

DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

AD-A244 914



Estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and reviewing information, and completing the review form. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Project (0704-0188), Washington, DC 20503.

2. REPORT DATE

January 1992

3. REPORT TYPE AND DATES COVERED

Professional paper

4. TITLE AND SUBTITLE

MARINE ECOLOGICAL RISK ASSESSMENT PILOT STUDY FOR ALLEN HARBOR, NARRAGANSETT BAY, RHODE ISLAND

5. FUNDING NUMBERS

PR: ME83
PE: OMN
WU: DN301108

6. AUTHOR(S)

R. K. Johnston

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

Naval Ocean Systems Center
San Diego, CA 92152-50008. PERFORMING ORGANIZATION
REPORT NUMBER

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

Naval Ocean Systems Center
San Diego, CA 92152-500010. SPONSORING/MONITORING
AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES

DTIC
SELECTE
JAN 24 1992
S B D

12a. DISTRIBUTION/AVAILABILITY STATEMENT

Approved for public release; distribution is unlimited.

12b. DISTRIBUTION CODE

13. ABSTRACT (Maximum 200 words)

An ecological risk assessment framework was applied to characterize aquatic risks associated with hazardous waste disposal at Naval Construction Battalion Center (NCBC) Davisville, Rhode Island. An initial screening phase (I) assessed exposure and related that exposure to toxicological endpoints for bivalves, amphipods, sea urchins, and biomarker assays. Results showed little evidence of major contamination in sediments or tissues except for relatively high levels of polychlorinated biphenols (PBC), butyltins compounds (TBT), and fecal coliforms observed in Allen Harbor. Effects were detected in mussel physiology, sea urchin fertilization and development, biomarker responses, and soft shell clam histology. Possible sources of contamination and toxicity from the landfill leachate, surface runoff, and recreational boating were examined using a temporal and spatial sampling scheme (Phase II). Chemical and toxicological information obtained implicated all three sources as affecting Allen Harbor water quality. Laboratory bioassays of landfill exposure media, employing a variety of marine species using acute and chronic endpoints (Phase III), are being used to provide data for the development of an exposure-response model for risk to the marine environment. The model will define current risk and provide an interpretive framework for long-term monitoring.

Presented at the (SETAC) Society of Environmental Toxicity and Chemistry Meeting, Seattle, WA, 3-7 November 1991.

92-01839

92 1 22 073



14. SUBJECT TERMS

marine chemistry
benthic flux

15. NUMBER OF PAGES

16. PRICE CODE

17. SECURITY CLASSIFICATION
OF REPORT

UNCLASSIFIED

18. SECURITY CLASSIFICATION
OF THIS PAGE

UNCLASSIFIED

19. SECURITY CLASSIFICATION
OF ABSTRACT

UNCLASSIFIED

20. LIMITATION OF ABSTRACT

SAME AS REPORT

UNCLASSIFIED

21a NAME OF RESPONSIBLE INDIVIDUAL R. K. Johnston	21b TELEPHONE (include Area Code) (619) 553-5330	21c OFFICE SYMBOL Code 522
--	---	-------------------------------

DTIC
COPY
INSPECTED

Accession For	
NTIS GRA&I	☒
DTIC TAB	☐
Unannounced	☐
Justification	
By _____	
Distribution/	
Availability Codes	
Dist	Avail and/or Special
A-1	

**MARINE ECOLOGICAL RISK ASSESSMENT
PILOT STUDY FOR ALLEN HARBOR,
NARRAGANSETT BAY,
RHODE ISLAND¹**

Robert K. Johnston*,
Naval Ocean Systems Center
c/o Graduate School Of Oceanography
University of Rhode Island
Narragansett, RI 02880

Wayne R. Munns, Jr.
and
Cornelia Mueller,
Science Applications International Corporation,
c/o Environmental Research Laboratory
27 Tarzwell Dr.
Narragansett, RI 02880

William G. Nelson
and
Gerald G. Pesch,
US Environmental Protection Agency
Environmental Research Laboratory Narragansett
27 Tarzwell Dr.
Narragansett, RI 02880

¹ Poster present at the Annual Meeting of the Society of Environmental Toxicology and Chemistry, Nov. 4-7, 1991, Seattle, WA.

* Author to whom correspondence should be addressed.

ABSTRACT

An ecological risk assessment framework was applied to characterize aquatic risks associated with hazardous waste disposal at Naval Construction Battalion Center (NCBC) Davisville, RI. An initial screening phase (I) assessed exposure and related that exposure to toxicological endpoints for bivalves, amphipods, sea urchins, and biomarker assays. Results showed little evidence of major contamination in sediments or tissues except for relatively high levels of polychlorinated biphenols (PBC), butyltin compounds (TBT), and fecal coliforms observed in Allen Harbor. Effects were detected in mussel physiology, sea urchin fertilization and development, biomarker responses, and soft shell clam histology. Possible sources of contamination and toxicity from the landfill leachate, surface runoff, and recreational boating were examined using a temporal and spatial sampling scheme (Phase II). Chemical and toxicological information obtained implicated all three sources as affecting Allen Harbor water quality. Laboratory bioassays of landfill exposure media, employing a variety of marine species using acute and chronic endpoints (Phase III), are being used to provide data for the development of an exposure-response model for risk to the marine environment. The model will define current risk and provide an interpretive framework for long-term monitoring.

INTRODUCTION

OBJECTIVE

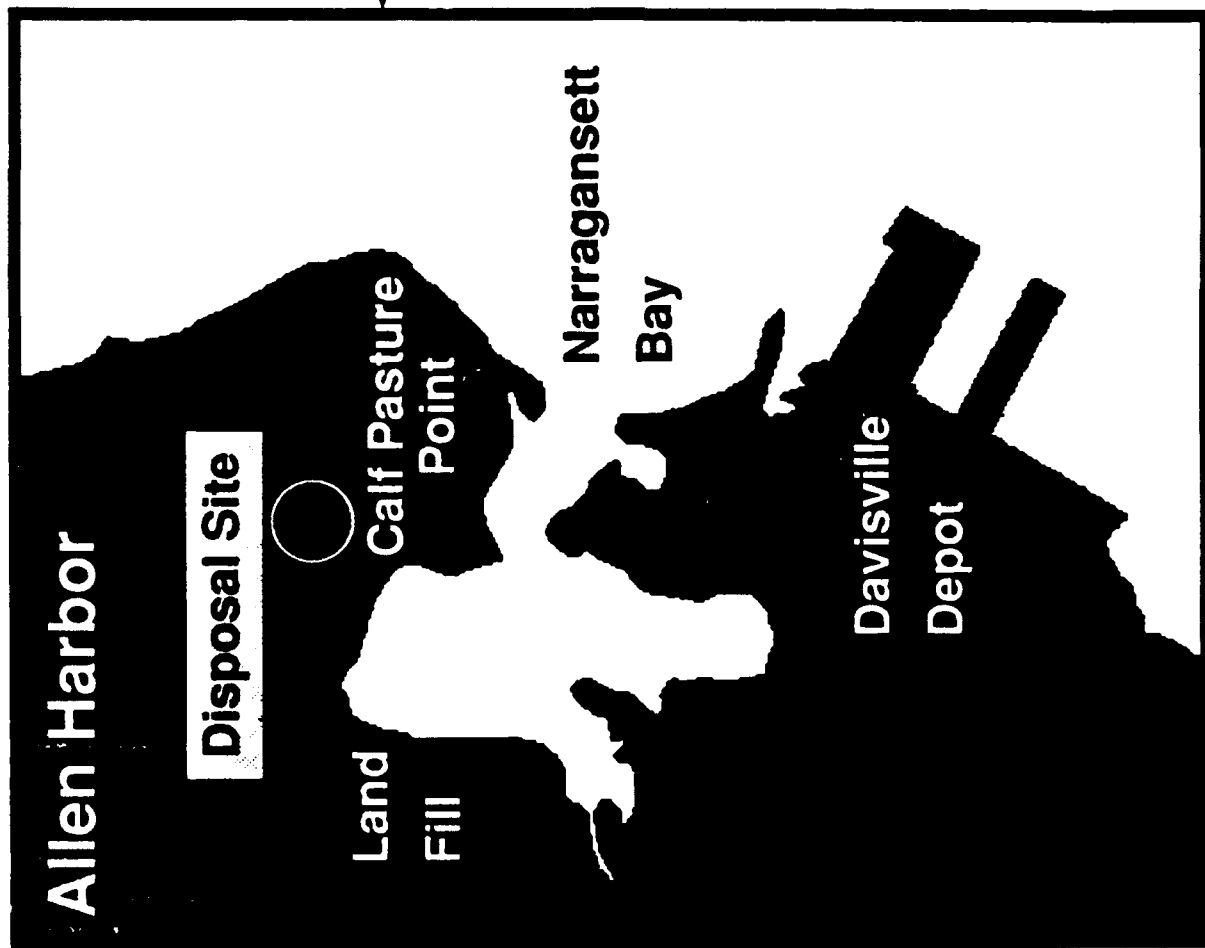
- Conduct a marine ecological risk assessment at NCBC Davisville to determine the impact of hazardous waste disposal on Allen Harbor and Narragansett Bay.

