1.34
Conimicut Pt.	3.00 ± 0.91
West Passage	1.51 ± 0.70
East Passage	1.02 ± 2.66

*PCBs are expressed as Ar 1254;

[1]values are for particulate fraction only.

Source: Latimer, unpublished data.

column levels. When these data are graphed against distance from Fox Point in the Providence River (not shown) it was apparent that, as would be expected if resuspension were occurring, the bottom waters did not show a strong dilution effect with distance but remained roughly constant or increased slightly at the Conimicut Point sampling location (see Appendix A for site location). Surface water data showed a distribution that would be more consistent with dilution of sources.

The distribution of CB138 (a hexachlorobiphenyl congener, dominant in Ar 1254 and Ar 1260), with depth in the water column suggested, in general, a well mixed system. Certain exceptions, however, were observed. For example, at station 2 (Fox Point), on the October survey, there was a maximum in concentration at the mid depth region of the water column (Figure 10). The levels determined at this depth appeared to be related to industrial or maritime activities in the vicinity (Latimer, 1989b). The influence of river inputs may have been the cause of the distribution of CB138 at this station on the May survey (Latimer, 1989b). On this date, the concentration showed a maximum at the surface and a strong gradient with depth (Figure 10). During the November sampling, the concentration was observed to increase at stations 2 and 4 in the bottom most portion of the water column suggesting the influence of bottom sediment resuspension. Summarizing, the distribution of PCBs in the water appeared to be a function of the relative magnitudes of

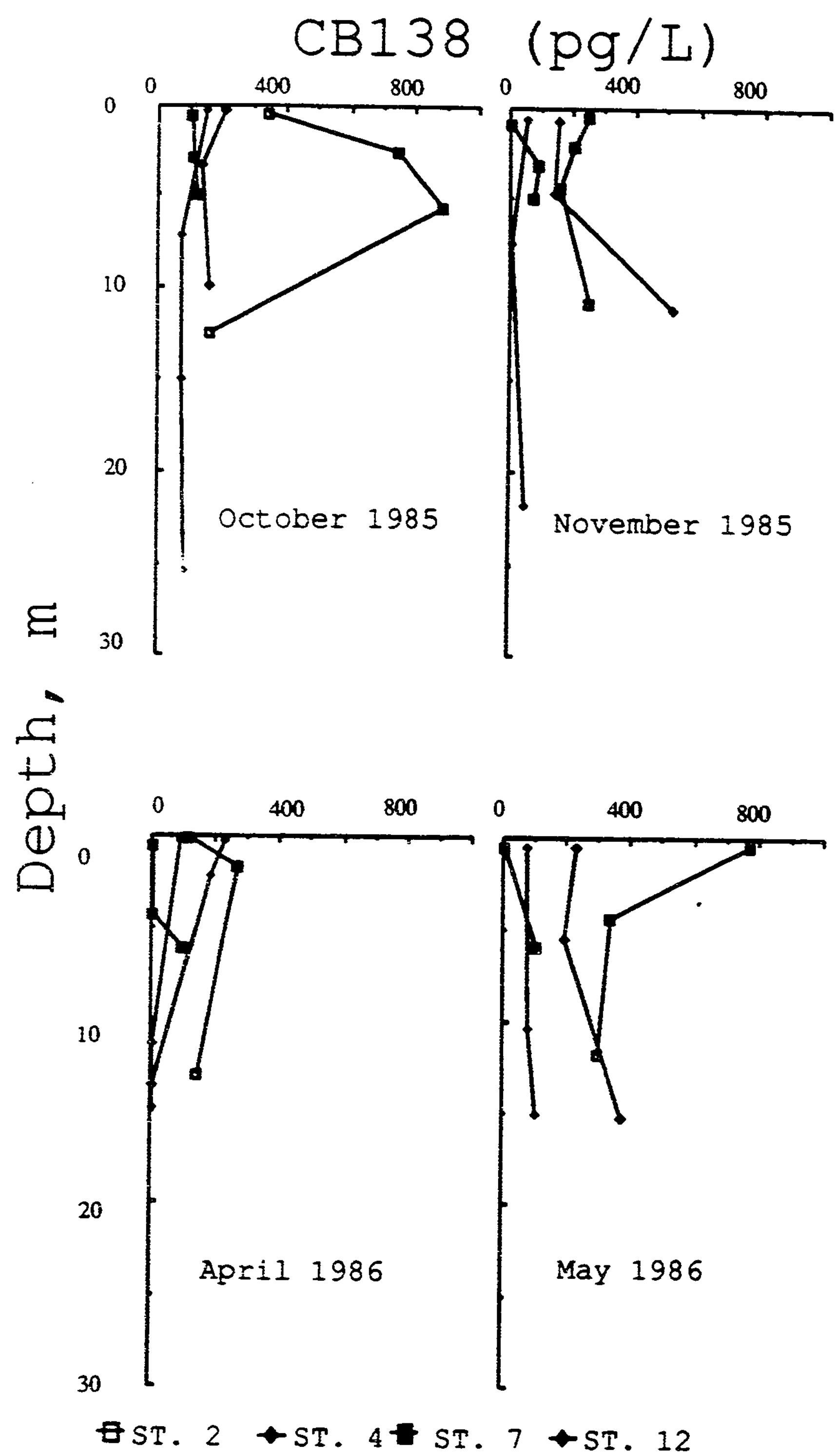


Figure 10. Concentration of CB138 (2,2',3,4,4',5'-hexachlorobiphenyl) in the water column of Narragansett Bay (1985-1986). See Appendix A, Figure A-II-3 for station locations.

industrial/maritime activities, sediment resuspension, and the relative source strengths of river and wastewater inputs.

B. The role of plankton

Since PCBs are highly hydrophobic, their distribution in the water column will be affected by the distribution of the particles themselves. The total amount of PCBs in a parcel of water will be (M_t):

$$M_t = M_{aq} + M_c + M_p$$

where M_{aq} is the truly dissolved component; M_c is that component associated with colloidal or ultra small particulates; M_p is the component associated with generic particles and these particles will be:

$$M_p = \Sigma M_i \quad (i = 1\text{-}n)$$

where i constituents make up the particle loads in the water, including autochthonous particles such as zooplankton, phytoplankton, detritus, fecal material, abiogenic suspended and resuspended solids and also allochthonous particles such as riverine, wastewater, industrial and atmospheric particulates.

In order to evaluate the geochemical cycling of PCBs in the marine environment, it is necessary, to evaluate the specific compartments that make up the particulate portion of the total. The ultimate fate of particles and associated contaminants in the marine environment, is to settle and eventually be incorporated into the sediments.

The impact of plankton on the water column levels of PCBs from the point of view of their effect on the representativeness of the samples during a specific time and at a specific place is here addressed. That is, in what way has the plankton caused temporal and spatial deviations in PCB levels when trying to determine the average concentrations in the water column. Brown and coworkers (1982) postulate; using a model incorporating sorption, ingestion of food, desorption and excretion as uptake/loss mechanisms for consumers; sorption and desorption as uptake/loss mechanisms for nonfeeding components; that the total percent of PCBs in the system is dominated by the dissolved fraction (as would be expected, since water is the largest reservoir, even when PCB concentrations are, in many cases, undetected or quite low). The second most important component was the suspended solids not associated with the food web (20-40% of the total PCB). Those particles associated with the food web (i.e., detritus, nannoplankton, net plankton, microzooplankton, macrozooplankton) generally comprised about 10% of the total PCB. Therefore the role of the food web associated "particles" would be quite minor although measurable in the water column in terms of concentrations, since the dissolved fraction would go under evaluated in the typical sampling protocol used in our lab. Thus, at any given time, the water column could show a different PCB signature during a bloom than during interbloom periods.

Any good scientific investigation designed to investigate the geochemistry of these compounds would allow sampling during times of the year that would incorporate the spatial and temporal variations caused by the plankton. Nevertheless, the role of plankton in causing anomalous concentrations should be considered in samples collected, since sampling and analysis is usually constrained and restricted by funding levels. One way to evaluate the role of phytoplankton in the PCB levels observed in the water column would be to search for significant correlations. If phytoplankton had a major impact, it would be expected that high PCB levels would be present with high levels of chlorophyll-a. Graphs of these variables for samples taken during the bay cruises of 1985 and 1986 indicated conflicting results (Figures 11 and 12) (Latimer, 1989b). In some cases chlorophyll-a seemed to be well correlated with PCBs (e.g., Figure 11,station 2, all dates) while in others, a strong inverse relationship was observed (e.g., Figure 11, station 4, all dates; Figure 12, Nov. 1985). Samples taken in April and May of 1986 showed a positive trend, although there is much variability.

It appears that, for plankton, direct partitioning of PCBs across the water/organism membrane is important in the uptake of these compounds in the marine environment. Levels of PCBs in plankton may be significant and have been shown to

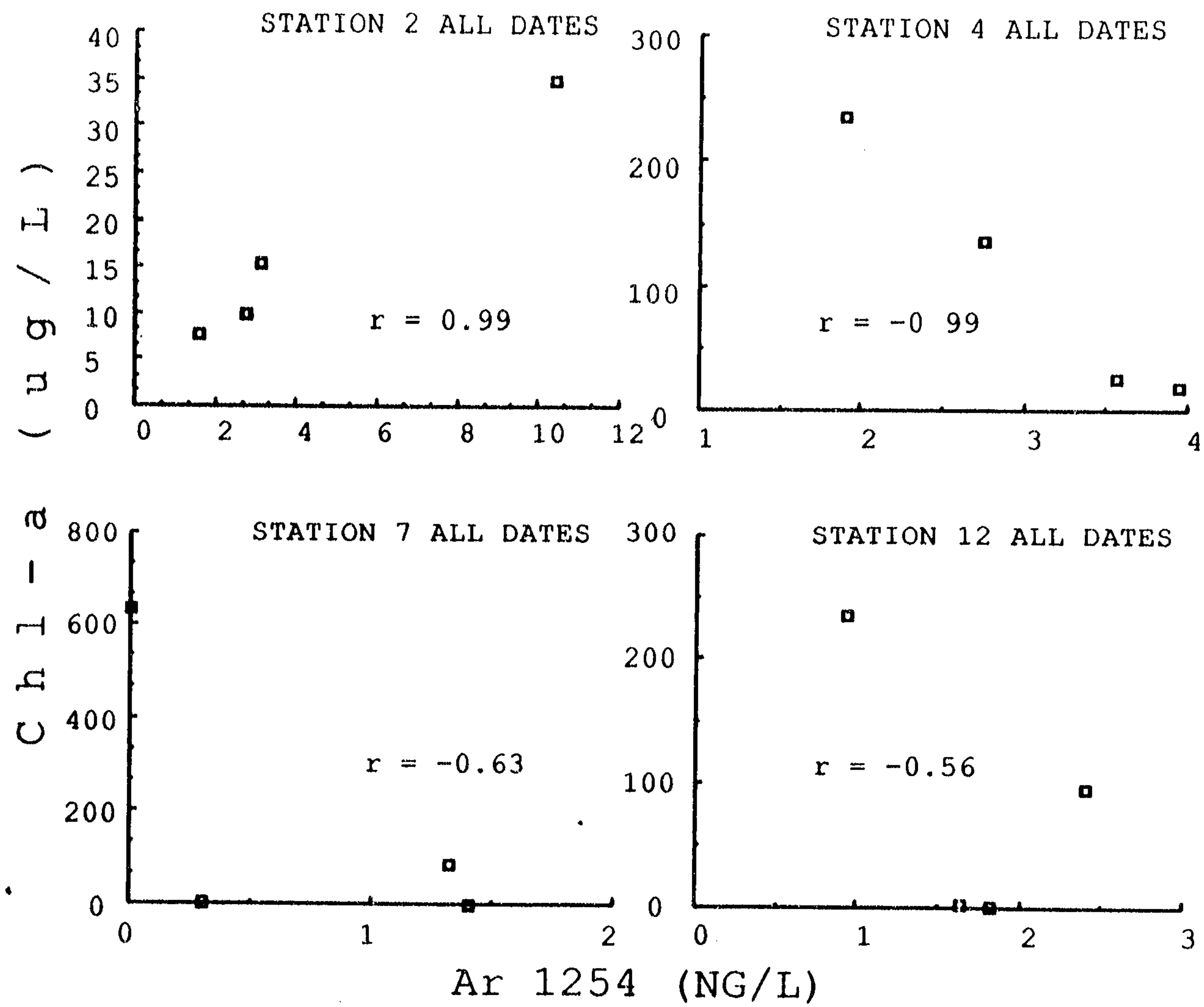


Figure 11. Ar 1254 concentration (particulate fraction) versus Chl-a levels for surface waters of Narragansett Bay. PCB data from Latimer, 1989b; Chl-a concentrations are from Hunt *et al*., 1987a, 1987b, 1987c, 1987d.

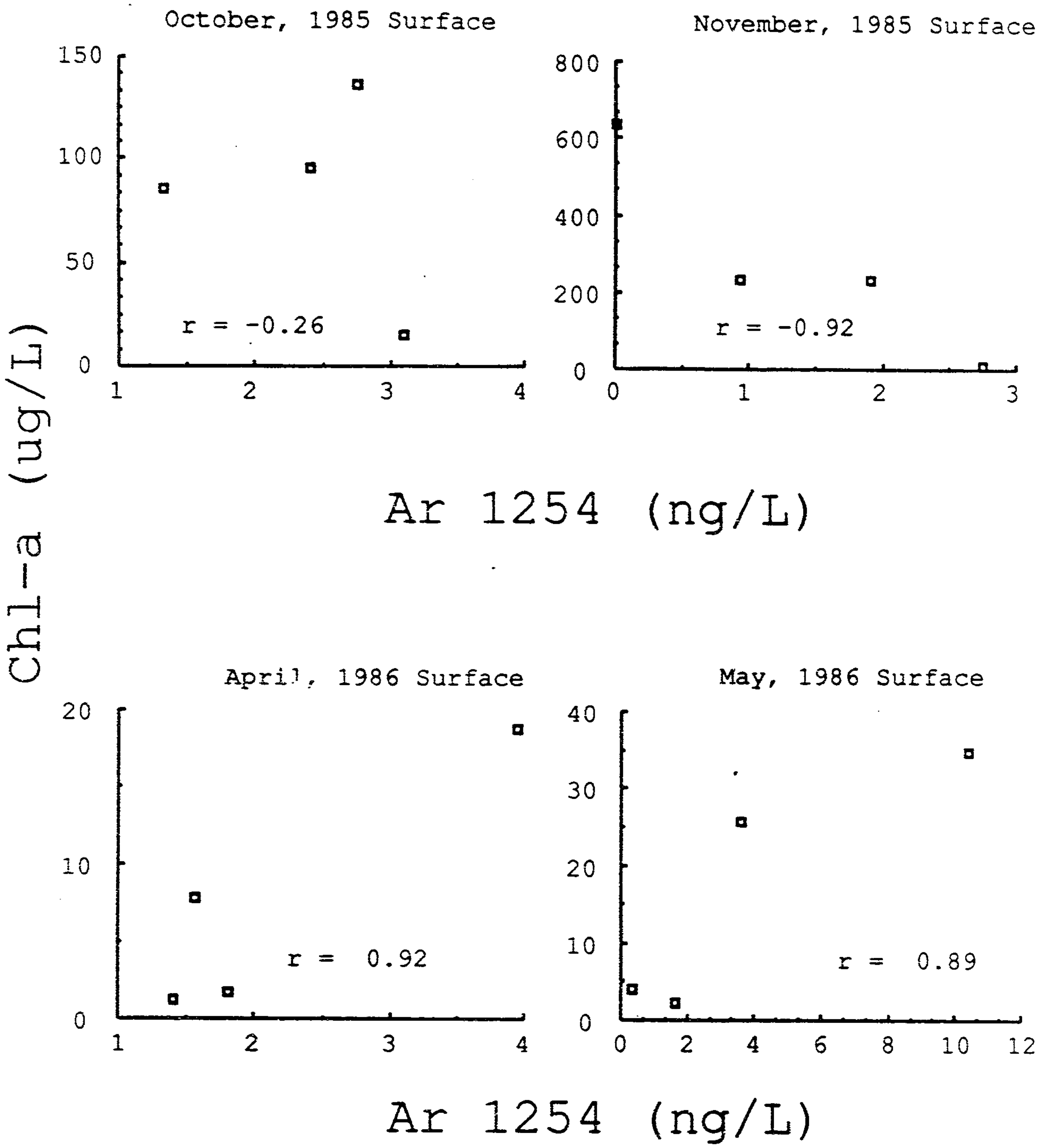


Figure 12. Ar 1254 concentrations (particulate fraction) versus Chl-a for surface waters of Narragansett Bay by date (all stations). PCB data from Latimer 1989b, Chl-a data from Hunt et al., 1987a, 1987b, 1987c, 1987d.

contribute to some food web bioaccumulation in higher trophic levels, although this has not been observed universally. The fate of plankton derived PCBs in Narragansett Bay would be similar to other particles in the system, eventually settling to the sediments, the repository of most particle active compounds. Plankton associated PCBs may cause spatial and temporal perturbations in the distribution of PCBs in the water column due to plankton population dynamics. Due to the spacing of the sampling events for the recent cruises, and the inconsistent trends of chlorophyll-a with PCB concentrations in the water column, the results and conclusions utilizing the data can be considered to be based on representative data which had not been severely biased by planktonic population dynamics.

V. PCBs in sediments

A. Freshwater sediments

The majority of PCB levels in ponds and lakes were in the range from <10 to 400 ng/gm dry weight in samples collected in 1970 and 1971 (Table 7). The commercial mixtures observed were divided between Ar 1242, 1248, and 1254. Pawtuxet River surface sediments showed higher levels than other areas evaluated (Tables 7 and 8). Concentrations of 5.4 ug/gm dry weight have been detected and a possible value as high as 10 ug/gm dry weight has been reported (U.S. Geological Survey, 1979; Olney, 1972). A core taken at a site near the mouth of the Pawtuxet River seemed to validate the high levels of PCBs

Table 7. Concentration of PCBs and other chlorinated hydrocarbons in freshwater sediments of Rhode Island.

Location		PCBs type	PCBs ng/gm	PESTICIDES (ng/L) DDE	DDD	DDT
1).	Slatersville Res.	1242	103	5	35	
2).	Nichols Pond	ND	ND	ND	11	3
3).	Keech Pond	1242	286	3	12	10
4).	Waterman Reservoir	1248	155	17	46	5
	Sediment behind orchard	1248	210	28	292	40
5).	Woonasquatucket Res.	1242	334	273	155	11
6).	Olney Pond	NC	NC	NC	NC	NC
7).	Scituate Reservoir					
a.	Bridge 251; Rt 116	1242	73	9	10	3
b.	Str. from Bardon Res.	1254	80	6	20	2
c.	Str. from West. Rv.	NC	NC	NC	NC	NC
8).	Str. from Flat Rv. Res.	1254	220	ND	107	ND
9).	Pawtuxet River and tributaries					
a.	Mouth:Many unid. pks; maxPCB-10 ug/gm; maxDDD 860 ng/gm					
b.	Elmwood Ave. Bridge	1254	300	50	34	37
c.	Print Works Pond	1254	55	13	8	ND
d.	Rhodes-on-the Pawt.*	1248	9320			
10).	Alton Jones Pond	1248	159	20	6	ND
11).	Belleville Pond	ND	ND	ND	ND	ND
12).	Annaquatucket Rv @ Rt1	ND	ND	27	1	2
13).	Indian Lake	1254	40	5	6	ND
14).	Card Pond	NC	NC	NC	NC	NC
15).	Yawgoog Pond	NC	NC	NC	NC	NC
16).	Ell Pond	NC	NC	NC	NC	NC
17).	Moscow Brook	NC	NC	NC	NC	NC
18).	Locustville Pond	1254	76	·16	34	16
19).	Yawgoo Pond	1242	400	78	127	26
20).	Hundred Acre Pond					
a.	Middle	1254	140	298	341	60
b.	South end	1254	91	40	45	16
21).	Thirty Acre Pond					
a.	North end	1248	250	130	250	69
b.	Below turf dr pipe	PCBs masked		50	1150	1330
22).	Wordens Pond	1242	100	3	4	ND
23).	Tuckers Pond	1248	105	6	15	2
24).	Wood River Pond	1248	300	140	189	70
25).	Brickyard Pond	1242	263	42	117	15
26).	One Hundred Acre Cove	1248	20	54	122	4
27).	Easton Pond					
a.	West	1242	100	10	9	8
b.	East	1242	105	9	5	8
28).	Jamestown Reservoir	1248	20	4	2	4
29).	Pond off Rt 3, Cov.	1254	220	ND	107	ND
30).	Melville Pond					
a.	Edge	1254	96	10	13	3
b.	Middle	1254	40	49	48	8
31).	Mashapaug Pond**	1254	39-108			

ND = <10 ng/gm dry weight; NC = not collected
Sources: Olney, 1972; *Quinn, *et al.*, 1985; **Quinn, *et al.*, 1986.

Table 8. Concentrations of selected organochlorine compounds in sediment determined by the USGS, ng/gm dry wt. (st. dev.) from 1978 to 1983. Samples collected once yearly during low flow conditions.

	No.	PCBs	DDD	DDE	DDT
Blackstone River at					
Milville, MA (01111230)	6	101(153)	8.91(10.6)	0.68(1.06)	1.32(1.41)
Forestdale* (01111500)	6	114(234)	14.2(18.4)	0.95(2.05)	3.27(5.18)
Manville (01112900)	6	117(98.1)	18.0(22.7)	5.38(8.40)	1.68(1.93)
Pawtuxet River at					
Cranston (01116500)	6	23.2(25.2)	3.32(6.30)	0.73(0.96)	0.55(0.84)
Pawtuxet (01116617)	6	986(2160)	32.9(63.0)	0.55(0.88)	3.42(7.64)
Pawcatuck River at					
Westerly (01118500)	6	0.33(0.82)	0.90(2.20)	0.18(0.30)	0.05(0.12)

Parenthetical digits represent USGS sampling sites.

*site on the Branch River

Source: U.S. Geological Survey, 1978-85.

in the Pawtuxet River over the years (Table 9). The concentration observed at a depth of about 25 cm (14 ug/gm) may correspond to the high values observed by the USGS in the river in the seventies. The core was collected in 1984 and surface concentrations were still relatively high and may reflect local conditions within the river.

B. Marine sediments

1. Surface Sediments

The major data sets evaluating PCBs in surface sediments throughout the bay can be found in Appendix E. The most recent data included 26 surface sediment stations throughout the main body of the bay. The top 0.5 cm was analyzed from diver collected short cores. The data were quite extensive and information from our lab is still increasing. Studies of cores throughout the bay are presently under investigation in order to characterize the contaminant inputs back to the turn of the century (Latimer, 1989c; Latimer, unpublished data).

The surface sediment concentrations exhibited a gradient from the Fox Point region of the Providence River to the lower bay (Figure 13). These data were consistent with information indicating that the inputs of PCBs to Narragansett Bay were primarily in the Blackstone/Seekonk River area. The concentrations of total PCBs (Ar 1242+1254+1260) in the Providence River, ranged from a high of 2.3 ug/gm dry weight in the Fox Point area to a minimum of 0.6 ug/gm dry weight at the mouth of the river (see Appendix

Table 9. PCB concentration in a sediment core taken from Rhodes-on-the-Pawtuxet (1984).

depth, cm	ng/gm dry Ar 1254	Ar 1248
0-1	N.D.	9320
4-7	N.D.	2440
12-17	N.D.	8330
22-27	N.D.	14400
32-37	1170	670
42-47	2070	2050
52-57	210	N.D.
62-67	210	N.D.
72-77	N.D.	N.D.
82-87	N.D.	N.D.

N.D. = none detected <100 ng/gm dry wt.

Source: Quinn, *et al.*, 1985

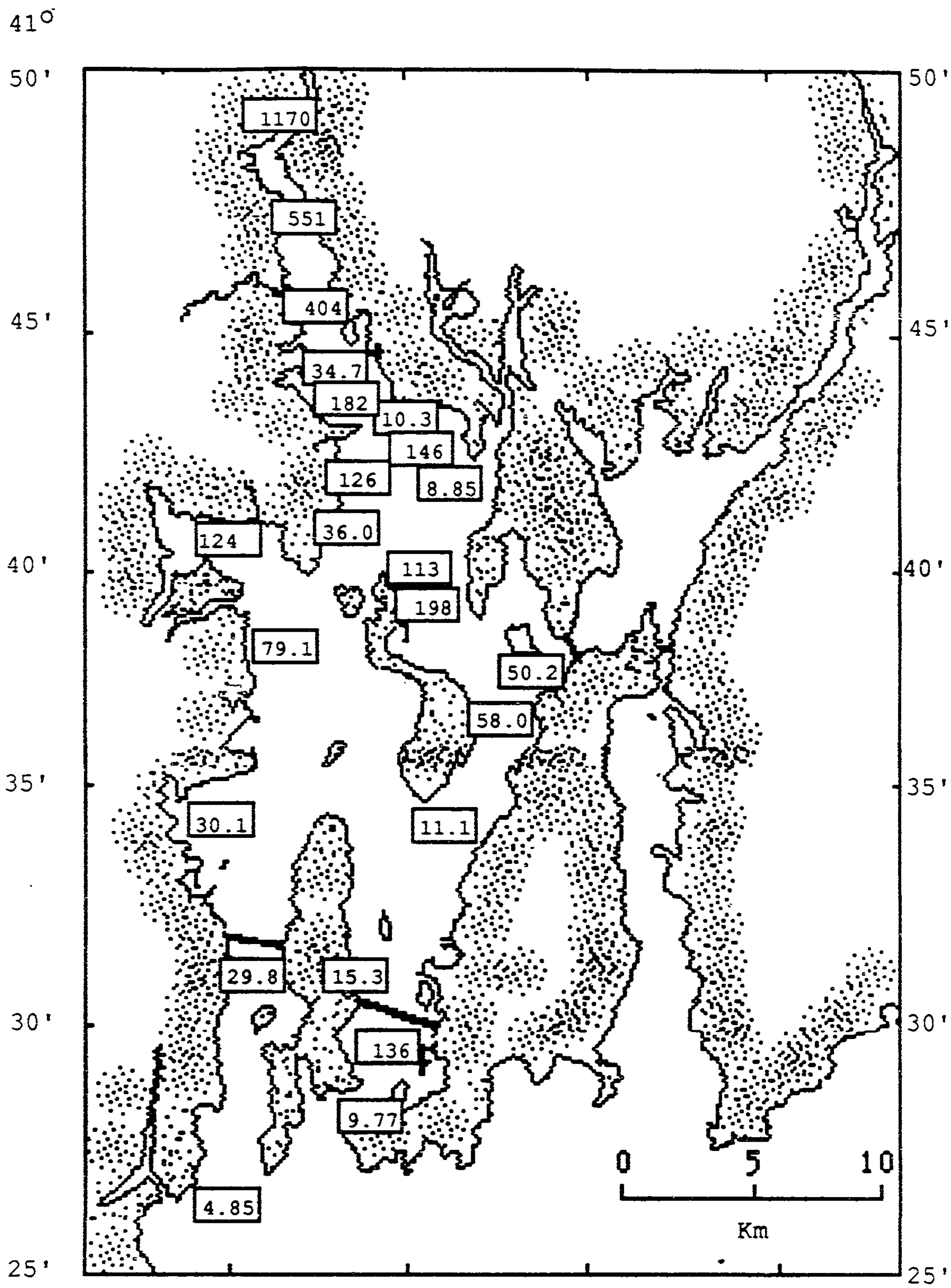


Figure 13. Concentration of Ar 1254 (ng/gm dry weight) in surface sediments collected in Narragansett Bay.

E for data). PCB values in the upper bay were variable due to areas of high erosion (non-depositional). In the depositional areas of the upper bay, however, the concentrations were approximately 0.2 ug/gm dry weight. Sediment concentrations above 0.36 ug/gm dry weight have been been proposed as a threshold value above which adverse effects in some organisms may occur (Tetra Tech, 1986). Clearly PCB levels in the Providence River were in this range and ecological degradation may be expected. The criteria were developed in other areas and may be of limited use in Narragansett Bay; however, a similar study designed to categorize sediment levels of pollutants and adverse biological effects for Narragansett Bay sediments would be useful in the absence of standardized national sediment quality criteria. For a more complete discussion of this method see Latimer (1989c).

The National Status and Trends (NS&T)-Mussel Watch and Benthic Surveillance Programs are studies designed to evaluate the long term trends in contamination in areas throughout the United States. Concentration data from NS&T sites within Narragansett Bay indicated PCB levels from 24 to 160 ng/gm dry wt., which were similar to data determined in our laboratory for nearby areas (Table 10; NS&T, 1985; NS&T, 1987).

There were also indications of local sources of these compounds, particularly near the Newport WWTF outfall. This area showed elevated PCB levels compared to other nearby

Table 10. National status and trends program summary of PCBs in surface sediment (ng/gm dry wt.).

Benthic Surveillance Project	1985		
Site	Lat.	Long.	PCB
Prudence Island	41°21'33"	71°12'53"	160 ± 89.8
Mussel Watch Program	1984		
Site	Lat.	Long.	PCB
Conanicut Island	41°29'47"	71°23'10"	23.9 ± 17.9

Source: NS&T Benthic Surveillance Project, 1985;
NS&T Mussel Watch Program, 1987.

sites. A comparison of our data with a benthic survey nearby showed conflicting results. For the May and September 1984 series by ERCO (st. 19, 5 and <100 ng/gm dry wt., respectively, Table 11) the concentrations appeared to be considerably lower than for our nearest station (st 15, 136 ng/gm dry wt., see Figure 13) (see Appendix A for locations). However, the results reported by ERCO for the July 1984 series of samples were very similar to those recorded by our group. The area was apparently extremely heterogeneous to have such results; however, this was not surprising due to the close proximity to the wastewater outfall.

In a study by Rubinstein and Pruell (unpublished data) surface sediments analyses showed results that were somewhat divergent, at least in the Providence River, from the recent results from our laboratory (see Appendix E for data). The differences in concentration may have been related to the spatial variability in the sediments near the dredged channel within the Providence River. This variability must be understood when estimating sediment fluxes.

In this context and as a point of reference for the forthcoming data, the results of recent research conducted at the MERL (Marine Ecosystems Research Laboratory, Graduate School of Oceanography, URI) mesocosm facility will be discussed. In this study mesocosms were utilized, in part, to assess the distribution of sewage sludge derived pollutants between water, sediment, and biota. The data indicated that the sediment was the major storage receptacle

Table 11

Summary of ERCO sediment analyses of sites near Newport WWTF outfall. PCB concentrations in ng/gm dry as Ar 1254.

Station	May 1984	July 1984	Sept 1984
3	18	130	ND
10	20	150	ND
11	23	90	ND
12	16	130	ND
13	5	150	ND
14	45	50	ND
15	6	110	ND
16	3	280	ND
17	18	100	ND
18	8	120	ND
19	5	140	ND
#95375	13	-	-
	ND = <2	ND = <50	ND = <100

Results of ERCO analyses for Metcalf and Eddy (submitted to Mr. Alan C. Ford, Box 4043, Woburn, MA 01888).

Samples collected with a Van Veen type device.

for PCBs associated with sludge (Oviatt et al., 1987; Latimer, 1989). The experiment indicated that from 68 to 109% of the added PCBs associated with the sludge could be accounted for in the sediments (Table 12).

Mass balance and storage considerations based on the most recent and extensive surface sediment data have been reported (Latimer, 1989c). Estimates of mass flux of Ar 1254, based on literature values for sedimentation rates, averaged 63.9 kg/yr, which greatly exceeded inputs calculated from the rivers and point sources under dry weather conditions (Table 13). These inputs comprised only 33% of that which was entering the sediments, suggesting other sources of PCBs to the estuary. It was postulated that inputs from rivers and point sources under wet weather conditions as well as atmospheric sources may well account for the missing PCBs (Latimer, 1989b; Latimer, 1989c). Research designed to evaluate these sources should be undertaken since such a large portion of the PCB input is unknown.

2. Sediment cores

Three data sets have been incorporated in the review of PCBs in sediment cores (Appendix E). A core collected in 1977 from the North Jamestown vicinity was analyzed for PCBs (Wade and Quinn, 1979). The data indicated a surface maximum (0-4 cm) of 39 ng/gm dry weight, decreasing to background levels in the 6-8 cm section (Figure 14A). Using a sedimentation rate of 0.15-0.2 cm/yr the top 4 cm of the core

Table 12. Mass balance data for PCBs added to MERL tanks during the sludge experiment (Oviatt *et al.*, 1988).

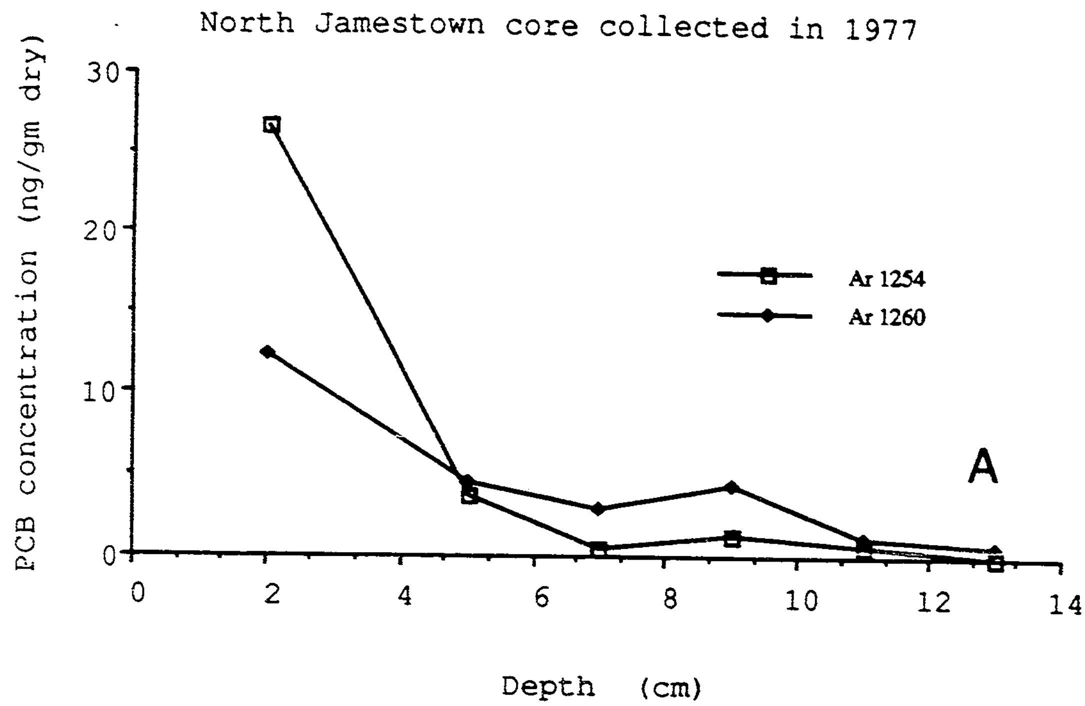
	Experiment 1		Experiment 2	
Mass Ar 1254 added:	0.533 mg		0.267	
Compartments	mg	%	mg	%
Water	0.02	4	<control	-
Sediment	0.36	68	0.29	109
Flushed out	0.09	17	<control	-
Phytoplankton	N.C.	-	N.C.	-
Zooplankton	N.D.	-	N.A.	-
Benthos	died N.A.	-	<control	-
Total	0.47	88	0.29	109

N.C. = not collected;
N.D. = not detected;
N.A. = not analyzed.

Table 13. Mass budget for PCBs in Narragansett Bay under dry weather conditions.