BACKGROUND

- Allen Harbor, located in Narragansett Bay, RI at NCBC Davisville was closed for shellfishing by Rhode Island Department of Environmental Management.
- Suspected contamination from a 15 acre landfill and disposal area located near Allen Harbor.
- Wastes disposed at the landfill included:

PCB contaminated waste oils	preservatives
solvents	paints
chromic acid	blasting grit
sewage sludge	industrial wastes

Location of Allen Harbor in Narragansett Bay, RI.



METHODS

PHASE I: INFORMATION GATHERING

- Determine the existence, nature, and extent of adverse effects in Allen Harbor resulting from contaminants originating from NCBC Davisville.
- Activities Included:
 1. Characterize sediment and water column quality
 2. Evaluate natural resources for:
abundance, condition indices, histology, and tissue burdens
 3. Evaluate toxicological responses to selected species
 4. Compare results with a series of mid-Narragansett Bay reference stations.

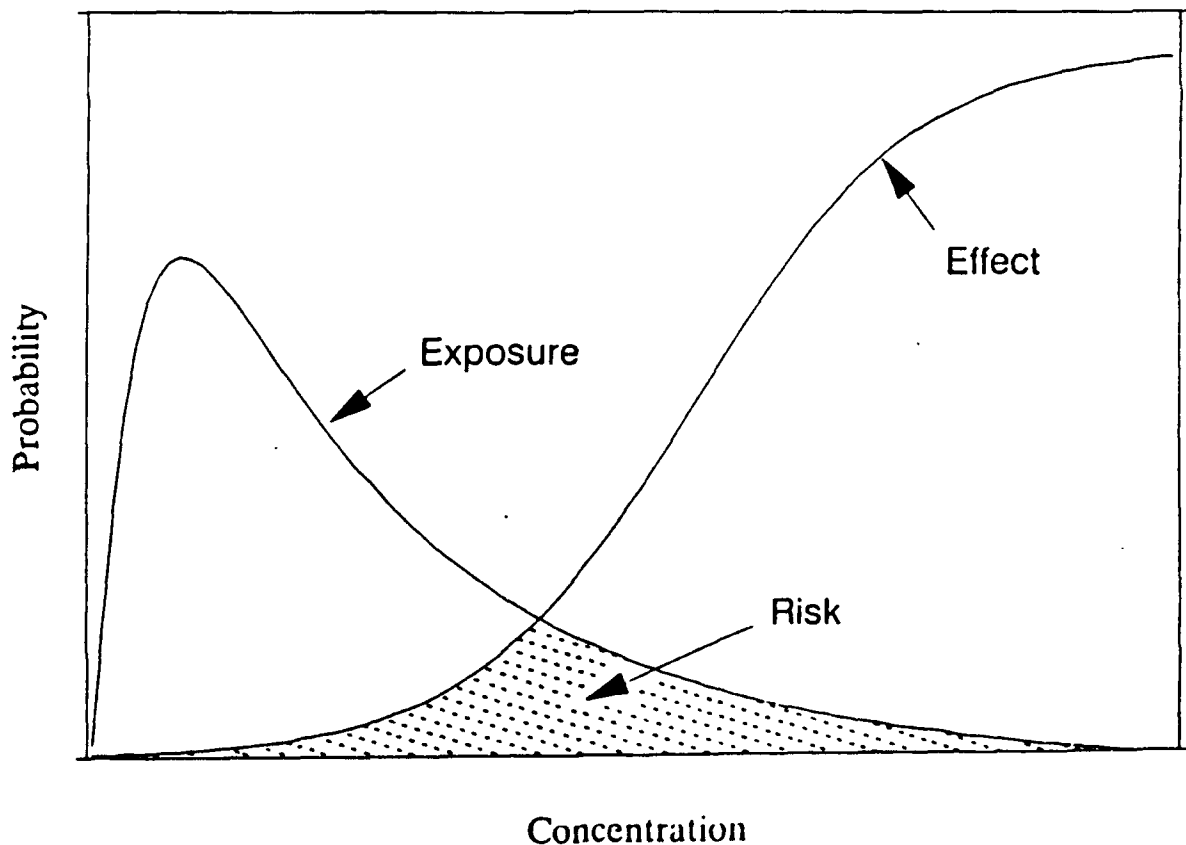
PHASE II: VERIFICATION AND QUANTIFICATION OF TOXICOLOGICAL EFFECTS

- Verify the lack of adverse environmental effects and determine the contribution of environmental effects from the landfill, runoff from the surrounding area, and marina activities.
- Activities included:
 1. Seasonal monitoring of pollution loading from:
landfill sources
runoff sources
boating sources
 2. Relating pollution loading to toxicological responses to:
Water Column Effects on:
sea urchin fertilization and development
deployed mussel physiology
deployed mysid survival, growth and fecundity
Sediment Effects on:
amphipod survival
indigenous clams
biomarker responses

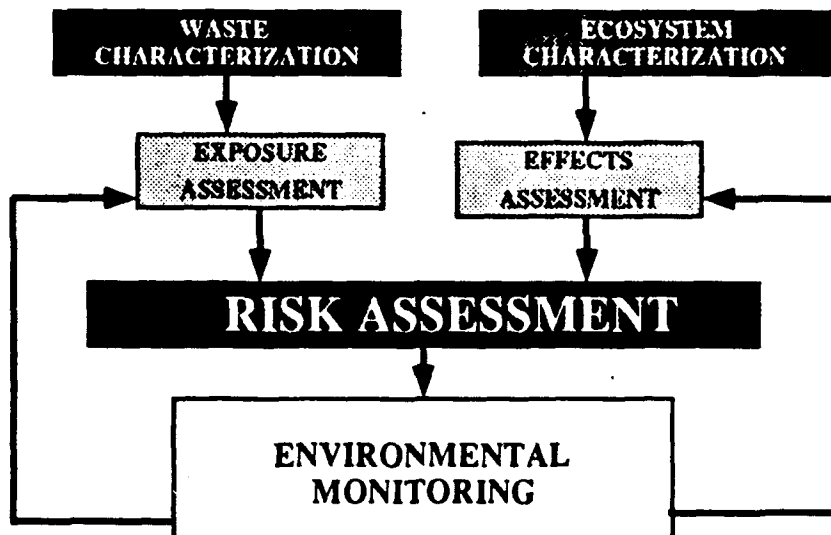
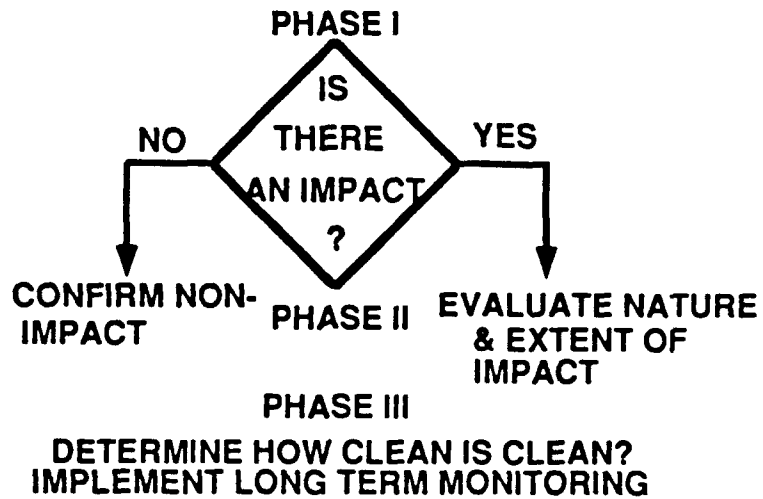
PHASE III: QUANTIFICATION OF ECOLOGICAL RISKS

- Evaluate the effects of landfill exposure on marine organisms and establish exposure-response relationship necessary for an ecological risk assessment model.
- Activities included:
 1. Performing laboratory bioassays of:
 - landfill seeps
 - sediments from the landfill
 - extracts of sediments and soils from the landfill
 2. Determining exposure-responses for acute and chronic effects to benthic and water column species.

Exposure-Response Risk Model



**ALLEN HARBOR RISK ASSESSMENT
PHASED APPROACH**



Risk Assessment Paradigm used for the Allen Harbor Study.

RESULTS

PHASE I EXPOSURE ASSESSMENT

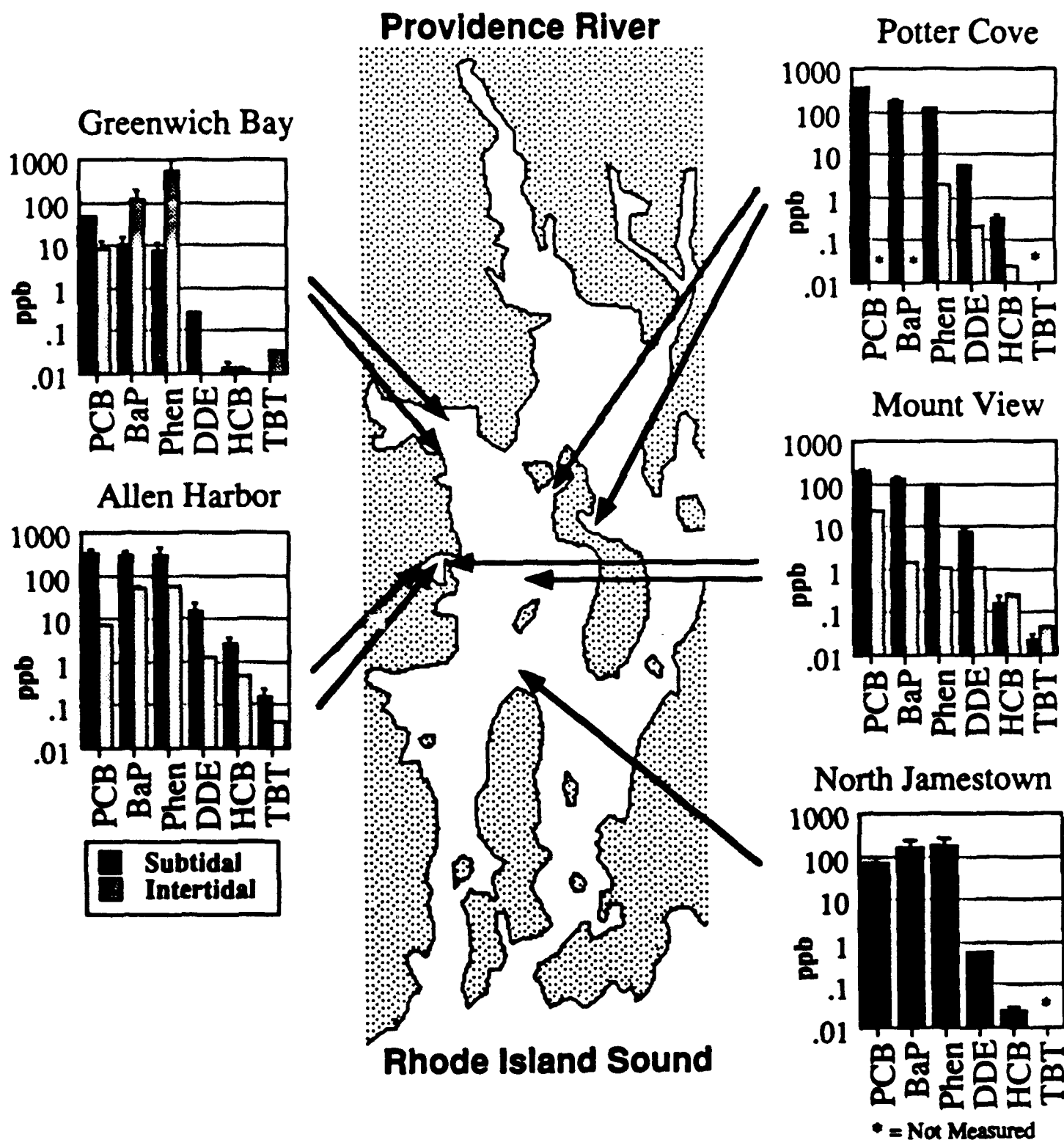
Organics

PCB	- Polychlorinated Biphenyls
BaP	- Benzo[a]pyrene
Phen	- Phenanthrene
DDE	- Dichlorodiphenyl- dichloroethene
HBC	- Hexachlorobenzene
TBT	- Tributyltin