	Ar 1254	CB101	CB209
		kg/yr	
Flux to sediment	63.9	5.11	2.58
INPUTS:			
Rivers	15.5	1.44	0.24
WWTF	5.9	0.64	< 0.01
Total inputs	21.4	2.01	0.25
% of Sed. Flux	33	39	9.7

Source: Latimer, 1989c



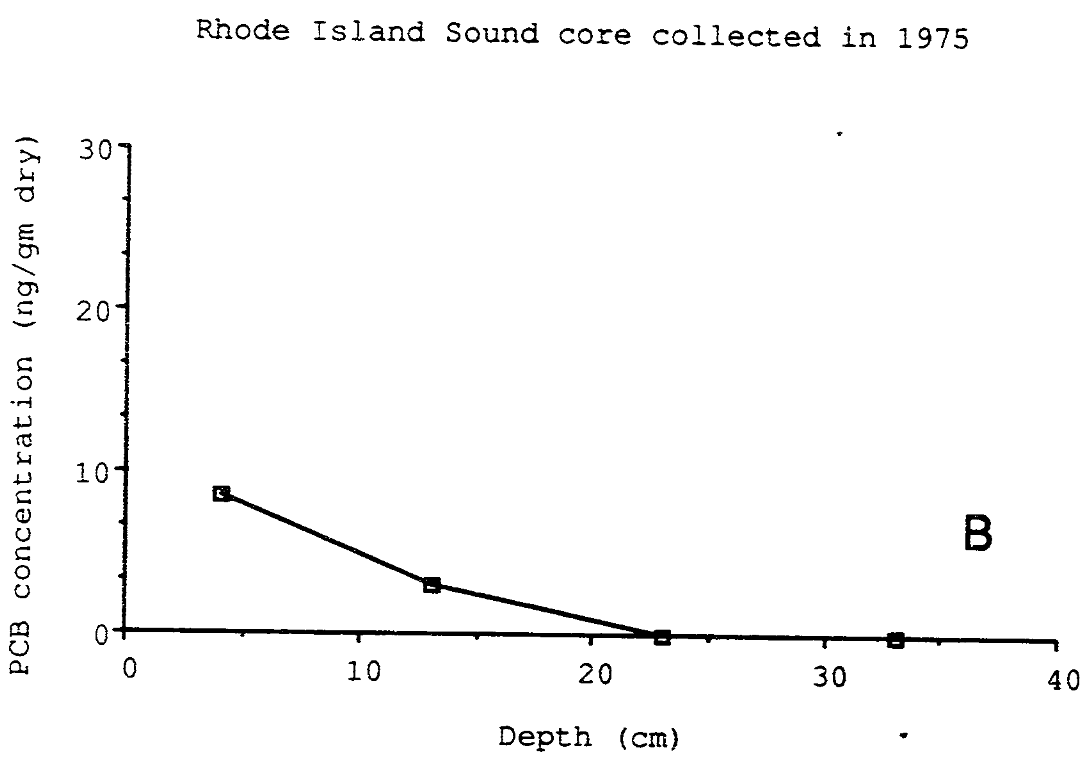


Figure 14. Concentration of PCBs in cores collected in the 1970s. Data from the North Jamestown core was from Wade and Quinn, 1979; for the RI Sound core, Boehm and Quinn, 1978.

would represent the past 20-30 years. Therefore the data indicated the maximum in PCB inputs occurred from 1947 to sometime near the year the sample was collected. Unfortunately the range cannot be narrowed because of the relatively course slices of the core (4 cm in the surface section).

Boehm and Quinn (1978) collected a core near the old dredge spoil dump site in Rhode Island Sound in 1975 (see Appendix A for locations). The analyses revealed relatively low concentrations and a surface maximum (Figure 14B). The sediment horizons analyzed in this study were approximately 10 cm in width so fine detail was lacking. At best, the data indicated that the inputs to the area over the last 24-57 years (from the time of collection) were the most significant.

Sediment cores collected in 1986 have been analyzed. Results and detailed interpretation of these data can be obtained elsewhere (Latimer, 1989c).

VI. PCB in biological samples

A. Freshwater organisms

As part of the survey of PCBs throughout Rhode Island, Olney (1972) analyzed fish in freshwaters all over the state (Table 14). Most of the samples showed PCB concentrations well below the FDA tolerance limit of 2 ppm wet weight. Generally, the data ranged from 0.01 to 0.18 ppm wet weight

Table 14. Concentration of PCBs and other chlorinated hydrocarbons in freshwater fish of Rhode Island.

		PCBs		PESTICIDES (ppb wet)		
Location		type	ppb wet	DDE	DDD	DDT
1).	Keech Pond-perch	1254	10	10	5	4
2).	Waterman Res.-perch	1260	65	413	29	32
3).	Olney Pond-sunfish	1254	58	69	50	8
4).	Scituate Reservoir					
	St. Bard. Res-perch	1260	131	120	28	86
5).	Pawtuxet River and tributaries					
	Prt Wks Pd-bluegill	1254	2580	374	270	215
6).	Alton Jones Pond					
a.	pumpkinseed	1254	26	16	17	8
b.	yellow perch	1248	28	21	9	7
7).	Bellev. Pd-yell. perch	1254	100	573	130	142
8).	Indian Lake-perch	1254	80	79	16	20
9).	Card Pond-herring	1254	165	114	43	62
10).	Yawgoog Pond-pickerel	1260	419	1022	ND	22
11).	Locustv. Pd-yel. perch	1254	34	74	25	33
12).	Hundred Acre Pond					
a.	yellow perch	1260	103	907	144	126
b.	yellow perch	1254	25	422	55	84
13).	Thirty Acre Pond					
a.	yellow shiner	1254	100	86	109	ND
b.	yellow perch	1254	180	473	125	239
14).	Larkins Pond					
a.	yellow perch	1254	47	145	24	23
b.	yellow perch	1248	88	238	41	53
15).	Wordens Pond					
a.	pumpkinseed	1260	77	40	3	8
b.	perch	1254	40	43	15	ND
16).	Tuckers Pond					
a.	perch	1254	36	66	12	8
b.	yellow perch	1254	62	73	21	16
17).	Wood Rvr Pd-perch	1254	56	694	93	33
18).	Brickyard Pd-perch	1254	60	112	212	14

ND = <10 ng/gm wet weight

Source: Olney, 1972.

with an average of 0.06 ± 0.04 ppm. There were two locations that showed higher values: one in pickerel from Yawgoog Pond (0.4 ppm) and one in bluegill from Printworks Pond near the Pawtuxet River (2.6 ppm). The Pawtuxet river value was above the FDA limit suggesting considerable PCB contamination in that area.

B. Marine organisms

1. Fish

The National Status and Trends-Benthic Surveillance Project has reported results of the analyses of livers from flounder collected in 1985 (Table 15; NS&T. 1985). The average reported value was 0.6 ppm wet weight which was less than the FDA tolerance limit. A comparison of the levels observed in Narragansett Bay with other areas in S.E. New England indicated similarities with sites in Long Island Sound and Buzzards Bay

2. Mussels Two data sets were available to assess the PCB levels in *Mytilus edulis*. In a study of mussels from a sample transect, Lake and coworkers (1981) found that PCB levels dropped by a factor of two from the Providence area to the lower bay (Table 16; see Appendix A for station locations). The data indicated that even the maximum PCB level observed (~0.2 ppm wet, assumed 20% dry wt.) was well below the FDA tolerance limit. Values of approximately 0.04 ppm have been reported in the areas near Conanicut and Dyer Islands by the NS&T Mussel Watch Project (Table 15; NS&T,

Table 15. National Status and Trends Program summary of PCBs in fish and shellfish (ng/gm dry wt.).

Benthic Surveillance Project		1985	
Site	Lat.	Long.	Flounder livers PCB
Prudence Island	41°21'38"	71°11'40"	2211 ± 528 (598 ± 143 ng/gm wet)

Mussel Watch	1984		
Site	Lat.	Long.	Mussels PCB
Conanicut Island	41°29'47"	71°23'10"	216 ± 92.9 *(43.2 ± 18.6 ng/gm wet)
Dyer Island	41°36'04"	71°17'09"	210 ± 119 *(42 ± 23.8 ng/gm wet)

*assumes 20% dry weight.

Source: NS&T Benthic Surveillance Project, 1985;
NS&T Mussel Watch Program, 1987.

1987). Based on these data, Narragansett Bay was one of areas with the lowest concentrations of all the sites in Southern New England.

3. Quahogs In a recent study of bay quahogs (*Mercenaria mercenaria*) from sites throughout the bay, a gradient in levels of PCBs from the Providence River to Mount View was observed (Pruell *et al*., 1988). However, PCB levels in quahogs from the Ohio Ledge area were not significantly different than those in the Providence River. PCB levels in Mt. Hope Bay quahogs frequently had the lowest concentrations (Table 17; see Appendix A for station locations). All the levels reported were well below the tolerance levels promulgated by the FDA.

It was apparent that the concentrations of PCBs in many organisms appeared to be related to the environment in which they live. In the case of Narragansett Bay the levels tended to follow the pollution gradient that had been observed in the sediments, except that the gradient for the shellfish did not seem to be as steep as that of the sediment. The tissue concentrations held to a range from 110 to 559 ng/gm dry weight for the quahogs, whereas the sediment values ranged from about 10 to 1200 ng/gm dry weight (Ar 1254). This may be due to the activity of the clam as an integrator of pollution as well as the depuration ability of these organisms; furthermore, the availability of PCBs for uptake would be inversely related to the organic carbon content of the sediments.

Table 16

Approximate concentration of PCBs (as Ar 1254 and 1260) in mussels and transplanted mussels from Narragansett Bay. Concentrations in ng/gm dry wt.

Location	Summer 1978	Summer 1979	Winter 1980
X*	150		
Y*	175		
Z*	400		
Sta. 1	650	-	460
Sta. 2	400	950	550
Sta. 3	440	900	400
Sta. 4	280	480	300
Sta. 5	380	480	380

*base population mussels in 1978;

Source: Modified from Lake *et al.*, 1981 (unpublished data).

Table 17. PCB concentrations in quahogs from Narragansett Bay in 1985 and 1986. Concentrations are in ng/gm dry weight.

Location	Ar 1242	Ar 1254	Sum PCBs
Providence River:			
St. 1	N.D.	559	559
St. 2	N.D.	496	496
St. 13	N.D.	228	228
St. 15	N.D.	432	432
St. 30	N.D.	231	231
St. 47	16.8	303	320
St. 49	12.0	353	365
Ohio Ledge	6.64	270	277
Greenwich Bay	10.6	152	163
Mount View			
St. 1	16.7	190	207
St. 2	26.1	254	280
Mt. Hope Bay			
St. 61	21.0	110	131
St. 62	13.1	132	145
St. 63	N.D.	148	148
St. 55	12.0	262	274
St. 64	13.5	186	200

N.D. = <5 ng/gm dry.

Source: Pruell *et al.*, 1988.

SUMMARY AND RECOMMENDATIONS

Most of the major data that have been generated since the early seventies have been summarized in the present review. There is a large data set concerned with the geochemistry of PCBs in sediment cores that is forthcoming (Latimer, 1989c). The data will be helpful in evaluating some of the historical information contained in this review. Notwithstanding, it appeared that, with the available information, Rhode Island has relatively low levels of PCBs in its water, sediment, and biota. There were, however, areas that exhibited concentrations that may be considered detrimental to aquatic organisms. The Blackstone and Woonasquatucket Rivers both had PCB values that were at or above the chronic water quality criteria for fresh-waters. While the Blackstone River concentrations would appear to be difficult to reduce, evidence suggested that the Woonasquatucket would be readily susceptible to clean up by point source regulation. Evaluation of the surface sediments of the bay revealed that concentrations may be high enough to be of concern but criteria for this type of determination are still under development. Further research on sediment quality criteria for toxicants should be an active area of investigation for the future and especially as dredging and dredge spoil disposal are of pressing urgency in Rhode Island. From results of historical studies of the rivers by the USGS and other information from water column and atmospheric samples, previous levels of PCBs in Rhode Island were considerably higher than at the present time, adding more concern that sediment deposits, if dredged, will need to be properly disposed of.

The evaluation of sedimentary fluxes of PCBs revealed a discrepancy in the quantity entering Narragansett Bay from rivers and point sources under dry weather conditions and what was entering the sediments. A significant portion of the sedimentary flux has not been accounted for by the sources evaluated. The probable source of this unaccounted for amount was postulated to be from rivers and point sources under wet weather conditions or from atmospheric sources. Future research should be directed to evaluate these specific sources.

Sediment quality criteria has been applied only in a cursory manner, in the present review, because any research that has been done on this topic is generally site-specific. The definitive application of these criteria for PCBs to sediments in Narragansett Bay was preliminary; however, these kinds of criteria should be developed for Narragansett Bay, especially as they may relate to selection of a water based dump site for future dredge spoils from the ship channel in the Providence River and as a tool for the management of fisheries throughout Narragansett Bay.

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APPENDIX A	Study locations.
APPENDIX B	River data.
APPENDIX C	Point sources data.
APPENDIX D	Water column data.
APPENDIX E	Sediment data.
APPENDIX F	Historical data sets summary sheets.

Appendix A. Study Locations.

	Designation
I. Rivers	
Pawtuxet (Quinn *et al.*, 1985, USGS).	A-I-1, A-I-2, A-I-3
Pawcatuck (Quinn *et al.*, 1987a, USGS).	A-I-4, A-I-5
Blackstone (Quinn *et al.*, 1987b, USGS).	A-I-6, A-I-7
II. Water column/Rivers/Point sources	
Duce *et al.*, 1972.	A-II-1
Quinn *et al.*, 1988.	A-II-2, A-II-3
III. Sediments	
ERCO, 1984.	A-III-1
Latimer, 1989c.	A-III-2, A-III-3
IV. Biota	
Lake *et al.*, 1981 (unpublished data)	A-IV-1, A-IV-2
Pruell *et al.*, 1988.	A-IV-3, A-IV-4
V. National Status and Trends Project	A-V-1, A-V-2

Table A-I-1

Location of sampling sites along the Pawtuxet River.

Sta. No.	Latitude 41° N min	Latitude 41° N sec	Longitude 71° W min	Longitude 71° W sec
*URI 1	47	20	36	00
URI 2	42	15	37	25
URI 2a	42	25	31	15
URI 3	42	50	31	25
URI 4	42	40	30	45
URI 5	43	20	29	20
URI 6	43	40	28	25
URI 7	44	55	26	40
URI 8	45	30	26	20
URI 9	45	45	25	30
**URI 10	46	15	24	20
URI 11	45	45	23	25
URI 12	45	40	23	15
USGS 01116500	45	03	26	44
USGS 01116617	45	51	23	45
Sediment core site	46	10	23	40

*Source: Quinn *et al.*,(1985), USGS records.

**Location of Rhodes-on-the-Pawtuxet core.

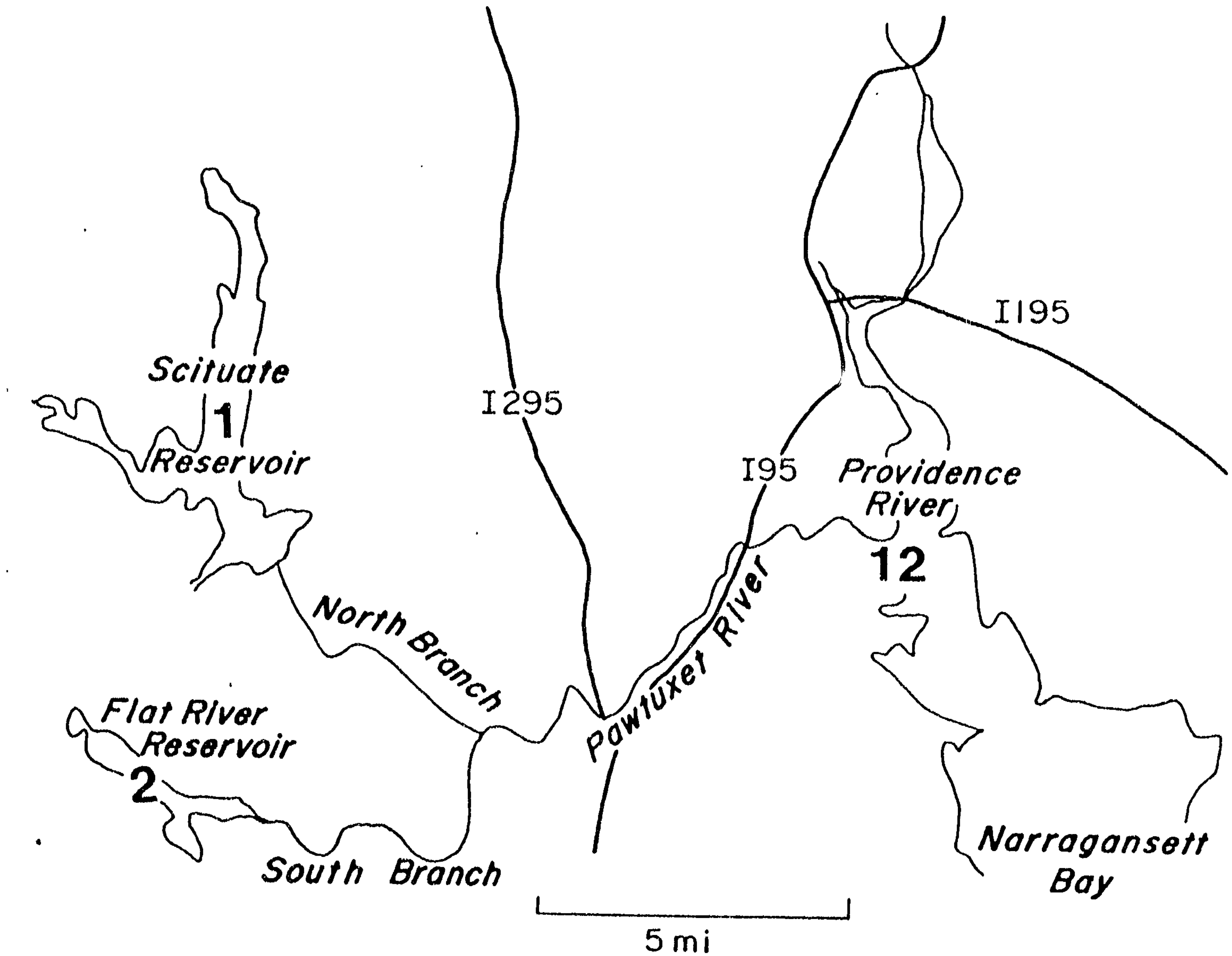


Figure A-I-2. Pawtuxet River upstream stations.