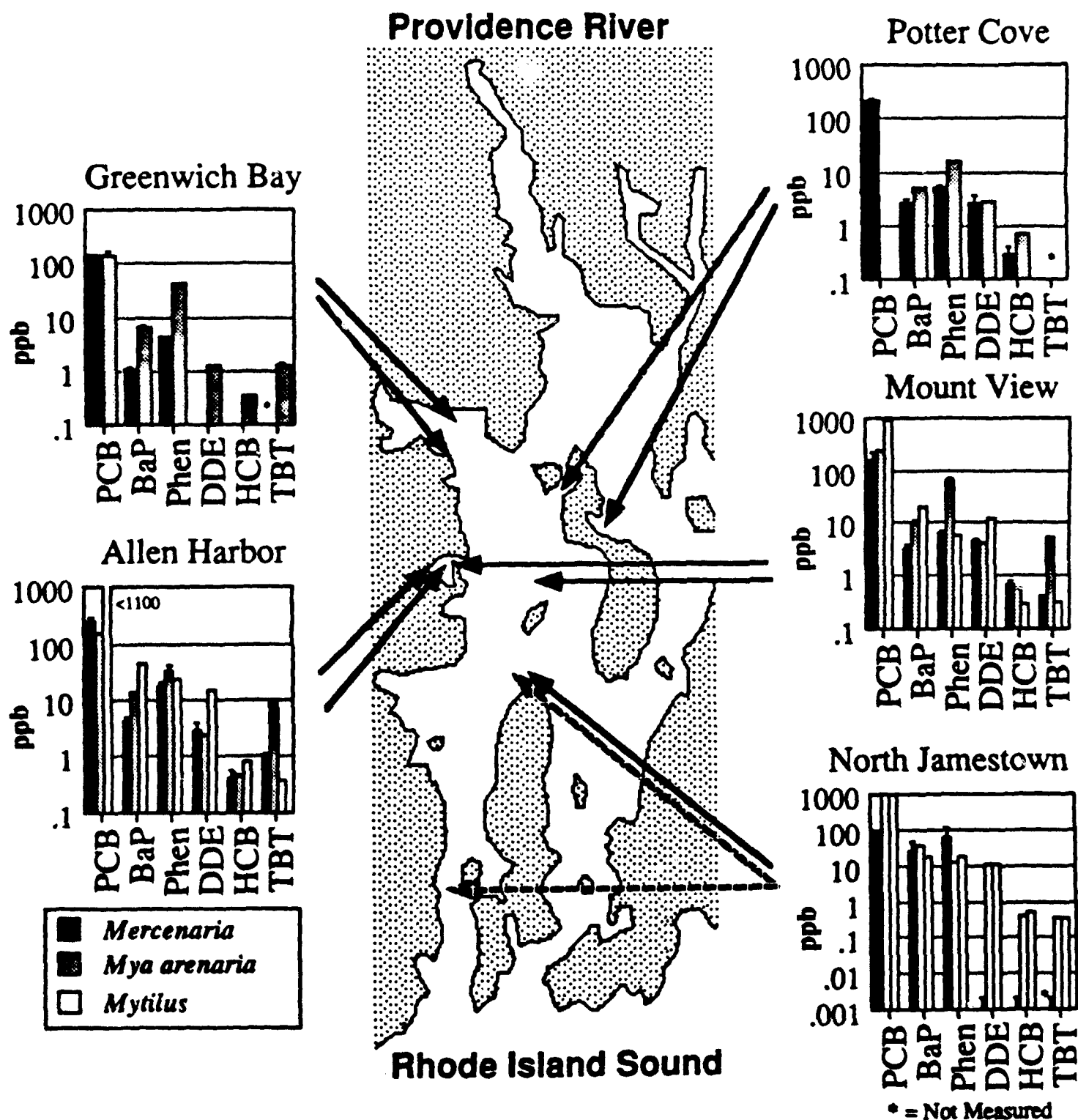
METALS

Cu	- Copper
Zn	- Zinc
Cr	- Chromium
Pb	- Lead
Ni	- Nickel
As	- Arsenic

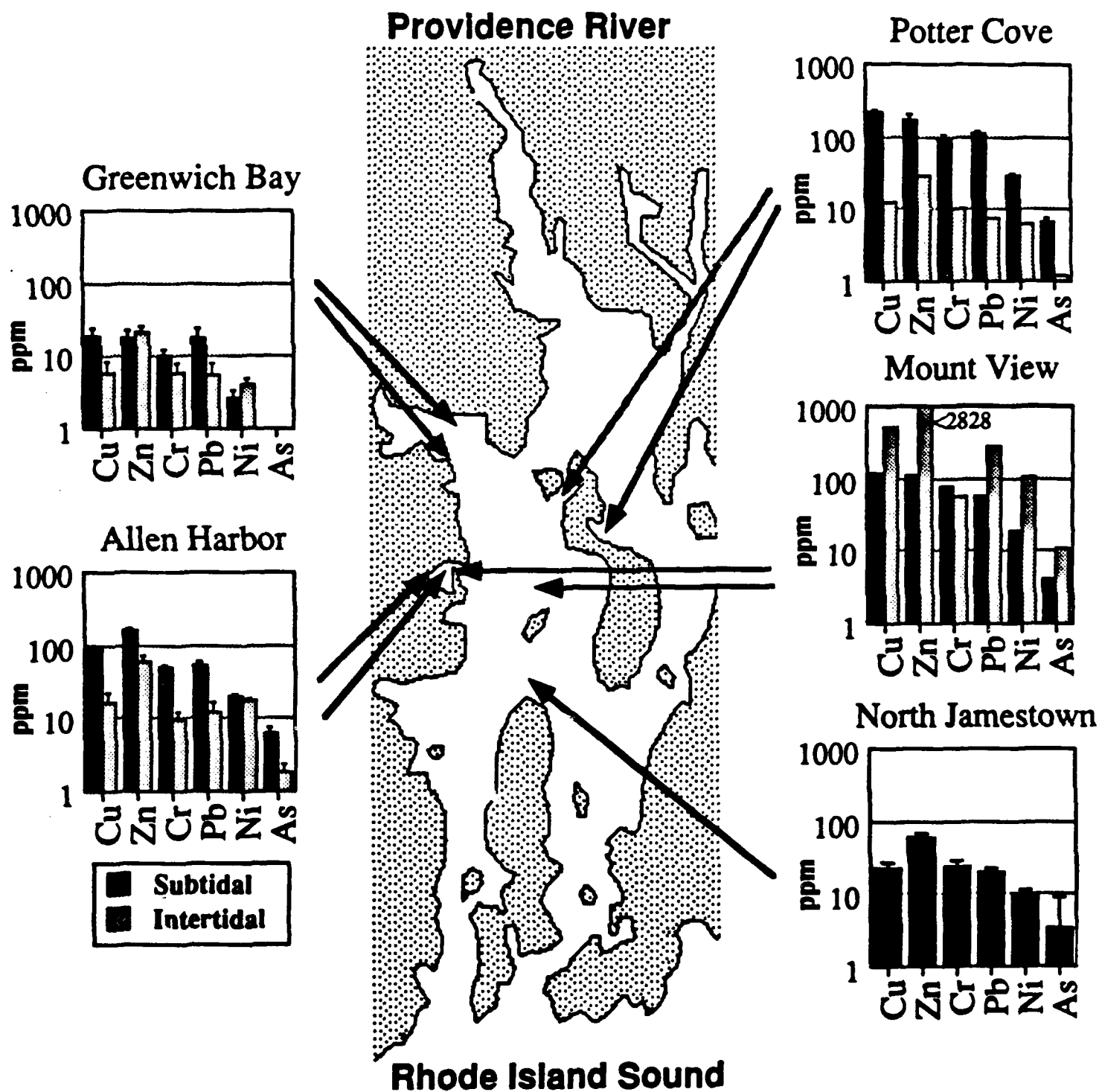
Concentrations of selected organic contaminants in subtidal and intertidal sediments at stations in Narragansett Bay, RI.



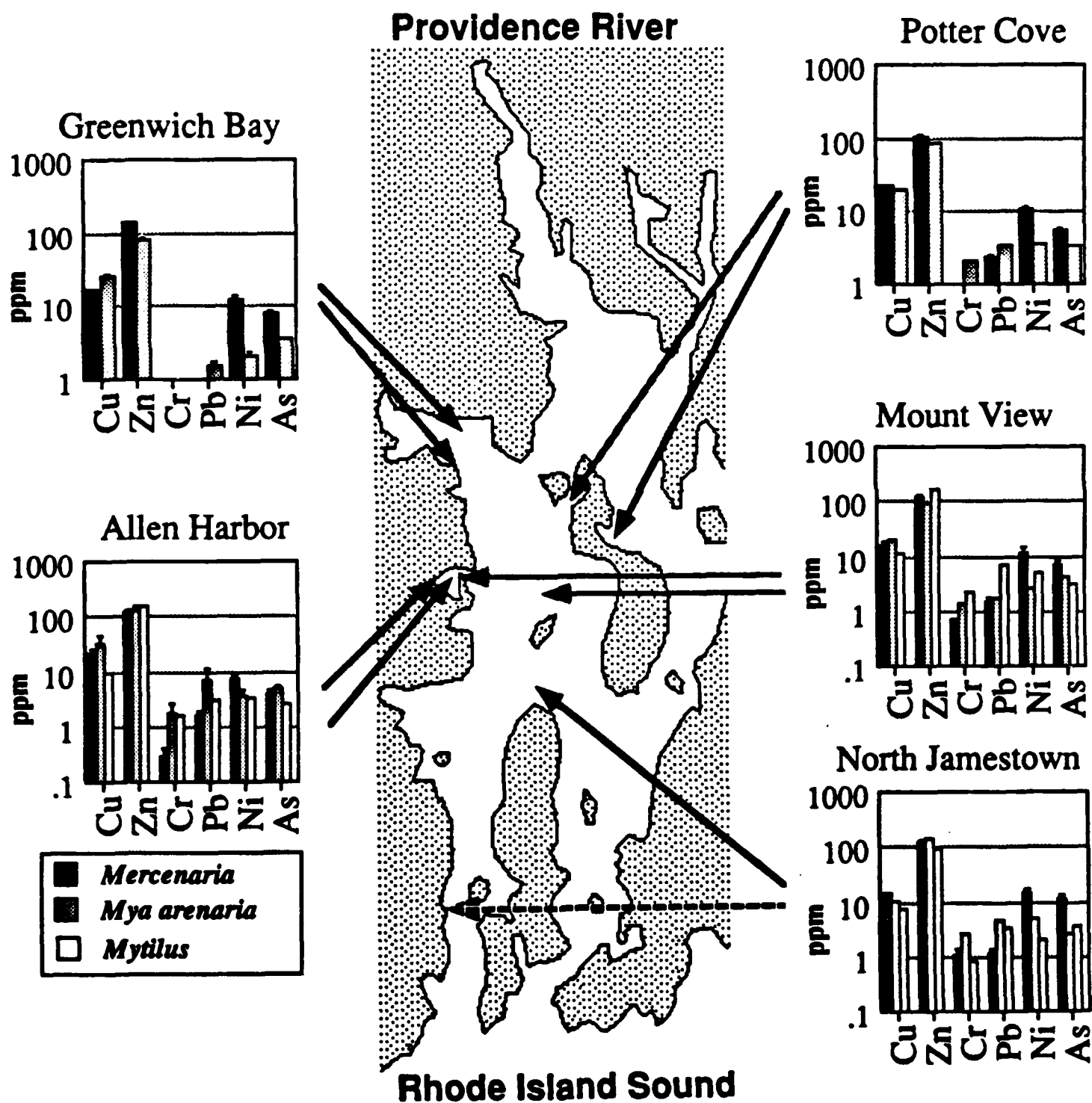
Tissue residues of selected organic contaminants in indigenous *Mercenaria mercenaria*, *Mya arenaria*, and deployed *Mytilus edulis*.



Concentrations of selected toxic metals in subtidal and intertidal sediments at stations in Narragansett Bay, RI.



Tissue residues of selected toxic metals in indigenous *Mercenaria mercenaria*, *Mya arenaria*, and deployed *Mytilus edulis*.



PHASE I EFFECTS ASSESSMENT

AMPHIPOD TOXICITY TEST: *Ampelisca abdita* were collected from a local site and exposed to homogenized whole sediment for 10 days.

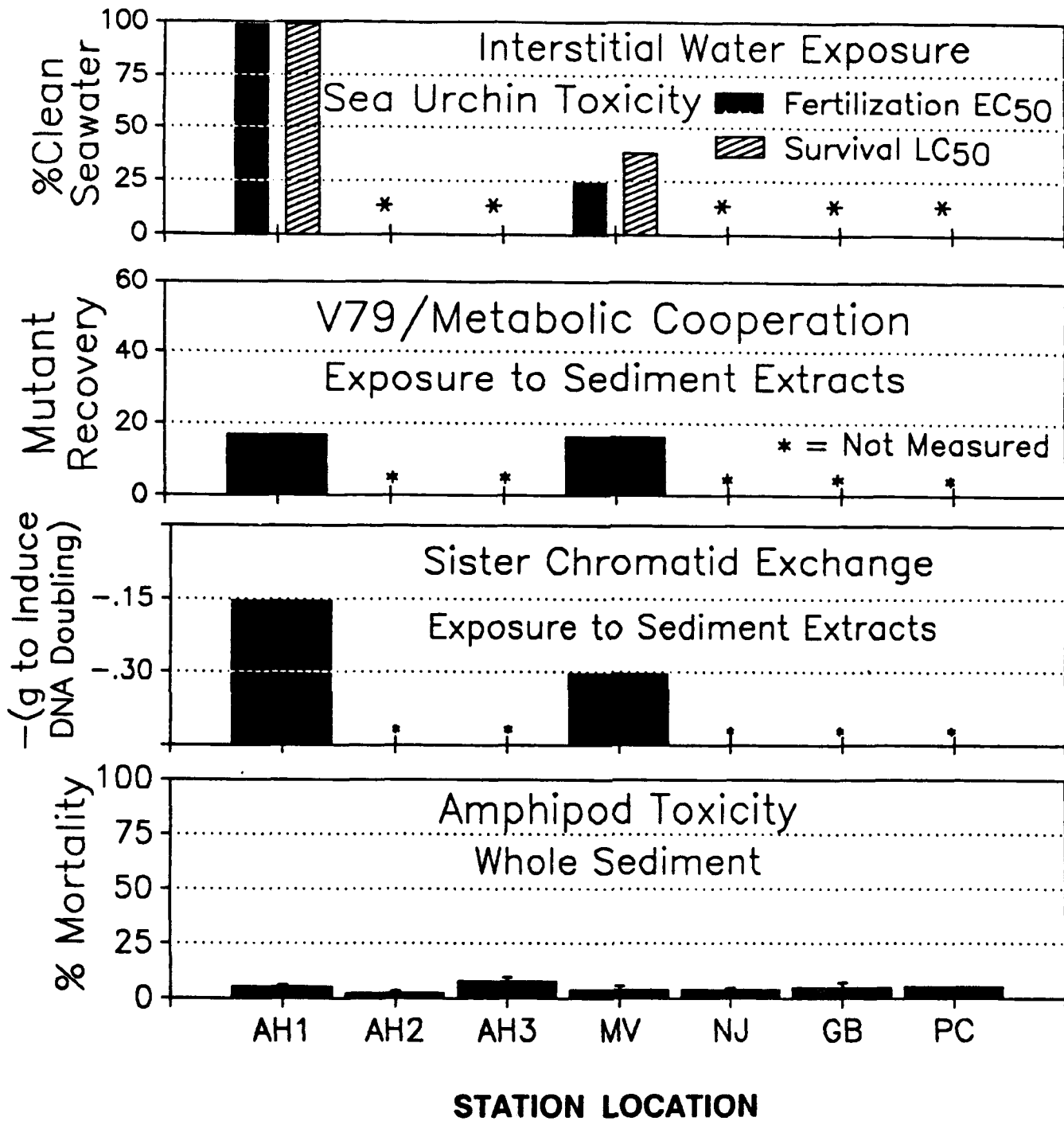
SEA URCHIN FERTILIZATION AND DEVELOPMENT: Gametes of *Arbacia punctulata* were obtained by electrical stimulation. Sperm and egg cells were exposed to interstitial water. Eggs were examined after 20 min for fertilization and after 48 hr for growth, development, and survival.