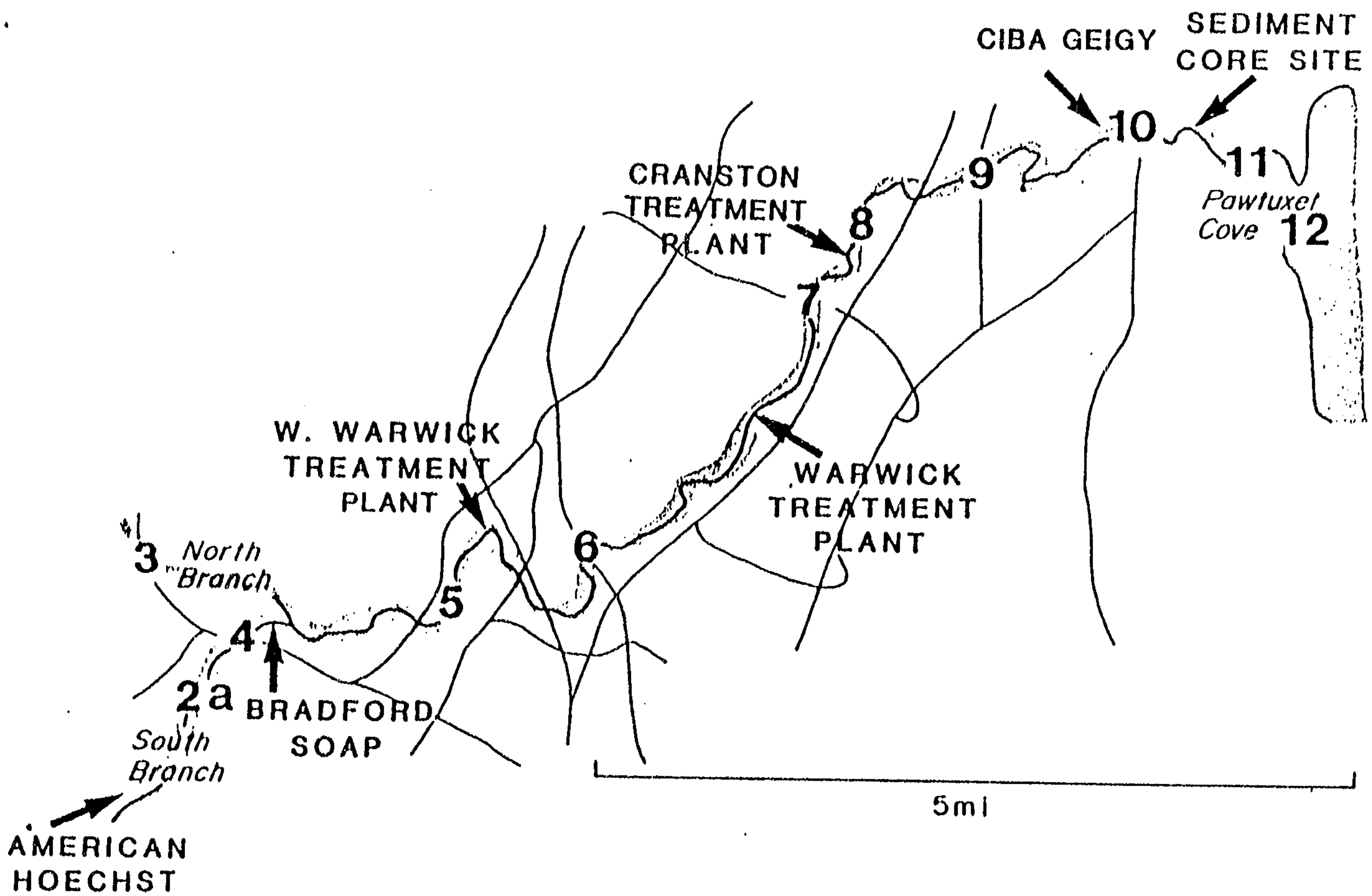


Figure A-I-3. Pawtuxet River downstream stations.

Table A-I-4

Location of sampling site along the Pawcatuck River.

Sta. No.	Latitude N	Longitude W
*URI 1	see map	see map
URI 2	"	"
URI 5	"	"
URI 8	"	"
URI 9	"	"
URI 10	"	"
URI 13	41°23'01"	71°50'01"
USGS 01118500	41°23'01"	71°50'01"

*Source: Quinn *et al.*, (1987a), USGS records.

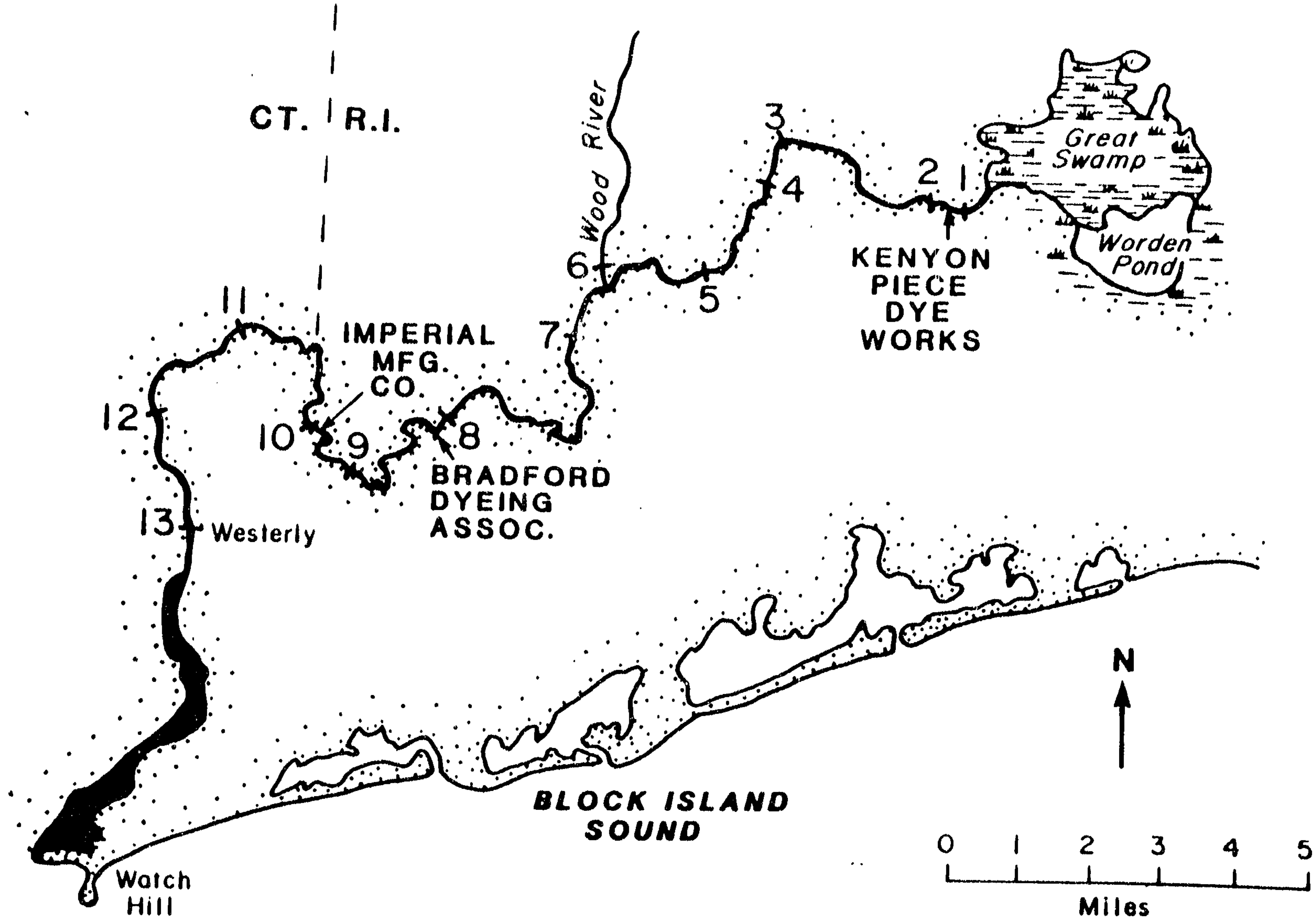


Figure A-I-5. Sampling locations on the Pawcatuck River.

Table A-I-6

Location of sampling sites along the Blackstone River.

Sta. No.	Latitude 41 °N min sec	Longitude 71°W min sec
*URI 1	00 00[a]	33 10
URI 2	01 00[a]	32 45
URI 3	00 20[a]	30 45
URI 4	58 15	28 15
URI 5	57 10	27 10
URI 6	55 40	25 50
URI 7	54 40	24 10
URI 8	53 50	23 25
URI 9	52 40	23 05
USGS 01111230	01 16[a]	34 04
USGS 01111500	59 47	33 47
USGS 01112900	58 18	28 14

*Source: Quinn *et al.*,(1987b), USGS records.

[a]Note: 42 °N latitude.

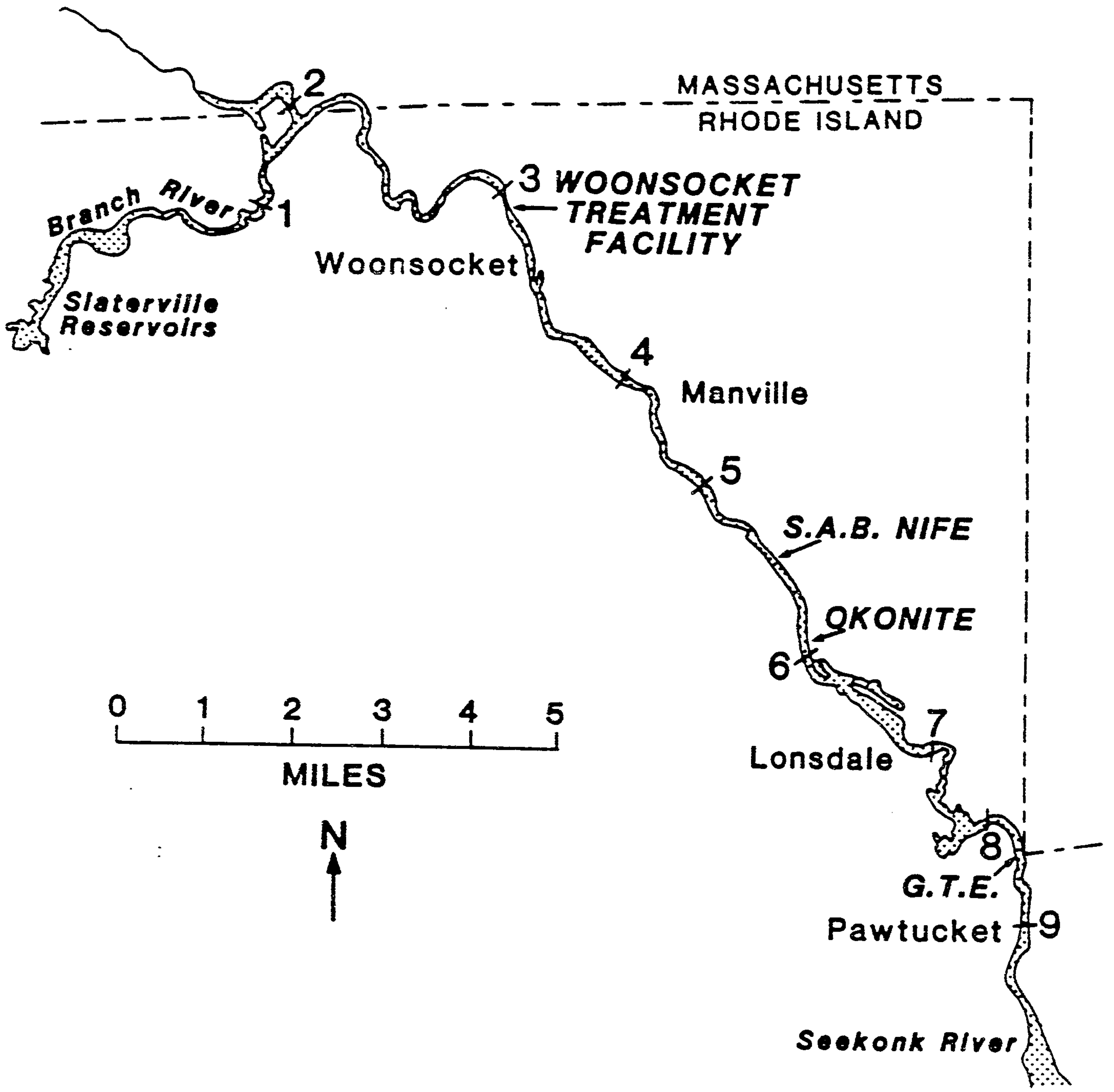


Figure A-I-7. Sampling locations on the Blackstone River.

II. Water column/River/Point Source

Table A-II-1

Locations of stations occupied during the water column study by Duce *et al.*, 1972.

	Latitude	Longitude
Sample 1	41°30'21"	71°23'30"
Sample 2	41°34'30"	71°23'00"

Table A-II-2

Location of stations occupied during Narragansett Bay Water Quality Surveys of 1985-86 for organic samples.

Station No.	Latitude N	Longitude W
No. 2	41°48'48"	71°23'54"
No. 4	41°43'35"	71°21'40"
No. 7	41°38'00"	71°22'18:
No. 12	41°38'58"	71°15'53"
Rivers		
Blackstone	see map	
Woonasquatucket	"	
Moshassuck	"	
Pawtuxet	"	
Taunton	"	
Point Sources		
See Table 2 for names;		
See map for locations.		

Source: Quinn *et al*., 1988.

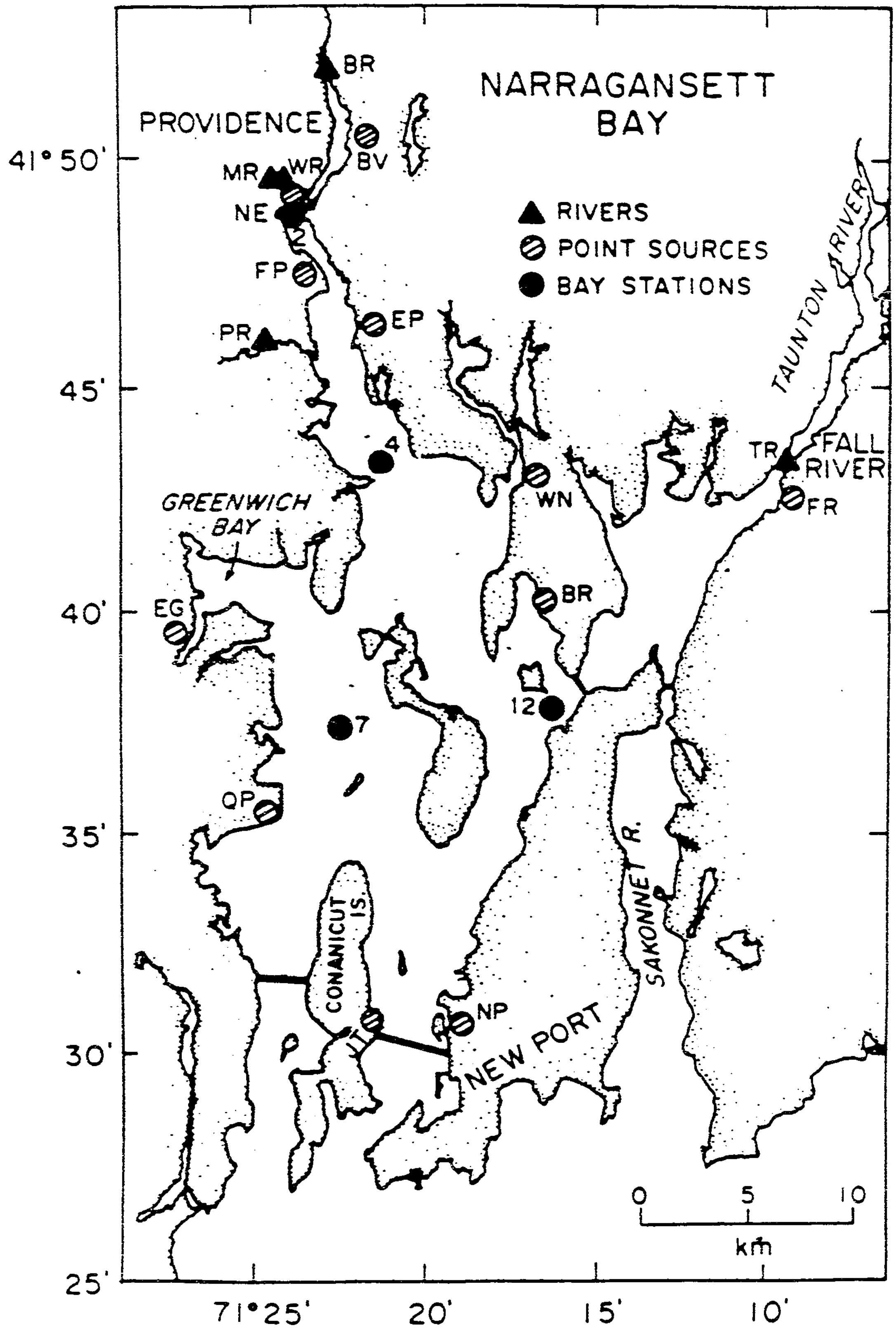
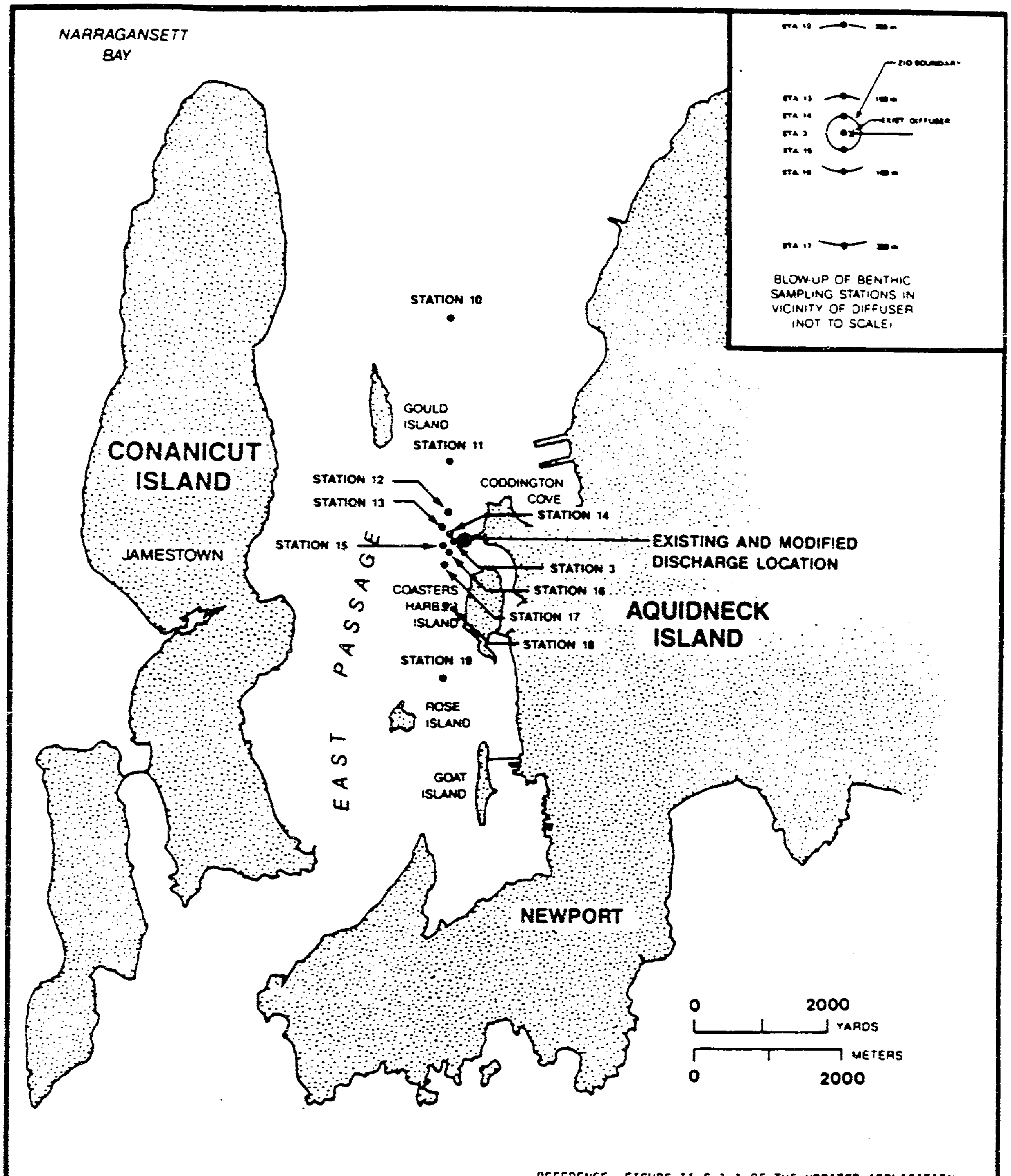


Figure A-II-3. Sampling locations for bay-wide cruises 1985-86.