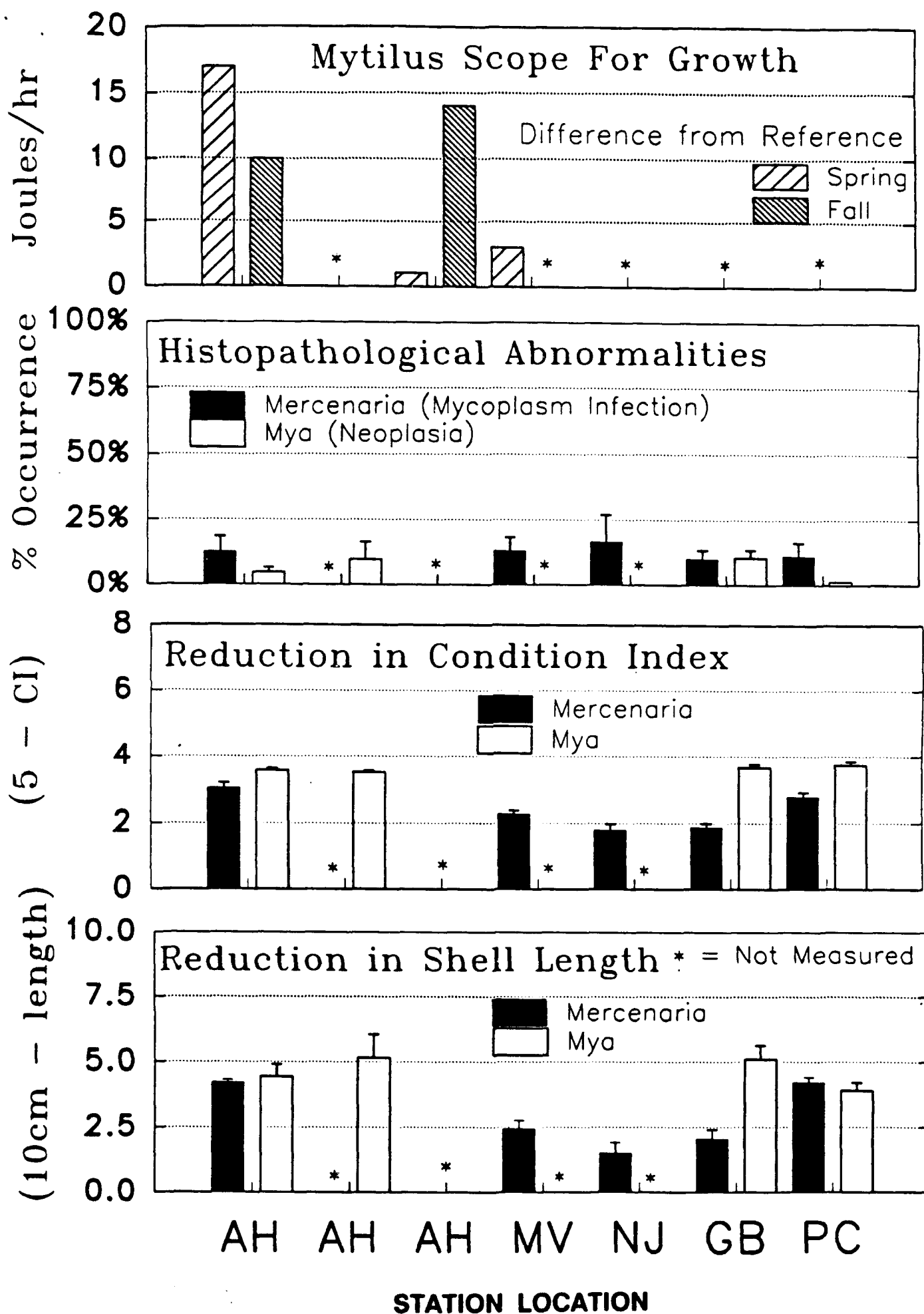
DEPLOYED MUSSEL SCOPE FOR GROWTH: *Mytilus edulis* (5-7 cm) were collected from a reference site, placed in polyethylene baskets, and deployed for 28 days. Scope for Growth was determined from measurements of assimilation efficiency, excretion rate, and respiration rate.

SISTER CHROMATID EXCHANGE (SCE) ASSAY: Chromosomal endpoint used to determine mutagenic potential of sediment contaminants by detecting breaking and symmetrical exchange of DNA in Chinese hamster lung fibroblast cells exposed to sediment extracts for 5 hr and incubated for 19 hr.

V79/METABOLIC COOPERATION ASSAY: Cellular endpoint used to determine tumor-promoting potential of sediment contaminants by detecting inhibition of normal intercellular communication in resistant mutant and sensitive wild type fibroblast cells exposed to sediment extracts.

SEDIMENT TOXICITY





PHASE II RESULTS

Seasonal variation of chemical and toxicological conditions were monitored at stations corresponding to landfill seeps -- North Seep (N), Middle Seep (M), South Seep; and runoff streams -- West Creek (W), North Creek (N), Spink Neck Creek (S).

Mussel cages were deployed in Allen Harbor (AH), at the entrance to Allen Harbor (TTN), and at the Mount View (MV) station.

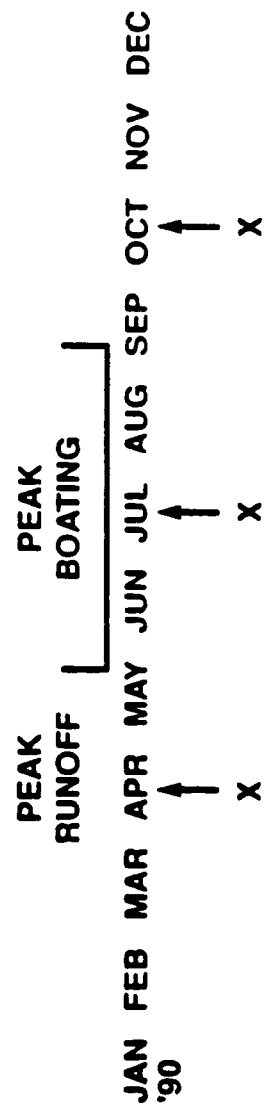
Mussel cages deployed at a reference station located near the mouth of Narragansett Bay (ERLN), were used for comparisons.

Fecal coliform densities within Allen Harbor and in stormwater runoff were also monitored.

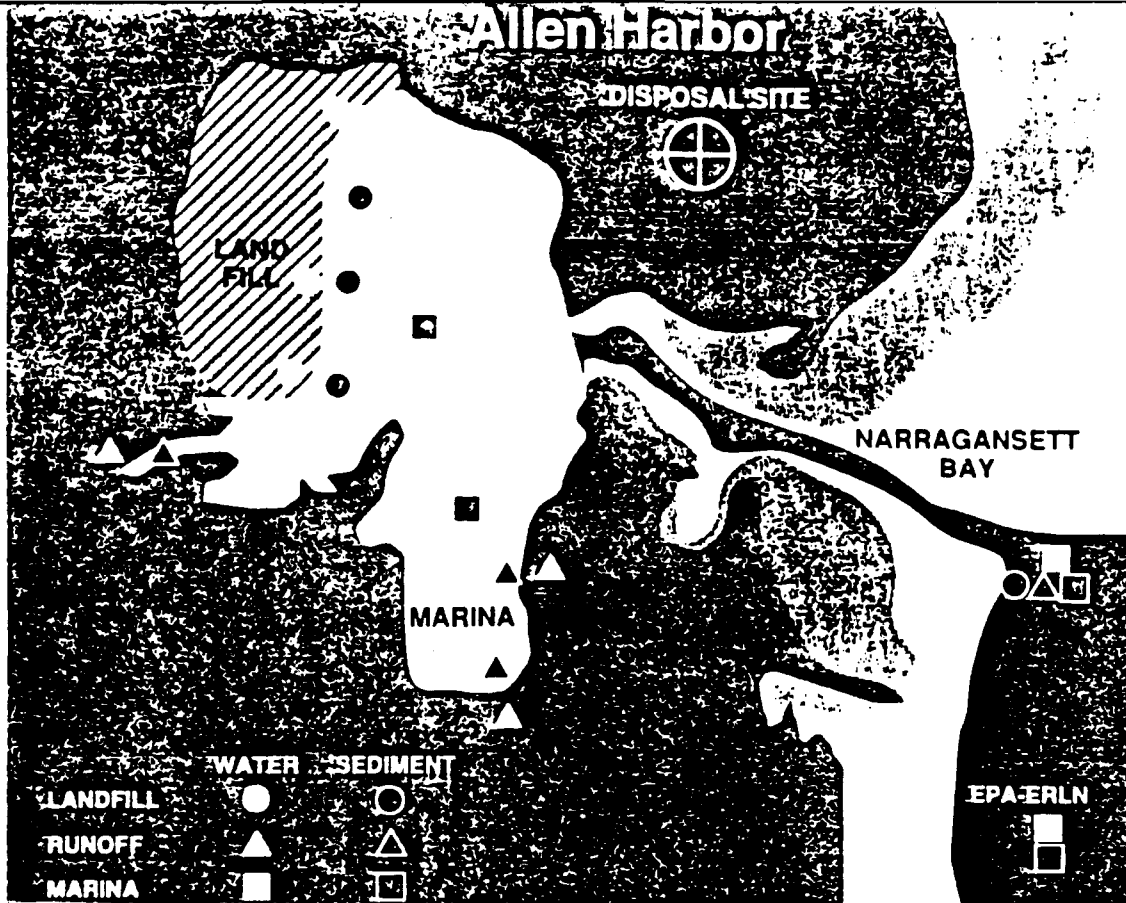
Summary of Sampling Events for Phase II

STATION LOCATION	CHEM ANAL		BAC		TOXICITY TEST		TEST SPECIES				MYSID		BIO-MARKER TEST
	WAT	SED			WAT	SED	CLAM	MUSSEL			MOR	REP	
LANDFILL	○	●	○		○	●	●						●
RUNOFF	△	▲	△		△	▲	▲						▲
MARINA		■	□			■	■					□	

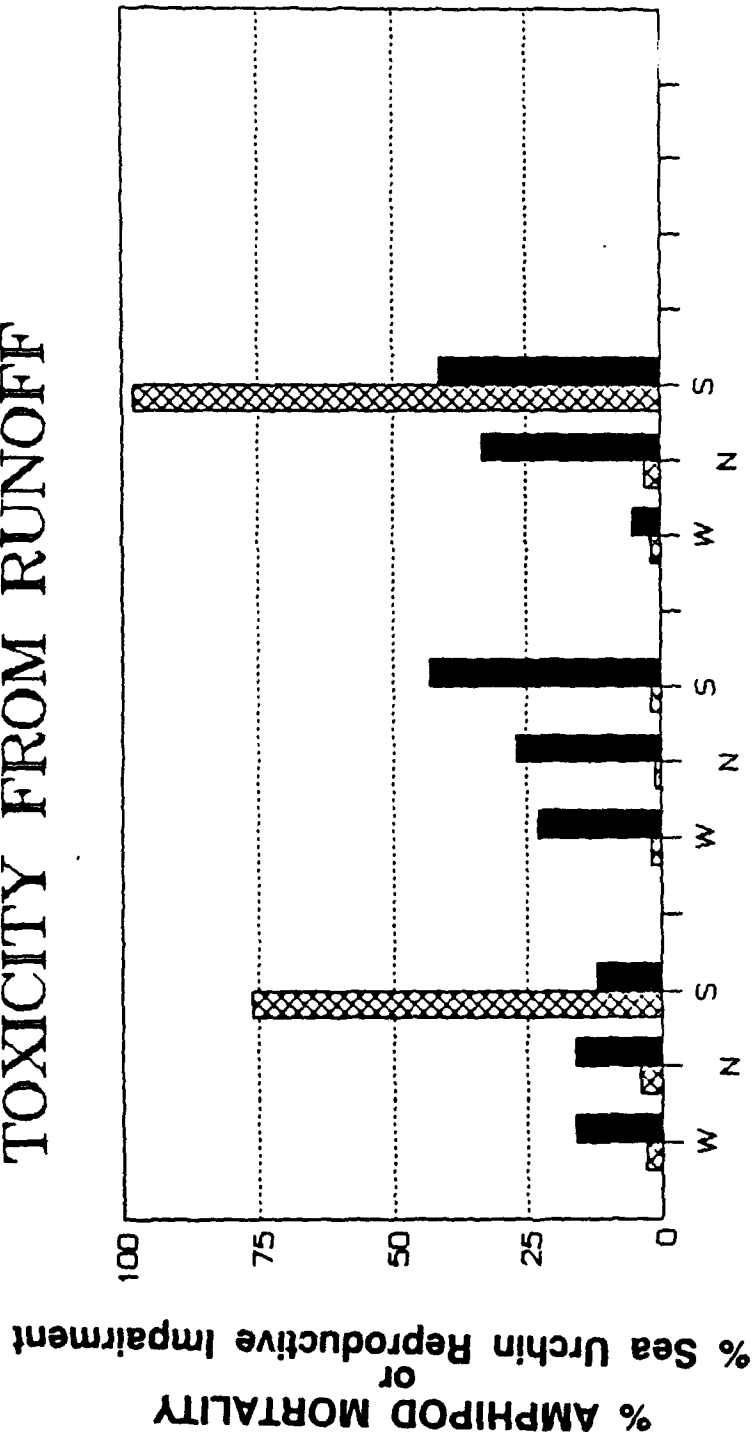
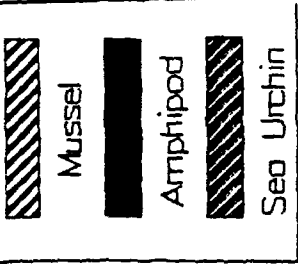
Sampling Schedule