III. Sediment



REFERENCE: FIGURE II.C.1-1 OF THE UPDATED APPLICATION.

Figure A-III-1. ERCO. Benthic sampling stations in East Passage in 1984.

Table A-III-2

Locations of stations for surface sediment and core samples.

Surface sediment	Latitude N	Longitude W
St. 1, (1a, Fox Pt. core)	41°48'55" (48'56")	71°23'50" (23'51")
St. 2, (2a, Fields Pt. core)	41°47'03" (47'13")	71°22'25" (22'28")
St. 3, (3a)	41°45'15" (45'45")	71°22'33" (22'54")
St. 4	41°43'47"	71°20'48"
St. 5	41°42'52"	71°20'08"
St. 6	41°41'38"	71°20'37"
St. 7	41°42'32"	71°20'08"
St. 8	41°40'34"	71°21'48"
St. 9	41°39'55"	71°19'25"
St. 10	41°41'52"	71°18'40"
St. 11	41°37'58"	71°15'50"
St. 12	41°36'35"	71°17'38"
St. 13	41°34'25"	71°18'45"
St. 14	41°31'03"	71°21'45"
St. 15	41°29'43"	71°19'40"
St. 16	41°28'35"	71°21'35"
St. 17	41°40'52"	71°25'32"
St. 18	41°38'18"	71°22'45"
St. 19	41°34'10"	71°24'05"
St. 20	41°30'55"	71°24'15"
St. 21	41°26'55"	71°25'05"
St. 4a, Conimicut Pt. core	41°43'55"	71°22'03"
St. 5a, Ohio Ledge core	41°40'97"	71°20'12"

Source: Latimer, unpublished data.

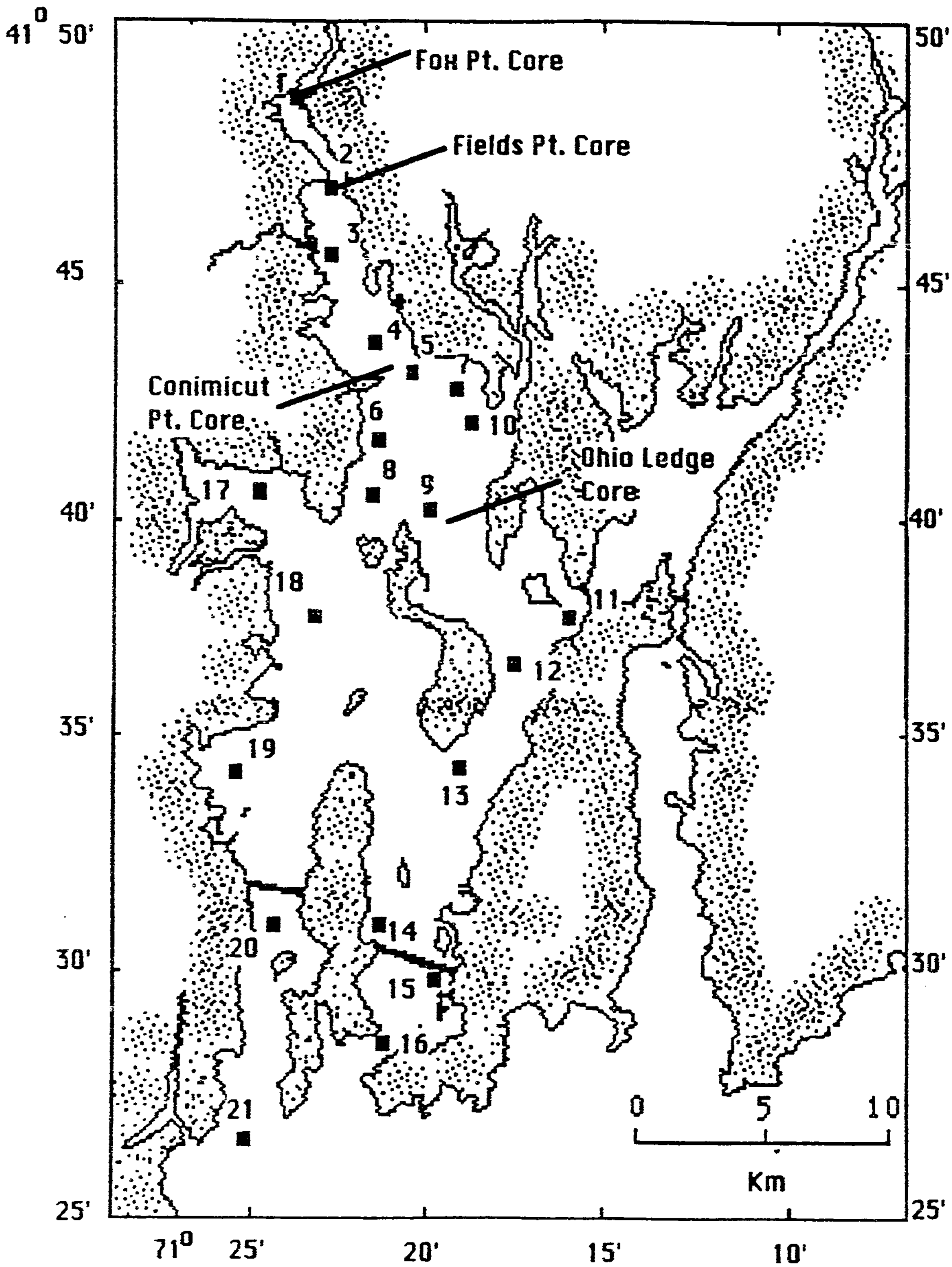


Figure A-III-3. Sampling locations for sediment studies (Latimer, 1989c).

IV. Biota

Table A-IV-1. Location of sites where mussels were collected in Lake *et al.*, 1981 study.

Site	Latitude N	Longitude W
St. X	see map	see map
St. Y	"	"
St. Z	"	"
St. 1	"	"
St. 2	"	"
St. 3	"	"
St. 4	"	"
St. 5	"	"

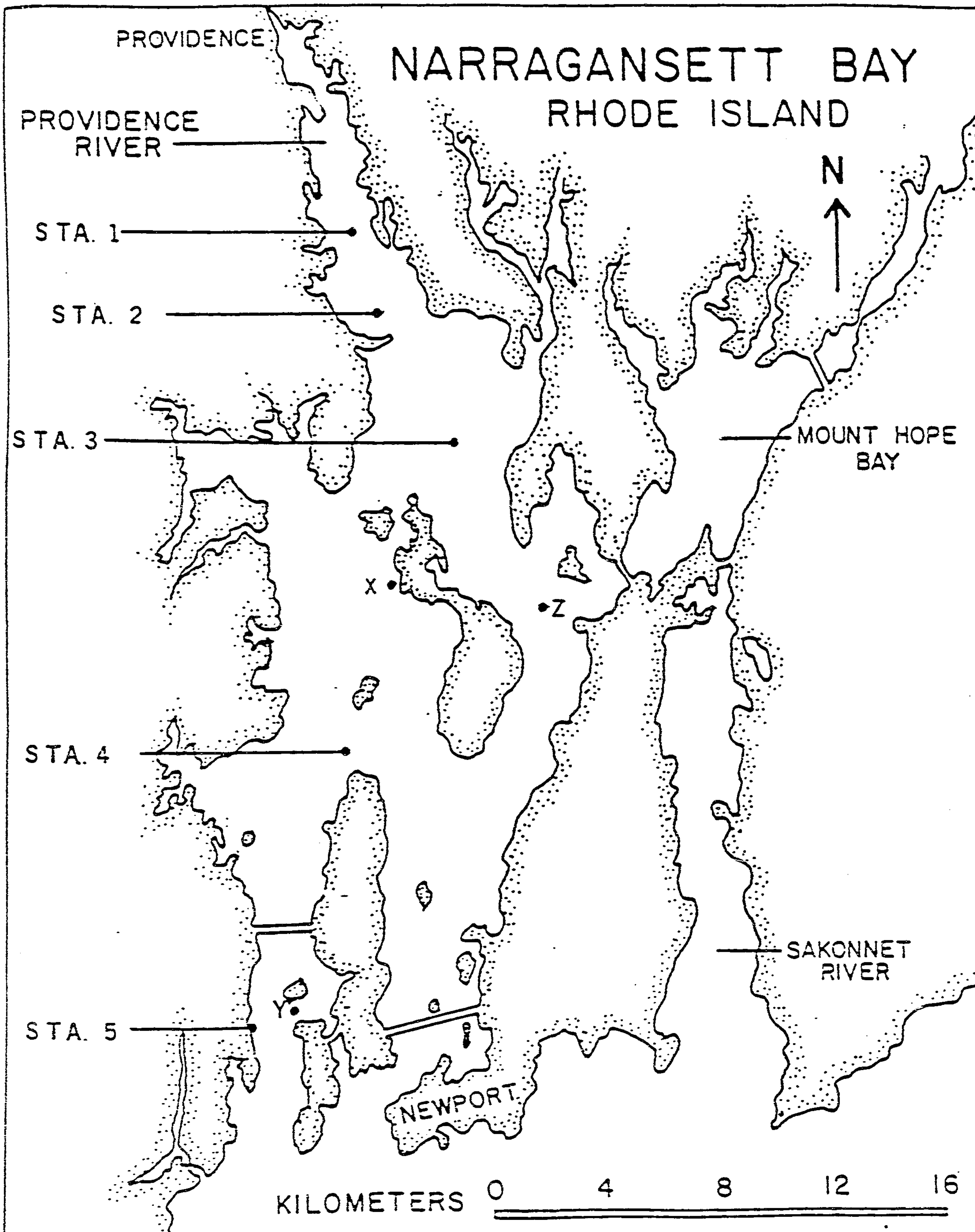


Figure A-IV-2. Mussel collection sites (Lake et al., 1981).

Table A-IV-3

Sampling stations used to collect quahog samples

(Pruell *et al.*, 1988).

Sample No.	Latitude 41°N min	Latitude 41°N sec	Longitude 71°W min	Longitude 71°W sec
PR-1	45	30	22	24
PR-2	45	30	22	18
PR-13	44	30	22	30
PR-15	44	24	22	36
PR-30	43	54	21	18
PR-47	43	42	21	06
PR-49	43	24	21	54
OL-1	40	45	19	45
OH-1	40	44	19	48
GR-1	40	24	24	35
GR-2	40	31	24	06
MV-1	37	25	23	38
MV-2	37	56	22	17
MHB-55	39	12	14	15
MHB-61	42	00	13	46
MHB-62	39	21	12	38
MHB-63	39	23	15	08
MHB-64	38	58	15	19

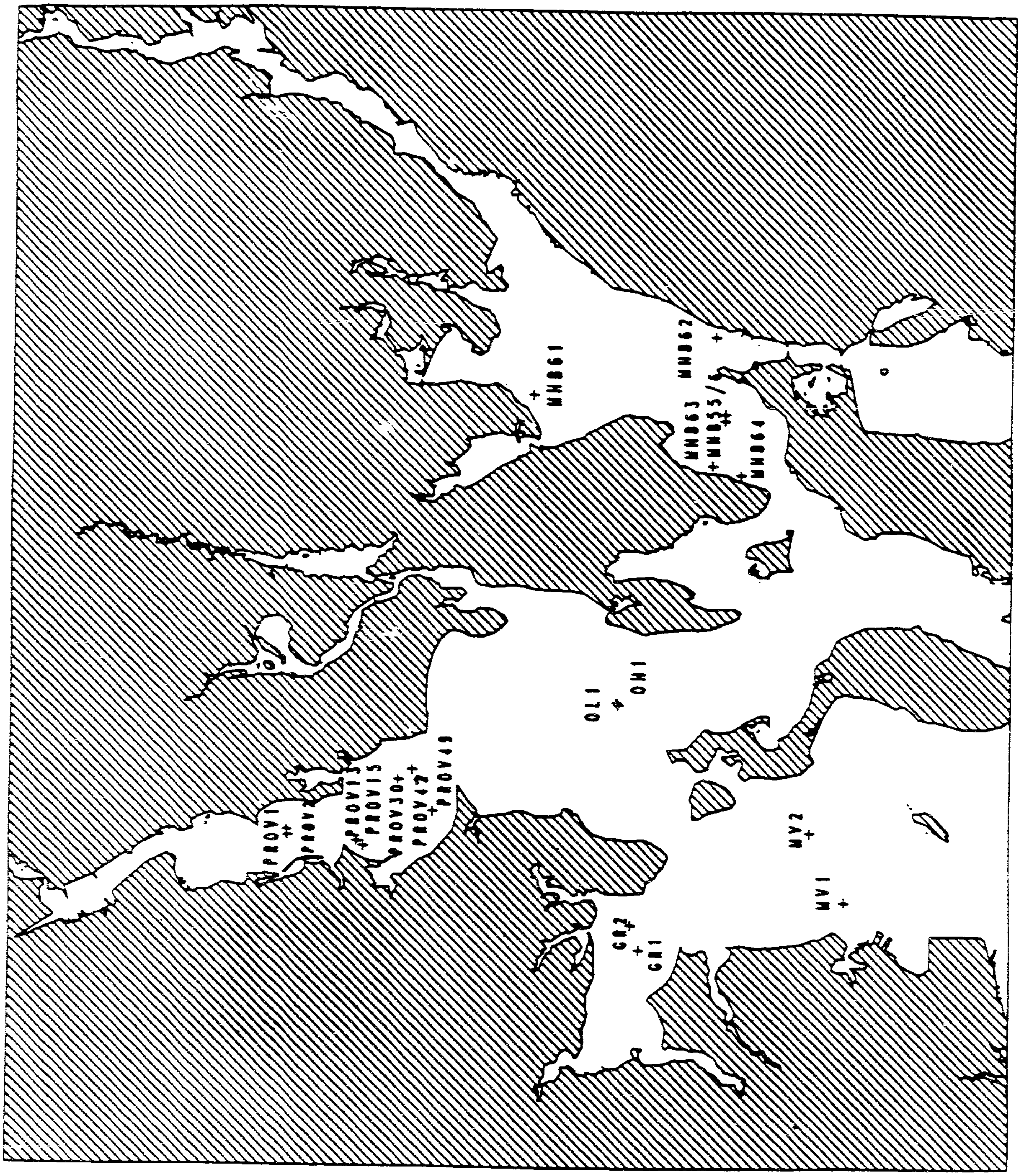


Figure A-IV-4. Sampling sites for quahog study (Pruell et al., 1988).

V. National Status and Trends Project.

Table A-V-1

Sampling site for the National Status and Trends-

Benthic Surveillance Project, 1984.

Sample type	Latitude N	Longitude W
sediment	41°21'33"	71°12'53"
trawl	41°21'38"	71°11'40"

Table A-V-2

Sampling site for National Status and Trends-

Mussel Watch Program, 1984.

Site No.	NOAA code	Area	Latitude N	Longitude W
No. 12	NBCI	Conanicut Isl.	41°29'47"	71°23'10"
No. 14	NBDI	Dyer Isl.	41°36'04"	71°17'09"

Appendix B. PCB concentrations data for Rhode Island rivers.

Table B1	Pawtuxet River, 1984
Tables B2-B4	Pawcatuck River, 1984-85
Tables B5-B7	Blackstone River, 1985
Table B8	USGS River data, 1978-85
Table B9	River data, 1985-1986

Table B1

Concentration of Ar 1254 in samples taken of the Pawtuxet River on 9/10/84 (ng/l).

Sta.	Soluble	Part.	Total
1	N.D.	1.08	1.08
2	N.D.	1.85	1.85
2a	N.D.	6.37	6.37
3	13.3	25.6	38.9
4	N.D.	6.99	6.99
5	N.D.	3.09	3.09
6	3.65	8.59	12.2
7	N.D.	5.15	5.15
9	N.D.	5.15	5.15
10	N.D.	7.26	7.26
11	N.D.	10.5	10.5

N.D. <1.0 ng/l;

Source: Quinn *et al*.,1985.

Table B2

Concentration of Ar 1254 in samples

taken of the Pawcatuck River on 7/3/84

Sta.	Soluble	Part.	Total
	ng/l	ng/l	ng/l
1	0.61	1.79	2.40
2	N.D.	2.00	2.00
5	0.51	3.04	3.55
8	0.77	3.19	3.96
9	0.50	2.23	2.73
10	N.D.	3.26	3.26
13	0.72	3.79	4.51

N.D. = <0.5 ng/l;

Source: Quinn *et al.*, 1987a.

Table B3

Concentration of Ar 1254 in samples taken

of the Pawcatuck River on 11/13/84

Sta.	Soluble	Part.	Total
	ng/l	ng/l	ng/l
1	N.D.	1.83	1.83
2	N.D.	1.72	1.72
5	1.34	14.1	15.4
8	N.D.	2.45	2.45
9	1.03	2.89	3.92
10	0.54	1.69	2.23
13	N.D.	5.69	5.69

N.D. = <0.5 ng/l; Source: Quinn *et al*., 1987a.

Table B4

Concentration of Ar1254 in samples taken

of the Pawcatuck River on 3/11/85.

Sta.	Soluble ng/l	Part. ng/l	Total ng/l
1	N.D.	1.26	1.26
2	N.D.	1.45	1.45
5	N.D.	0.83	0.83
8	0.50	0.70	1.20
9	0.61	0.88	1.49
10	0.59	0.74	1.33
13	0.56	0.76	1.32

N.D. = <0.5 ng/l; Source: Quinn *et al*., 1987a.

Table B5

Concentration of PCBs in samples from the Blackstone River Survey of 7-8-85 (ng/L).

	SOLUBLE				PARTICULATE				TOTAL			
Station	Ar 1248	Ar 1254	Ar 1260	Total	Ar 1248	Ar 1254	Ar 1260	Total	Ar 1248	Ar 1254	Ar 1260	Total
1	0.00	0.00	0.00	0.00	0.00	4.28	0.00	4.28	0.00	4.28	0.00	4.28
2	1.43	1.54	0.75	3.72	2.61	7.21	10.80	20.62	4.04	8.75	11.55	24.34
3	1.59	1.58	0.85	4.02	1.21	1.55	1.47	4.23	2.80	3.13	2.32	8.25
4a	0.00	1.26	0.00	1.26	2.97	4.24	4.79	12.00	2.97	5.50	4.79	13.26
4b	0.00	0.00	0.00	0.00	3.24	6.03	7.88	17.15	3.24	6.03	7.88	17.15
4c	0.00	0.00	0.00	0.00	4.06	6.23	7.48	17.77	4.06	6.23	7.48	17.77
4d	0.00	0.00	0.00	0.00	3.03	4.68	5.58	13.29	3.03	4.68	5.58	13.29
5	0.00	0.94	0.00	0.94	2.47	4.61	5.14	12.22	2.47	5.55	5.14	13.16
6	0.00	0.68	0.00	0.68	0.00	3.77	0.00	3.77	0.00	4.45	0.00	4.45
7	0.64	0.79	0.00	1.42	0.00	2.82	2.66	5.48	0.64	3.61	2.66	6.90
8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	1.46	1.64	0.72	3.82	3.19	6.22	5.61	15.02	4.65	7.86	6.33	18.84

Source: Latimer, 1989.

Table B6

Concentration of PCBs in samples from the Blackstone River Survey of 8-20-85 (ng/L).

	SOLUBLE				PARTICULATE				TOTAL			
Station	Ar 1248	Ar 1254	Ar 1260	Total	Ar 1248	Ar 1254	Ar 1260	Total	Ar 1248	Ar 1254	Ar 1260	Total
1	0.00	0.00	0.00	0.00	1.31	2.07	1.72	5.10	1.31	2.07	1.72	5.10
2	1.00	2.01	1.34	4.35	4.70	7.94	14.60	27.24	5.70	9.95	15.94	31.59
3	0.00	1.56	1.24	2.80	4.15	10.30	11.80	26.25	4.15	11.86	13.04	29.05
4a	2.17	3.05	1.56	6.78	3.97	9.07	12.10	25.14	6.14	12.12	13.66	31.92
4b	0.00	2.94	1.40	4.34	2.75	4.76	6.53	14.04	2.75	7.70	7.93	18.38
4c	1.17	1.47	0.77	3.41	3.45	6.10	7.26	16.81	4.62	7.57	8.03	20.22
4d	1.17	1.47	0.77	3.41	2.19	5.60	9.29	17.08	3.36	7.07	10.06	20.49
5	1.16	1.43	0.74	3.33	2.76	6.48	9.11	18.35	3.92	7.91	9.85	21.68
6	0.73	0.83	0.41	1.97	2.31	4.69	6.00	13.00	3.04	5.52	6.41	14.97
7	3.01	3.68	2.17	8.86	1.95	3.80	4.43	10.18	4.96	7.48	6.60	19.04
8	0.72	1.74	0.78	3.24	2.22	5.55	5.71	13.48	2.94	7.29	6.49	16.72
9	0.00	2.04	0.85	2.89	3.31	8.12	8.10	19.53	3.31	10.16	8.95	22.42

Source: Latimer, 1989.

Table B7

Concentration of PCBs in samples from the Blackstone River Survey of 10-8-85 (ng/L).

	SOLUBLE				PARTICULATE				TOTAL			
Station	Ar 1248	Ar 1254	Ar 1260	Total	Ar 1248	Ar 1254	Ar 1260	Total	Ar 1248	Ar 1254	Ar 1260	Total
1	0.93	0.69	0.46	2.08	1.95	2.95	2.26	7.16	2.88	3.64	2.72	9.24
2	2.77	3.12	1.89	7.78		21.70	26.40	48.10	2.77	24.82	28.29	55.88
3	2.27	2.81	1.59	6.67		16.70	19.30	36.00	2.27	19.51	20.89	42.67
4a	1.10	1.21	0.84	3.15		17.80	18.50	36.30	1.10	19.01	19.34	39.45
4b		0.36		0.36		9.53	16.20	25.73	0.00	9.89	16.20	26.09
4c	1.27	1.46	0.79	3.52		9.41	14.50	23.91	1.27	10.87	15.29	27.43
4d	1.32	1.47	0.73	3.52		8.37	12.10	20.47	1.32	9.84	12.83	23.99
5	1.57	2.05	1.28	4.90		12.00	16.40	28.40	1.57	14.05	17.68	33.30
6	1.38	1.89	1.08	4.35		10.10	14.80	24.90	1.38	11.99	15.88	29.25
7	2.15	2.54	1.53	6.22		9.96	14.40	24.36	2.15	12.50	15.93	30.58
8	2.86	2.78	1.43	7.07		16.40	20.30	36.70	2.86	19.18	21.73	43.77
9	2.49	2.74	1.62	6.85		18.90	17.40	36.30	2.49	21.64	19.02	43.15

Source: Latimer, 1989.

Table B8

PCB concentrations in the Blackstone and Pawtuxet Rivers determined by the USGS (ng/L) from 1979 through 1985.

WATER YEAR:	1979			1980	1981	1982	1983	1983	1984	1984	1985	1985
date of sample:	11/78	5/79	9/79	9/80	9/81	8/82	4/83	5/83	4/84	5/84	4/85	9/85
BLACKSTONE RIVER												
MILLVILLE	<100	N.A.	100	<100	<100	<100	N.A.	<100	<100	<100	<100	<100
BRANCH @ FORESTDALE	<100	N.A.	<100	200	<100	<100	N.A.	<100	<100	<100	<100	<100
MANVILLE	N.A.	N.A.	200	N.A.	<100	<100	N.A.	<100	<100	<100	<100	<100

WATER YEAR:	1979			1980	1981	1982	1983	1983	1984	1984	1985	1985
date of sample:	11/78	5/79	9/79	9/80	9/81	8/82	4/83	5/83	4/84	5/84	4/85	9/85
PAWTUXET RIVER												
CRANSTON	2800	200	1900	<100	200	<100	N.A.	<100	<100	<100	<100	<100
PAWTUXET	4300	N.A.	1600	N.A.	N.A.	<100	N.A.	<100	<100	<100	<100	<100

Source: U. S. Geological Survey, 1979-85.

Table B9. Concentrations of PCBs in rivers discharging into Narragansett Bay.

		SS (MG/L)	PCBs (NG/L) Ar 1242	Ar 1254	Ar 1260
October 21-25, 1985					
PR	P	6.73	3.42	4.54	2.25
	S		N.D.	N.D.	N.D.
MR	P	2.94	2.56	3.54	2.00
WR	P	9.34	7.89	19.5	13.4
	S		N.D.	N.D.	N.D.
BR	P	4.52	3.47	8.55	5.88
	S		N.D.	1.16	N.D.
TR	P	18.3	N.D.	1.68	N.D.
November 18-21, 1985					
PR	P	8.08	N.D.	4.29	2.45
	S		N.D.	N.D.	N.D.
MR	P	4.09	N.D.	5.06	5.16
WR	P	4.81	N.D.	6.60	5.07
BR	P	7.66	N.D.	11.6	13.4
	S		N.D.	N.D.	N.D.
TR	P	3.99	N.D.	2.18	N.D.
	S		N.D.	N.D.	N.D.
April 7-10, 1986					
PR	P	7.25	N.D.	3.23	1.46
	S		N.D.	N.D.	N.D.
MR	P	13.20	N.D.	13.6	N.D.
	S		28.6	11.6	N.D.
WR	P	9.79	N.D.	13.80	7.01
BR	P	4.31	N.D.	4.86	5.37
	S		0.35	0.25	N.D.
TR	P	5.50	N.D.	3.08	N.D.
	S		N.D.	N.D.	N.D.
May 19-22, 1986					
dry weather					
PR	P	5.89	N.D.	5.51	N.D.
	S		0.46	N.D.	N.D.
MR	P	7.23	4.38	9.54	N.D.
WR	P	7.82	4.57	12.5	10.6
BR	P	6.89	5.48	16.7	8.34
	S		0.30	0.54	N.D.
TR	P	6.12	2.16	3.28	N.D.
wet weather					
PR	P	67.6	30.1	66.7	27.4
	S		N.D.	N.D.	N.D.
MR	P	88.1	52.9	179	N.D.
WR	P	45.0	5.37	15.6	9.94
BR	P	13.8	N.D.	20.9	N.D.
	S		0.68	0.46	N.D.

N.C.= Not collected P= Particulate S= Soluble
N.D.= Not detected

Source: Latimer, 1989.

Appendix C PCB concentrations in point sources within each river system.

Table C1 Pawtuxet River, 1984

Table C2 Pawcatuck River, 1984-85

Table C3 Blackstone River, 1985

Table C4 Narragansett Bay, 1985-86.

Table C1

Concentration of Ar 1254 in industrial and municipal point sources along the Pawtuxet River (ng/l).

September 10, 1984

Point Source	Soluble	Particulate	Total
Industrial:			
American Hoechst	N.D.	N.D.	N.D.
Municipality:			
West Warwick	N.D.	33.6	33.6
Warwick	N.D.	25.7	25.7
Cranston	6.94	6.40	12.9

Source: Quinn *et al*., 1985.

Table C2

Concentration of Ar 1254 in industrial point sources along the Pawcatuck River (ng/l).

Industry	7/3/84			11/13/84			3/11/85		
	S	P	T	S	P	T	S	P	T
Kenyon Piece Dyeworks									
Lagoon	N.D.	5.05	5.05	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
Marsh	N.C.	N.C.	N.C.	N.C.	N.C.	N.C.	N.D.	N.D.	N.D.
Bradford Dyeing Association									
Lagoon	N.C.	N.C.	N.C.	1.37	10.6	12.0	N.D.	N.D.	N.D.
Marsh	N.D.	N.D.	N.D.	0.91	3.37	4.28	N.D.	2.85	2.85
Imperial Manuf. Co.	N.D.	14.1	14.1	2.85	9.96	12.8	N.D.	4.93	4.93

N.D. = <0.5 ng/l
N.C. = not collected
S = soluble
P = particulate
T = total

Source: Quinn *et al.*, 1987a.

Table C3

Concentration of PCBs in industrial and municipal samples from the Blackstone River Surveys (ng/L).

	SOLUBLE				PARTICULATE				TOTAL			
7/8/85	Ar 1248	Ar 1254	Ar 1260	Total	Ar 1248	Ar 1254	Ar 1260	Total	Ar 1248	Ar 1254	Ar 1260	Total
WTP	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NFE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
OKO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
GTE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8/20/85												
WTP	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NFE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
OKO	2.15	1.47	0.65	4.27	0.00	1.74	1.54	3.28	2.15	3.21	2.19	7.55
GTE	0.00	0.00	0.00	0.00	12.60	15.50	8.86	36.96	12.60	15.50	8.86	36.96
10/8/85												
WTP	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NFE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
OKO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
GTE	0.00	0.00	0.00	0.00	0.00	5.94	0.00	5.94	0.00	5.94	0.00	5.94

WTP= Woonsocket waste water treatment facility
NFE= S.A.B. Nife, Inc.
OKO= Okonite Co.
GTE= Corning/G.T.E. Products

Source: Latimer, 1989.

Table C4. CONCENTRATIONS OF PCBS IN POINT SOURCES DISCHARGING INTO NARRAGANSETT BAY.

		SS (MG/L)	PCBS (NG/L) AR 1242	AR 1254	AR 1260
OCTOBER 21-25, 1985					
BR	P	68.6	47.3	61.9	N.D.
BV	P	66.9	89.1	56.9	N.D.
	S		11.6	3.7	N.D.
EG	P	51.9	41.5	43.4	N.D.
	S		N.D.	N.D.	N.D.
EP	P	10.3	N.D.	12.7	N.D.
FP	P	61.6	N.D.	103	N.D.
	S		N.D.	N.D.	N.D.
FR	P	34.8	29.5	27.2	N.D.
NE	P	11.1	N.D.	N.D.	N.D.
NP	P	92.0	N.D.	39.4	N.D.
	S		N.D.	N.D.	N.D.
WN	P	4.53	N.D.	5.27	N.D.
JT		N.C.	N.C.	N.C.	N.C.
QP		N.C.	N.C.	N.C.	N.C.
NOVEMBER 18-21, 1985					
BR	P	47.7	37.5	78.8	N.D.
BV	P	31.0	49.1	33.1	N.D.
	S		N.D.	N.D.	N.D.
EG	P	75.3	75.8	75.6	N.D.
	S		N.D.	N.D.	N.D.
EP	P	10.8	N.D.	9.05	N.D.
FP	P	32.1	N.D.	66.2	N.D.
	S		N.D	N.D.	N.D.
FR	P	14.8	N.D.	N.D.	N.D.
NE	P	1.87	N.D.	N.D.	N.D.
NP	P	61.7	N.D.	50.4	N.D.
WN	P	37.1	N.D.	21.4	N.D.
JT	P	16.5	N.D.	22.3	N.D.
QP	P	42.4	N.D.	37.0	N.D.
APRIL 7-10, 1986					
BR	P	47.50	N.D.	47.2	N.D.
BV	P	40.00	N.D.	37.8	N.D.
	S		8.90	N.D.	N.D.
EG	P	134.00	N.D.	64.0	N.D.
EP	P	12.50	N.D.	11.3	N.D.
FP	P	30.00	N.D.	N.D.	N.D.
	S		N.D.	N.D.	N.D.
FR	P	23.90	N.D.	N.D.	N.D.
	S		N.D.	N.D.	N.D.
NE	P	2.38	N.D.	4.40	N.D.
NP	P	71.90	N.D.	N.D.	N.D.
WN	P	42.20	N.D.	N.D.	N.D.
JT	P	6.42	N.D.	4.72	N.D.
QP	P	56.30	N.D.	70.0	N.D.
MAY 19-22, 1986					
BR	P	80.8	N.D.	60.9	N.D.
BV	P	109	112	74.9	N.D.
	S		N.D.	N.D.	N.D.
EG	P	78.7	N.D.	N.D.	N.D.
	S		N.D.	N.D.	N.D.
EP	P	20.0	N.D.	15.0	N.D.
FP	P	59.2	N.D.	N.D.	N.D.
	S		N.D.	N.D.	N.D.
FR	P	34.4	N.D.	N.D.	N.D.
NE	P	5.77	3.22	7.86	N.D.
NP	P	105	N.D.	65.0	N.D.
WN	P	58.9	N.D.	39.1	N.D.
JT	P	9.36	N.D.	10.6	N.D.
QP	P	67.7	94.1	104	N.D.

N.C. = NOT COLLECTED P= PARTICULATE S= SOLUBLE
N.D = NOT DETECTED

Source: Latimer, 1989.

Appendix D

PCB concentrations in the water column of Narragansett Bay (1985-86). Source: Latimer, 1989.

Table D1. Concentrations of PCBs in the waters of Narragansett Bay.

Date	Station *	Depth, m	Fraction	SS (MG/L)	PCBs (NG/L) Ar 1242	Ar 1254	Ar 1260
10/21/85	2	0.4	P	N.A.	N.D.	3.09	1.99
		2.5	P	N.A.	2.64	5.33	6.09
			S		1.13	1.00	N.D.
		5.6	P	N.A.	2.88	8.39	6.17
			S		N.D.	N.D.	N.D.
		12.5	P	N.A.	0.69	1.53	1.23
	4	0.3	P	N.A.	2.37	2.75	1.36
		3.3	P	N.A.	1.32	1.56	1.06
		9.9	P	N.A.	0.89	1.53	1.19
	7	0.5	P	N.A.	0.97	1.32	0.89
		2.9	P	N.A.	0.88	1.37	0.94
		5.0	P	N.A.	1.17	1.40	1.06
	12	0.3	P	N.A.	2.85	2.40	1.35
		7.2	P	N.A.	0.99	1.29	0.83
		15.0	P	N.A.	0.62	0.98	0.76
		25.4	P	N.A.	0.95	1.08	0.87
11/18/85	2	0.4	P	2.84	N.D.	2.74	2.67
		2.1	P	2.01	N.D.	2.23	1.51
		4.4	P	2.19	N.D.	1.85	1.38
		10.7	P	4.04	N.D.	2.65	1.59
	4	0.7	P	1.89	N.D.	1.90	1.32
		4.7	P	4.58	N.D.	1.86	N.D.
		11.1	P	33.6	N.D.	5.35	2.96
			S		N.D.	N.D.	N.D.
	7	0.9	P	2.19	N.D.	N.D.	N.D.
		3.1	P	3.17	N.D.	1.45	1.01
		5.0	P	2.92	N.D.	1.15	N.D.
	12	0.6	P	1.16	N.D.	0.93	N.D.
		7.5	P	1.68	N.D.	N.D.	N.D.
		21.8	P	3.15	N.D.	0.66	N.D.
4/7/86	2	0.1	P	3.96	N.D.	1.56	1.00
		1.7	P	4.05	N.D.	3.59	N.D.
		13.0	P	2.27	N.D.	1.24	0.52
	4	0.3	P	3.84	N.D.	3.94	N.D.
		2.2	P	4.04	N.D.	1.05	1.06
		13.6	P	3.42	N.D.	N.D.	N.D.
	7	0.5	P	2.00	N.D.	1.40	N.D.
		4.3	P	1.81	N.D.	N.D.	N.D.
		6.1	P	2.79	N.D.	2.13	N.D.
	12	0.3	P	1.67	N.D.	1.81	0.58
		11.3	P	1.89	N.D.	0.72	0.25
		14.8	P	2.11	N.D.	0.44	N.D.
5/19/86	2	0.4	P	6.57	N.D.	10.40	5.45
		4.4	P	4.40	N.D.	4.62	2.64
		11.8	P	3.48	N.D.	4.20	N.D.
	4	0.5	P	5.72	N.D.	3.56	1.49
		5.5	P	5.81	N.D.	2.73	N.D.
		15.3	P	16.2	N.D.	5.13	2.24
	7	0.5	P	2.31	N.D.	0.30	N.D.
		5.9	P	3.99	N.D.	1.69	1.01
	12	0.5	P	1.84	N.D.	1.63	0.72
		10.4	P	2.54	1.37	1.80	0.77
		15.1	P	3.66	1.06	1.98	0.96

N.D.= Not detected P= Particulate S= Soluble

Appendix E PCB concentration in sediments of Narragansett Bay.

Surface sediments

Table E1 Rubinstein and Pruell, unpublished data;

Table E2 Latimer, 1989.

Table E3 Boehm and Quinn, 1978.

Cores

Table E4 Wade and Quinn, 1979.

Table E1

Surface sediment (0-10 cm depth)

Location	Ar 1254 ng/gm dry	st. dev. ng/gm dry	rsd %	number of analyses
Con. Pt.	274	49.6	18	3
Grn.Bay	60.2	0	0	1
N. Jam.	50.4	3.22	6	3
Ohio L.	142	0	0	1
Quon. Pt.	45.4	5.44	12	3
Sabin Pt.	903	83.5	9	3

Rubinstein, N. I. and R. J. Pruell, 1985 unpublished data

Table E2. **Concentration of PCBs in surface sediment collected throughout Narragansett Bay.**

Station #	mg/gm TOC	PCBs (ng/gm dry) Ar 1242	Ar 1254	Ar 1260
1	85.64	391.295	1217.575	799.410
2	49.11	161.760	693.810	340.400
3	52.80	0.000	360.470	211.625
4	8.54	0.000	34.728	0.000
5	2.94	0.000	10.320	0.000
6	49.13	0.000	125.736	71.760
7	50.29	0.000	146.321	78.963
8	12.63	0.000	35.957	21.702
9	41.83	0.000	112.771	77.063
10	9.99	0.000	8.849	4.546
11	33.22	0.000	50.197	29.066
12	35.39	0.000	57.956	60.207
13	5.57	0.000	11.089	10.028
14	8.96	0.000	15.295	11.051
15	36.41	0.000	136.189	47.497
16	8.72	0.000	30.134	21.750
17	65.82	0.000	123.665	81.437
18	37.47	0.000	79.109	53.171
19	16.04	0.000	30.134	21.750
20	21.71	0.000	29.797	17.734
21	4.97	0.000	4.847	2.795
1-a	66.15	412.740	1123.495	774.935
2-a	61.18	0.000	407.970	279.340
3-a	51.82	0.000	447.480	276.360
4-a	46.94	0.000	182.125	111.925
5-a	39.99	0.000	197.727	143.311

Source: Latimer, 1989.

Table E3.

Sediment core #17 (41 22 50N, 71 20 15W)
RI sound near dump site

depth, cm	PCB (ng/gm dry)
0-8	8.5
8-18	3.1
18-28	nd
28-38	nd

Boehm and Quinn (1978); core collected in 1975

Table E4.

Sediment core (41 34 30N, 71 22W)
North Jamestown (between St4 &8 of Shultz and Quinn, 1977)

	ng/gm dry		
depth, cm	Ar 1254	Ar 1260	total
0-4	26.8	12.4	39.2
4-6	3.8	4.6	8.4
6-8	0.5	3.0	3.5
8-10	1.3	4.4	5.7
10-12	0.7	1.2	1.9
12-14	0.0	0.7	0.7
blank	5.4	1.3	6.7

Wade and Quinn (1979); core collected in 1977

Appendix F

Historical data sets summary sheets.

Title of study: Transfer of pesticides through water, sediments, and aquatic life

Purpose of study: Broad survey of PCBs, pesticides in RI environment

Summary: No extremely high levels observed, some PCB hot spots - Pawtuxet River

Variables & units: PCB, DDE, DDD, DDT, chlordane, dieldrin, HCH, endosulformal ponds, fish, sediment

Sample locations: see particular tables in text

Sample frequency: grabs | Sample span: 1970-1971

Principal Investigator:

PI name: C. Olney

PI organization: URI

Address: URI | city: Kingston | state: RI | zip: 02881

Telephone #:

Contacted: No

Funding Agency: Office of Water Res~rce Research

Citation for published data:

Author: C. Olney | Year: 1971

Title: same as study

Journal/report: 8th Annual Report RIWRC | V: | P: 26

Lib of Congress #: | Location of original:

Contact Person:

	Original Data:	Summarized Data:
Are data computerized?	Yes [ ] No [ ]	Yes [X] No [ ]
Hardware format:		Macintosh
Software format:		MS Word
Location of data:		GSO
Contact person:		Latimer

Data Quality:

Accuracy: good [X] fair [ ] poor [ ] unknown [ ]

Precision: good [X] fair [ ] poor [ ] unknown [ ]

Strong Points: broad and comprehensive survey

Weak Points: detection limits somewhat high

Quality checks: good history

Data usefulness: limited serve as baseline PCB data

Report inclusion: Accepted: [x] Rejected: [ ] Should computerized version be archived? [N]

Are data suitable for ARC/INFO system? Yes [ ] No [x]

Comments: dated information, update is necessary

Form completed by: J. S. Latimer | Date of completion: 5/3/88 | Index: 1

Title of study: Enrichment of heavy metals and organic compounds in the surface microlayer of Narragansett Bay

Purpose of study: Evaluate role of microlayer in concentrating organic and inorganic compounds.

Summary: Microlayer was enriched in organic compounds to a greater extent than inorganic compounds.

Variables & units: Pb, Fe, Ni, Cu, fatty acids, PHC, PCB, concentration units

Sample locations: Appendix E

Sample frequency: grab samples   Sample span: 1971

Principal Investigator:

PI name:

PI organization: URI-GSO

Address: URI   city Kingston   state RI   zip 02881

Telephone #:

Contacted: no

Funding Agency: NSF

Citation for published data:

Author: R.A. Duce, J.G. Quinn, C.E. Olney, S.R. Piotrowicz, B.J. Ray, T.L. Wade   Year: 1972

Title: same as study title

Journal/report: Science   V: 176   P: 161

Lib of Congress #:   Location of original: unknown

Contact Person:

	Original Data:	Summarized Data:
Are data computerized?	Yes [ ] No [ ]	Yes [X] No [ ]
Hardware format:		Macintosh
Software format:		MS Excel/Word
Location of data:		GSO
Contact person:		Latimer

Data Quality:

Accuracy: good [X] fair [ ] poor [ ] unknown [ ]

Precision: good [X] fair [ ] poor [ ] unknown [ ]

Strong Points: 1st measurement of this kind in RI

Weak Points: spatial and temporal information lacking

Quality checks: good history

Data usefulness: limited due to spatial /temporal constraints, also dated

Report inclusion: Accepted: [X] Rejected: [ ] Should computerized version be archived? [N]

Are data suitable for ARC/INFO system? Yes [ ] No [X]

Comments:

Form completed by: J. S. Latimer   Date of completion: 5/3/88   Index: 2

Title of study: Atmospheric removal processes for high molecular weight organochlorines

Purpose of study: Atmospheric source of PCBs

Summary: Measureable amounts of PCB, pesticides from dry deposition

Variables & units: PCB, DDT, Chordane, toxaphene, concentration units, flux units

Sample locations: Kingston, RI

Sample frequency: 2-5 day samples per annum

Sample span: 1973-1975

Principal Investigator:

PI name: unknown

PI organization: Univ. of S. Carolina

Address: Inst. for Mar. Bio/Coast Res.

city: Columbia

state: SC

zip: 29208

Telephone #: unknown

Contacted: no

Funding Agency: NSF

Citation for published data:

Author: T. F. Bidleman, E. J. Christensen

Year: 1979

Title: same as study title

Journal/report: J. Geo. Res.

V: 84

P: 7857

Lib of Congress #:

Location of original: unknown

Contact Person:

	Original Data:	Summarized Data:
Are data computerized?	Yes [ ] No [ ]	Yes [X] No [ ]
Hardware format:		Macintosh
Software format:		MS Excell/Word
Location of data:		GSO
Contact person:		Latimer

Data Quality:

Accuracy: good [X] fair [ ] poor [ ] unknown [ ]

Precision: good [X] fair [ ] poor [ ] unknown [ ]

Strong Points: 1st measurement of its kind in RI

Weak Points: one sampling location limits geographical extrapolation

Quality checks: good history

Data usefulness: Atmos. estimate of PCBs, outdated for present sources

Report inclusion: Accepted: [x] Rejected: [ ] Should computerized version be archived? [N]

Are data suitable for ARC/INFO system? Yes [ ] No [X]

Comments: New studies on RI atmosphere should be done

Form completed by: J. S. Latimer

Date of completion: 5/3/88

Index: 3

Title of study:	Benthic hydrocarbons of RI Sound
Purpose of study:	Evaluate distribution of orgnics near site of previous dredge spoil dump
Summary:	
Variables & units:	PHC, HC 344, HC 348, PCB, concentration units
Sample locations:	Appendix E
Sample frequency:	One set of sediment samples
Sample span:	1975

Principal Investigator:

PI name:	J. G. Quinn
PI organization:	GSO
Address:	S. Ferry Rd.
city	Narragansett
state	RI
zip	02882
Telephone #:	401-792-6615
Contacted:	yes
Funding Agency:	USEPA, AAPG

Citation for published data:

Author:	P. D. Boehm, J. G. Quinn
Year:	1978
Title:	same as title of study
Journal/report:	Est. Coast. Mar. Sci.
V:	6
P:	471
Lib of Congress #:	
Location of original:	Organic Geochemistry Lab-GSO
Contact Person:	J. S. Latimer

	Original Data:	Summarized Data:
Are data computerized?	Yes [ ] No [X]	Yes [X] No [ ]
Hardware format:		Macintosh
Software format:		MS Excel/Word
Location of data:		GSO
Contact person:		Latimer

Data Quality:

Accuracy:	good [X] fair [ ] poor [ ] unknown [ ]
Precision:	good [X] fair [ ] poor [ ] unknown [ ]
Strong Points:	Good spatial coverage of surface sediments
Weak Points:	Core horizons too wide, very little PCB data
Quality checks:	good history
Data usefulness:	Geochemistry of PCBs

Report inclusion: Accepted: [X] Rejected: [ ] Should computerised version be archived? [N]

Are data suitable for ARC/INFO system? Yes [ ] No [X]

Comments:	PCB data too scanty for inclusion
Form completed by:	J. S. Latimer
Date of completion:	5/3/88
Index:	4

Title of study: Geochemical distribution of hydrocarbons in sediments from mid-Narragansett Bay, Rhode Island

Purpose of study: Evaluate compounds in sediments of mid-bay, geochemistry

Summary: Levels reflect anthropogenic inputs to N.B.

Variables & units: PHC, OC, aromatics, HC 344, PCB, chlordane, DDT

Sample locations: Appendix D

Sample frequency: 2 cores Sample span: 1976-1977

Principal Investigator:

PI name: J. G. Quinn

PI organization: GSO

Address: S. Ferry Rd. city Narragansett state RI zip 02882

Telephone #: 792-6219

Contacted: yes

Funding Agency: EPA

Citation for published data:

Author: T. L. Wade, J. G. Quinn Year: 1979

Title: same as study

Journal/report: Organic Geochemistry V: 1 P: 157

Lib of Congress #:   Location of original: Organic Geochemistry Lab

Contact Person: J. G. Quinn

	Original Data:	Summarized Data:
Are data computerized?	Yes [ ] No [X]	Yes [X] No [ ]
Hardware format:		Macintosh
Software format:		MS Excel
Location of data:		GSO
Contact person:		Latimer

Data Quality:

Accuracy: good [X] fair [ ] poor [ ] unknown [ ]

Precision: good [X] fair [ ] poor [ ] unknown [ ]

Strong Points: One of the earliest PCB evaluations in Bay

Weak Points: spatial coverage poor, depth horizons coarse

Quality checks: good history

Data usefulness: limited due to one core

Report inclusion: Accepted: [X] Rejected: [ ] Should computerized version be archived? [N]

Are data suitable for ARC/INFO system? Yes [ ] No [X]

Comments:

Form completed by: J. S. Latimer Date of completion: 5/4/88 Index: 5

Title of study: PCBs and other chlorinated organic compounds in sediments, transplanted mussels, and suspended particulate material from a New England estuary

Purpose of study: Evaluate CH levels in sediments and mussels

Summary: PCB gradient is observed in sediments and organisms

Variables & units: PCB, DDE, CDE, CDF concentration units

Sample locations: Appendix E

Sample frequency: seasonal samples | Sample span: 1978-1980

Principal Investigator:

PI name: J. L. Lake

PI organization: ERL-EPA

Address: EPA | city Narragansett | state RI | zip 02882

Telephone #:

Contacted: no

Funding Agency: unknown

Citation for published data:

Author: J. L. Lake, S. Pavignano, C.W. Dimock, C.B. Norwood, P.F. Rogerson, D.K | Year: 1981

Title: same as study

Journal/report: unpublished | V: | P:

Lib of Congress #: | Location of original:

Contact Person: J. L. Lake

	Original Data:	Summarized Data:
Are data computerized?	Yes [ ] No [ ]	Yes [X] No [ ]
Hardware format:		Macintosh
Software format:		MS Excel/Word
Location of data:		GSO
Contact person:		Latimer

Data Quality:

Accuracy: good [X] fair [ ] poor [ ] unknown [ ]

Precision: good [X] fair [ ] poor [ ] unknown [ ]

Strong Points: Observed important distinctions between sample types

Weak Points: No data presented on suspended solids

Quality checks: good history

Data usefulness: Evaluating PCB levels in late 1970s, bioconcentration of PCBs

Report inclusion: Accepted: [X] Rejected: [ ] Should computerized version be archived? [N]

Are data suitable for ARC/INFO system? Yes [ ] No [X]

Comments: dated information except bioconcentration info

Form completed by: J. S. Latimer | Date of completion: 5/3/88 | Index: 6

Title of study: Water resources data for MA, RI water years: 1979 through 1985

Purpose of study: Annual evaluation of WQ at selected stations in Blackstone, Pawtuxet, Pawcatuck rivers

Summary:

Variables & units: PCB, organics, coonventionals, metals concentration units, flow

Sample locations: Appendix E

Sample frequency: once or twice year   Sample span: 1978-1985

Principal Investigator:

PI name:

PI organization: USGS

Address: city   state   zip

Telephone #:

Contacted:

Funding Agency:

Citation for published data:

Author: Year: 1978-85

Title: same as study title

Journal/report: USGS report MA-RI-yr-1   V: P: ca 300

Lib of Congress #:   Location of original: Pell Library

Contact Person:

	Original Data:	Summarized Data:
Are data computerized?	Yes [ ] No [X]	Yes [X] No [ ]
Hardware format:		Macintosh
Software format:		MS Excel
Location of data:		GSO
Contact person:		Latimer

Data Quality:

Accuracy: good [X] fair [ ] poor [ ] unknown [ ]

Precision: good [X] fair [ ] poor [ ] unknown [ ]

Strong Points: useful in long term trends

Weak Points: single samples per year

Quality checks: QA/QC report

Data usefulness: long term trends

Report inclusion: Accepted: [X] Rejected: [ ] Should computerized version be archived? [Y]

Are data suitable for ARC/INFO system? Yes [X] No [ ]

Comments:

Form completed by: J. S. Latimer   Date of completion: 5/4/88   Index: 7

Title of study: A Study of the Water Quality of the Pawtuxet River: Chemical Monitoring and Computer Modeling of Pollutants

Purpose of study: Evaluate the sources, transport of organics in the Pawtuxet River

Summary: Organics generally increase from headwaters to mouth due to in situ sources

Variables & units: PAH, PHC, coprostanol, BZT, DEHP, PCB, Cd, Cr, Cu, Pb, Ni, Ag, concentration units

Sample locations: Appendix E

Sample frequency: 3 times per annum **Sample span:** 1983-1984

Principal Investigator:

PI name: J. G. Quinn, R. M. Wright

PI organization: URI, GSO

Address: S. Ferry Rd. **city** Narragansett **state** RI **zip** 02882

Telephone #: 401-792-6615

Contacted: Yes

Funding Agency: RIDEM, USEPA

Citation for published data:

Author: J. G. Quinn, E. J. Hoffman, J. S. Latimer, C. G. Carey **Year:** 1985

Title: same as title of study

Journal/report: Report to RI DEM **V:** **P:** 249

Lib of Congress #: None **Location of original:** Organic Geochemistry Lab-GSO

Contact Person: Jim Latimer

	Original Data	Summarized Data
Are data computerized?	Yes [X] No [ ]	Yes [X] No [ ]
Hardware format:	Macintosh	Macintosh
Software format:	MS Excel	MS Excel
Location of data:	GSO	GSO
Contact person:	Latimer	Latimer

Data Quality:

Accuracy: good [ ] fair [x] poor [ ] unknown [ ]

Precision: good [ ] fair [x] poor [ ] unknown [ ]

Strong Points: All major sources evaluated, good spatial coverage

Weak Points: PCB methods developing; only one survey for PCBs, metals only 24 hr. composite available

Quality checks: QA/QC report and good history

Data usefulness: Within river soruces, Bay input data back to 1983, urban river

Report inclusion: Accepted: [X] Rejected: [ ] Should computerized version be archived? [Y]

Are data suitable for ARC/INFO system? Yes [X] No [ ]

Comments: Station locations must be digitized

Form completed by: J. S. Latimer **Date of completion:** 5/3/88 **Index:** 8

Title of study: Fate and effects of sewage sludge in the coastal marine environment: a mesocosm experiment

Purpose of study: Examine the distribution of compounds in the environment after subjection to sludge

Summary: Most PCBs are stored in the sediment

Variables & units: PCB, COP, PHC, PAH, sediment, water, biota, concentration units

Sample locations: MERL

Sample frequency: Sample span: 1984

Principal Investigator:

PI name: Oviatt, C. A.

PI organization: GSO-MERL

Address: URI city Narragansett state RI zip 02882

Telephone #: 792-6132

Contacted: No

Funding Agency: EPA, NOAA

Citation for published data:

Author: C.A.Oviatt,J.G.Quinn,J.T.Maughn,J.T.Ellis,B.K.Sullivan,J.N.Gearing,P.J.Gea Year: 1987

Title: same as above title

Journal/report: Mar. Ecol. Prog. Ser. V: 41 P: 187

Lib of Congress #: Location of original: Organic Geochemistry Lab-GSO

Contact Person: J. S. Latimer

	Original Data:	Summarized Data:
Are data computerized?	Yes [ ] No [X]	Yes [X] No [ ]
Hardware format:		Macintosh
Software format:		MS Excel/Word
Location of data:		GSO
Contact person:		Latimer

Data Quality:

Accuracy: good [X] fair [ ] poor [ ] unknown [ ]

Precision: good [X] fair [ ] poor [ ] unknown [ ]

Strong Points: evaluation of all important ecosystem compartments

Weak Points: detection limits reached for water and organism analysis

Quality checks: QA/QC records, good history

Data usefulness: Pollutant biogeochemical cycling

Report inclusion: Accepted: [x] Rejected: [ ] Should computerized version be archived? [N]

Are data suitable for ARC/INFO system? Yes [ ] No [x]

Comments:

Form completed by: J. S. Latimer Date of completion: 5/5/88 Index: 9

Title of study: Unpublished data

Purpose of study: Evaluate organic contaminants in Narragansett Bay sediment

Summary: PCB gradient from Sabin Pt. to N. Jamestown

Variables & units: PCB, OC, pesticides, sediment, concentration units

Sample locations: see table in Appendix D

Sample frequency: grabs Sample span: 1984

Principal Investigator:

PI name: N.I. Rubenstein and R. J. Pruell

PI organization: SAIC/ JRB Assoc.

Address: S. Ferry Rd. city Narragansett state RI zip 02882

Telephone #:

Contacted: yes

Funding Agency: unknown

Citation for published data:

Author: Year:

Title:

Journal/report: V: P:

Lib of Congress #: Location of original: SAIC/JRB Assoc.

Contact Person: R. J. Pruell

	Original Data:	Summarized Data:
Are data computerized?	Yes [ ] No [ ]	Yes [X] No [ ]
Hardware format:		Macintosh
Software format:		MS Excel
Location of data:		6SO
Contact person:		Latimer

Data Quality:

Accuracy: good [X] fair [ ] poor [ ] unknown [ ]

Precision: good [X] fair [ ] poor [ ] unknown [ ]

Strong Points: Good spatial coverage

Weak Points: Other components should be analyzed; PAH, PHC, COP

Quality checks: good history

Data usefulness: PCB distribution in sediments

Report inclusion: Accepted: [X] Rejected: [ ] Should computerized version be archived? [Y]

Are data suitable for ARC/INFO system? Yes [x] No [ ]

Comments: exact location of sites unknown, sed collection info lacking

Form completed by: J. S. Latimer Date of completion: 5/4/88 Index: 10

Title of study: National status and trends - Mussel Watch Program- phase 1

Purpose of study: Spatial and temporal variation of pollutants throughout the US

Summary:

Variables & units: PCB, pesticides, metals, PAH, major elements, sediment, mussels, concentration units

Sample locations: Appendix E

Sample frequency: yearly; ongoing   Sample span: 1984

Principal Investigator:

PI name: unknown

PI organization: Battelle and SAIC

Address: 397 Washington St   city Duxbury   state MA   zip 02332

Telephone #:

Contacted: no

Funding Agency: NOAA/OAD

Citation for published data:

Author: P. D. Boehm, S. Freitas, E. Crecelius, R. Hillman, J. Payne, G. Farmer, A   Year: 1987

Title: Collection of bivalves and surface sediment from coastal US Atlantic and Pacific locations an

Journal/report: Report to NOAA/OAD   V: P: 203

Lib of Congress #:   Location of original: unknown

Contact Person:

Original Data:

Are data computerized? Yes [ ] No [X]

Hardware format:

Software format:

Location of data:

Contact person:

Summarized Data:

Yes [x] No [ ]

Hardware format: Macintosh

Software format: MS Word/ Excel

Location of data: GSO

Contact person: Latimer

Data Quality:

Accuracy: good [X] fair [ ] poor [ ] unknown [ ]

Precision: good [X] fair [ ] poor [ ] unknown [ ]

Strong Points: Will serve as historical monitoring data

Weak Points: Limited use for NB due to paucity of sampling sites, Data for 1984 only as yet

Quality checks: QA/QC records

Data usefulness: historical monitoring data

Report inclusion: Accepted: [x] Rejected: [ ] Should computerized version be archived? [Y]

Are data suitable for ARC/INFO system? Yes [x] No [ ]

Comments: Will help evaluate conditions of NB over time

Form completed by: J. S. Latimer   Date of completion: 5/5/88   Index: 11

Title of study:	City of Newport's application for modification of secondary treatment requirement for its water pollution control plant effluent discharge into marine waters
Purpose of study:	Eval. sediment for organics related to municipal effluent
Summary:	data for PCBs extremely variable
Variables & units:	PCB, concentraion units, DEHP
Sample locations:	Appendix E
Sample frequency:	3 grabs — Sample span: 1984

Principal Investigator:

PI name:	Bob Kovaks or Gregg Heath
PI organization:	Energy Resources Co.
Address:	city: state: zip:
Telephone #:	617-246-5200
Contacted:	yes
Funding Agency:	Metcalf and Eddy

Citation for published data:

Author:	unpublished data — Year:
Title:	
Journal/report:	V: P:
Lib of Congress #:	Location of original: unknown
Contact Person:	

	Original Data:	Summarized Data:
Are data computerized?	Yes [ ] No [ ]	Yes [X] No [ ]
Hardware format:		Macintosh
Software format:		MS Excel/Word
Location of data:		GSO
Contact person:		Latimer

Data Quality:

Accuracy: good [ ] fair [ ] poor [ ] unknown [X]

Precision: good [ ] fair [ ] poor [ ] unknown [X]

Strong Points:	unknown
Weak Points:	good spatial coverage
Quality checks:	unknown
Data usefulness:	local information near Newport WWTF

Report inclusion: Accepted: [X] Rejected: [ ] Should computerized version be archived? [N]

Are data suitable for ARC/INFO system? Yes [ ] No [x]

Comments: not enough known about samples to accept at present

Form completed by: J. S. Latimer — Date of completion: 5/3/88 — Index: 12

Title of study:	A study of the water quality of the Pawcatuck River: chemical monitoring and computer modeling of pollutants
Purpose of study:	Evaluate the sources, transport of organics in the Pawcatuck River
Summary:	Organics decrease throughout river system, influxes of P.S. minor, some influxes from city of Westerly
Variables & units:	PAH, PHC, DEHP, COP, PCB, Cd, Cr, Cu, Pb, Ni, concentration units
Sample locations:	Appendix E
Sample frequency:	3 times per annum
Sample span:	1984-1985

Principal Investigator:

PI name:	J. G. Quinn, R. M. Wright
PI organization:	URI-GSO
Address:	S. Ferry Rd.
city	Narragansett
state	RI
zip	02882
Telephone *:	401-792-6615
Contacted:	yes
Funding Agency:	RIDEM-USEPA

Citation for published data:

Author:	J. G. Quinn, J. S. Latimer, C. G. Carey, E. J. Hoffman
Year:	1987
Title:	same as title of study
Journal/report:	Report to RI DEM
V:	
P:	157
Lib of Congress *:	none
Location of original:	Organic Geochemistry Lab-GSO
Contact Person:	J. S. Latimer

	Original Data:	Summarized Data:
Are data computerized?	Yes [X] No [ ]	Yes [X] No [ ]
Hardware format:	Macintosh	Macintosh
Software format:	MS Excel	MS Excel
Location of data:	GSO	GSO
Contact person:	Latimer	Latimer

Data Quality:

Accuracy: good [X] fair [ ] poor [ ] unknown [ ]

Precision: good [X] fair [ ] poor [ ] unknown [ ]

Strong Points:	All major sources evaluated, good spatial coverage
Weak Points:	Only 3 surveys; 24 hour composited samples only
Quality checks:	QA/QC report and good history
Data usefulness:	Within river sources, rural river

Report inclusion: Accepted: [X] Rejected: [ ] Should computerized version be archived? [N]

Are data suitable for ARC/INFO system? Yes [ ] No [x]

Comments: Doesn't discharge into N.B. therefore not included

Form completed by: J. S. Latimer Date of completion: 5/3/88 Index: 13

Title of study: National Status and Trends - Benthic Surveilance Project & Mussel Watch

Purpose of study: Evaluate temporal changes and spatial distributions of compounds in US marine waters

Summary:

Variables & units: PCB, pesticides, metals, major element, concentration units, sediment, flounder livers

Sample locations: Appendix E

Sample frequency: yearly, ongoing Sample span: 1985

Principal Investigator:

PI name: unknown

PI organization: NOAA/Ocean Assessments Div (OAD)

Address: city Rockville state ML zip 20852

Telephone #: 301-443-8655

Contacted: yes

Funding Agency: NOAA/OAD

Citation for published data:

Author: unpublished Year:

Title: as above

Journal/report: V: P:

Lib of Congress #: Location of original: NOAA/OAD

Contact Person: Jim Price

	Original Data:	Summarized Data:
Are data computerized?	Yes [X] No [ ]	Yes [X] No [ ]
Hardware format:	Macintosh	Macintosh
Software format:	MS Excel	MS Excel
Location of data:	Ocean Assess/ NOAA	GSO
Contact person:	Gary Shigenaka	Latimer

Data Quality:

Accuracy: good [X] fair [ ] poor [ ] unknown [ ]

Precision: good [X] fair [ ] poor [ ] unknown [ ]

Strong Points: Allows for long term integrative evaluation

Weak Points: not enough data available as yet

Quality checks: QP/QC records

Data usefulness: Evaluating changes in PCB levels over time in Narragansett Bay

Report inclusion: Accepted: [X] Rejected: [ ] Should computerized version be archived? [Y]

Are data suitable for ARC/INFO system? Yes [Y] No [ ]

Comments: use for ecosystem changes with time

Form completed by: J. S. Latimer Date of completion: 5/3/88 Index: 14

Title of study:	A report on the distribution of organic components and trace metals in Mashpaug Pond sediments
Purpose of study:	Evaluate the levels of toxicants in sediment
Summary:	PCB levels were similar to other urban ponds in RI
Variables & units:	PCB, PHC, PAH, phthalates, COP, Cd, Cu, Pb, Ni, Ag, Zn concentration units sediment, fresh-water
Sample locations:	See particular tables in text
Sample frequency:	grabs
Sample span:	1985

Principal Investigator:

PI name:	J. G. Quinn
PI organization:	GSO
Address:	S. Ferry Road
city	Narragansett
state	RI
zip	02882
Telephone #:	401-792-6615
Contacted:	yes
Funding Agency:	RIDOH

Citation for published data:

Author:	J. G. Quinn, J. S. Latimer, J. T. Ellis
Year:	1986
Title:	same as study
Journal/report:	report to RIDOH
V:	
P:	12
Lib of Congress #:	
Location of original:	Organic Geochemistry Lab
Contact Person:	J. S. Latimer

	Original Data:	Summarized Data:
Are data computerized?	Yes [ ] No [X]	Yes [X] No [ ]
Hardware format:		Macintosh
Software format:		MS Excel/Word
Location of data:		GSO
Contact person:		Latimer

Data Quality:

Accuracy:	good [X] fair [ ] poor [ ] unknown [ ]
Precision:	good [X] fair [ ] poor [ ] unknown [ ]
Strong Points:	Analysis of organics and metals, comprehensive
Weak Points:	Limited spatial relevance - one pond
Quality checks:	QA/QC records, good history
Data usefulness:	Limited to one area

Report inclusion: Accepted: [X] Rejected: [ ] Should computerised version be archived? [N]

Are data suitable for ARC/INFO system? Yes [ ] No [X]

Comments:

Form completed by: J. S. Latimer Date of completion: 5/4/88 Index: 15

Title of study:	Organic contaminants in quahogs, Mercenaria mercenaria, collected from Narragansett Bay
Purpose of study:	Describe the present levels of organics in quahogs of N.B.
Summary:	PCBs were observed to follow a gradient, decreasing away from Providence River
Variables & units:	PCB, HCB, DDE, DDD, DDT, HCH, PAHs, quahogs, congeners, concentration units
Sample locations:	Appendix E
Sample frequency:	transect 2 per 12 mo
Sample span:	1985, 1986

Principal Investigator:

PI name:	R. J. Pruell
PI organization:	USEPA
Address:	S. Ferry Rd.
city	Narragansett
state	RI
zip	02882
Telephone #:	
Contacted:	none
Funding Agency:	N.B.P.

Citation for published data:

Author:	R. J. Pruell, C. B. Norwood, R. D. Bower, R. E. Palmquist, S. J. Fluck
Year:	1988
Title:	same as study
Journal/report:	Report to N.B.P.
V:	
P:	20 pp.
Lib of Congress #:	
Location of original:	
Contact Person:	

	Original Data:	Summarized Data:
Are data computerized?	Yes [X] No [ ]	Yes [X] No [ ]
Hardware format:	Macintosh	Macintosh
Software format:	MS Excel	MS Excel
Location of data:	GSO	GSO
Contact person:	Latimer	Latimer

Data Quality:

	good	fair	poor	unknown
Accuracy:	[X]	[ ]	[ ]	[ ]
Precision:	[X]	[ ]	[ ]	[ ]

Strong Points:	Comprehensive analysis
Weak Points:	Analysis of coprostanol, PHC lacking; samples from Lower Bay to contrast needed
Quality checks:	Good record
Data usefulness:	Up to date quahog insult

Report inclusion: Accepted: [X] Rejected: [ ] Should computerized version be archived? [Y]

Are data suitable for ARC/INFO system? Yes [X] No [ ]

Comments:	
Form completed by:	J. S. Latimer
Date of completion:	5/4/88
Index:	16

Title of study:	Development of a one dimensional water quality model of the Blackstone River: chemical monitoring of pollutants
Purpose of study:	Evaluate the sources, transport of organics in the Belckstone River
Summary:	Organic decrease from headwaters in MA to mouth reflecting a dominant role from the MA end number
Variables & units:	PAH, PHC, COP, PCB, HCH, Cd, Cr, Cu, Pb, Ni, Ag, concentration units
Sample locations:	Appendix E
Sample frequency:	3 times per annum
Sample span:	1985-1986

Principal Investigator:

PI name:	J. G. Quinn; R. M. Wright
PI organization:	URI-GSO
Address:	S. Ferry Rd.
city	Narragansett
state	RI
zip	02882
Telephone #:	401-792-6615
Contacted:	yes
Funding Agency:	N.B.P.

Citation for published data:

Author:	J. Quinn, J. S. Latimer, C. G. Carey, J. T. Ellis, J. Zheng
Year:	1987
Title:	same as title of study
Journal/report:	Report to N.B.P.
V:	
P:	171
Lib of Congress #:	none
Location of original:	Organic Geochemistry Lab-GSO
Contact Person:	J. S. Latimer

	Original Data:	Summarized Data:
Are data computerized?	Yes [X] No [ ]	Yes [X] No [ ]
Hardware format:	Macintosh	Macintosh
Software format:	MS Excel	MS Excel
Location of data:	GSO	GSO
Contact person:	Latimer	Latimer

Data Quality:

Accuracy:	good [X] fair [ ] poor [ ] unknown [ ]
Precision:	good [X] fair [ ] poor [ ] unknown [ ]
Strong Points:	Major source evaluated, good spatial coverage, good temporal coverage for metals
Weak Points:	Only 3 surveys; 24 composite samples only organics, 2 surveys similar-flow
Quality checks:	QA/QC reported good history
Data usefulness:	within river sources, urban river

Report inclusion: Accepted: [X] Rejected: [ ] Should computerized version be archived? [Y]

Are data suitable for ARC/INFO system? Yes [X] No [ ]

Comments:	Station locations need to be digitized
Form completed by:	J. S. Latimer
Date of completion:	5/3/88
Index:	17

Title of study: Analysis of archived samples for organic pollutants

Purpose of study: To characterize the sourse, transport of PCBs and other organics in NB

Summary: Analysis of municipalities, rivers and water column for particulate (some dissolved) PCBs, other organics

Variables & units: PAH, PHC, coprostanol, BZT, DEHP, PCB concentration units

Sample locations: Appendix E

Sample frequency: Once each season | Sample span: 1985-1986

Principal Investigator:

PI name: J. G. Quinn

PI organization: GSO, URI

Address: S. Ferry Rd. | city: Narragansett | state: RI | zip: 02882

Telephone #: 401-792-6615

Contacted: Yes

Funding Agency: EPA-RIDEM

Citation for published data:

Author: J. G. Quinn, J. S. Latimer, J. T. Ellis, L. A. LeBlanc, J. Zheng | Year: 1988

Title: same as study title

Journal/report: Draft final report to NBP | V: | P: 74

Lib of Congress #: none | Location of original: Organic Geochemistry Lab-GSO

Contact Person: J. S. Latimer

	Original Data	Summarized Data
Are data computerized?	Yes [X] No [ ]	Yes [X] No [ ]
Hardware format:	Macintosh	Macintosh
Software format:	MS Excel	MS Excel
Location of data:	GSO	GSO
Contact person:	Latimer	Latimer

Data Quality:

Accuracy: good [X] fair [ ] poor [ ] unknown [ ]

Precision: good [X] fair [ ] poor [ ] unknown [ ]

Strong Points: Survey includes all major sources well characterized

Weak Points: Only 4 bay stations: upper bay, soluble fraction near detection limits for PCBs

Quality checks: QA/QC report and good history

Data usefulness: Mass inputs, chemical characterization, sources, transport

Report inclusion: Accepted: [X] Rejected: [ ] Should computerized version be archived? [Y]

Are data suitable for ARC/INFO system? Yes [X] No [ ]

Comments: Point source and river stations must be digitized

Form completed by: J. S. Latimer | Date of completion: 4/27/88 | Index: 18

Title of study:	The sources, transport, and fate of PCBs in Narragansett Bay
Purpose of study:	Examine the sources, transport and fate of PCBs in NB
Summary:	Blackstone River major river source; Fields Pt WWTF major point source; seds reflect these and other sources in the Prov River; Other sources of PCB may be significant- atmos, storm
Variables & units:	PCB, congener concentration, flux, rivers, point sources, surface sediment, cores
Sample locations:	Appendix E
Sample frequency:	
Sample span:	1986-1987

Principal Investigator:

PI name:	J. G. Quinn
PI organization:	GSO
Address:	S. Ferry Rd.
city	Narragansett
state	RI
zip	02882
Telephone #:	401-792-6615
Contacted:	yes
Funding Agency:	NBP

Citation for published data:

Author:	J. S. Latimer
Year:	1989
Title:	same as above
Journal/report:	PhD thesis related
V:	
P:	
Lib of Congress #:	
Location of original:	Organic Geochemistry Lab-GSO
Contact Person:	J. S. Latimer

	Original Data:	Summarized Data:
Are data computerized?	Yes [X] No [ ]	Yes [X] No [ ]
Hardware format:	Macintosh	Macintosh
Software format:	MS Excel/Word	MS Excel/Word
Location of data:	GSO	GSO
Contact person:	Latimer	Latimer

Data Quality:

Accuracy:	good [X] fair [ ] poor [ ] unknown [ ]
Precision:	good [X] fair [ ] poor [ ] unknown [ ]
Strong Points:	good spatial and depth coverage, cores sufficiently sampled
Weak Points:	near detection limits for soluble water column samples
Quality checks:	QA/QC reports; good history
Data usefulness:	PCB budget, sediment levels, sources

Report inclusion: Accepted: [X] Rejected: [ ] Should computerized version be archived? [Y]

Are data suitable for ARC/INFO system? Yes [X] No [ ]

Comments:	some sample locations need to be digitized
Form completed by:	J. S. Latimer
Date of completion:	2/20/89
Index:	19