X = SAMPLING DATE

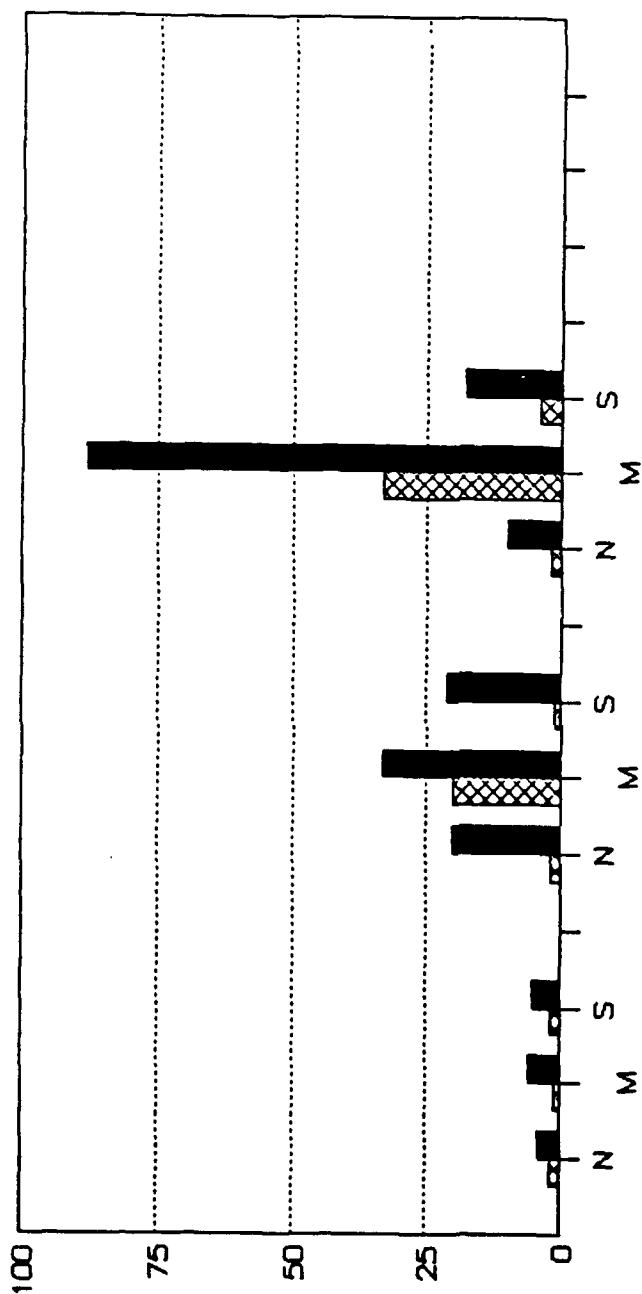


TOXICITY FROM RUNOFF

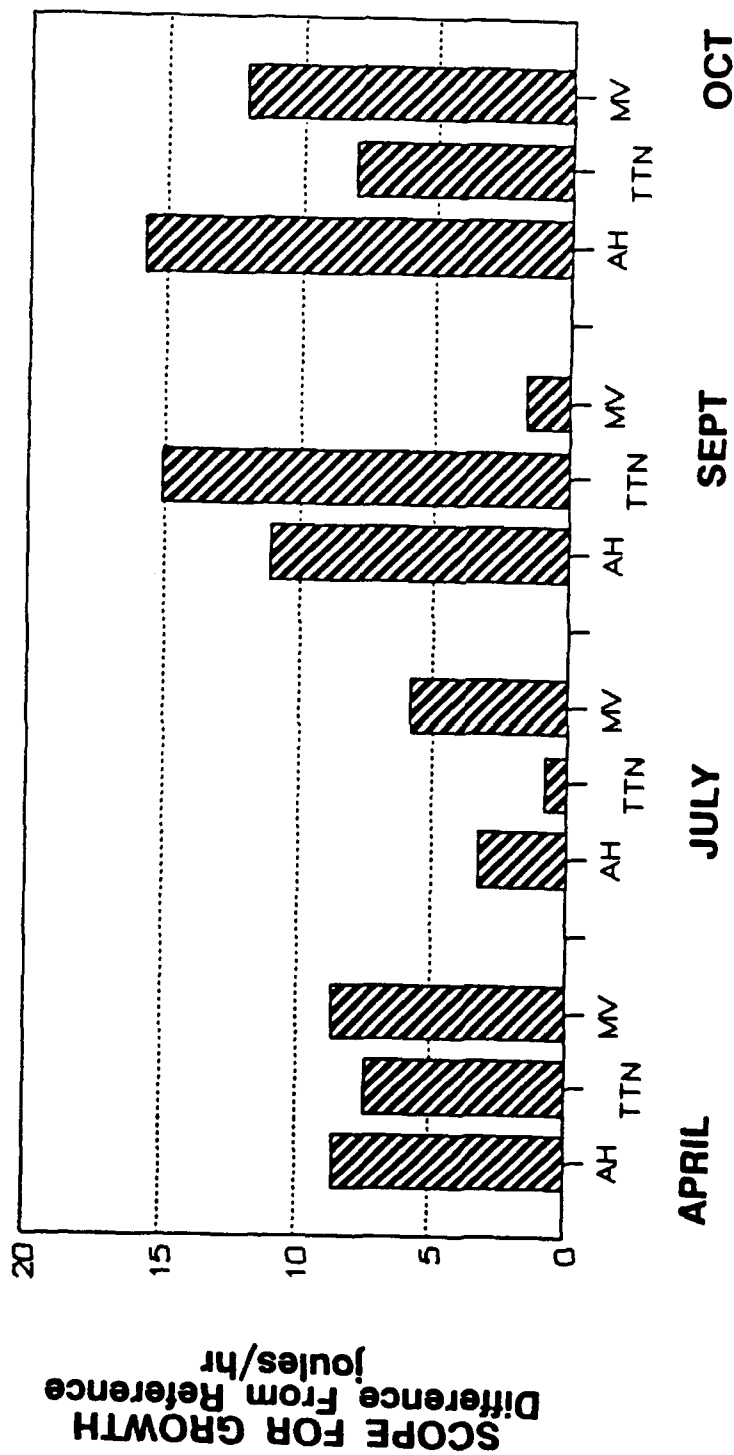


TOXICITY FROM LANDFILL SEEPS

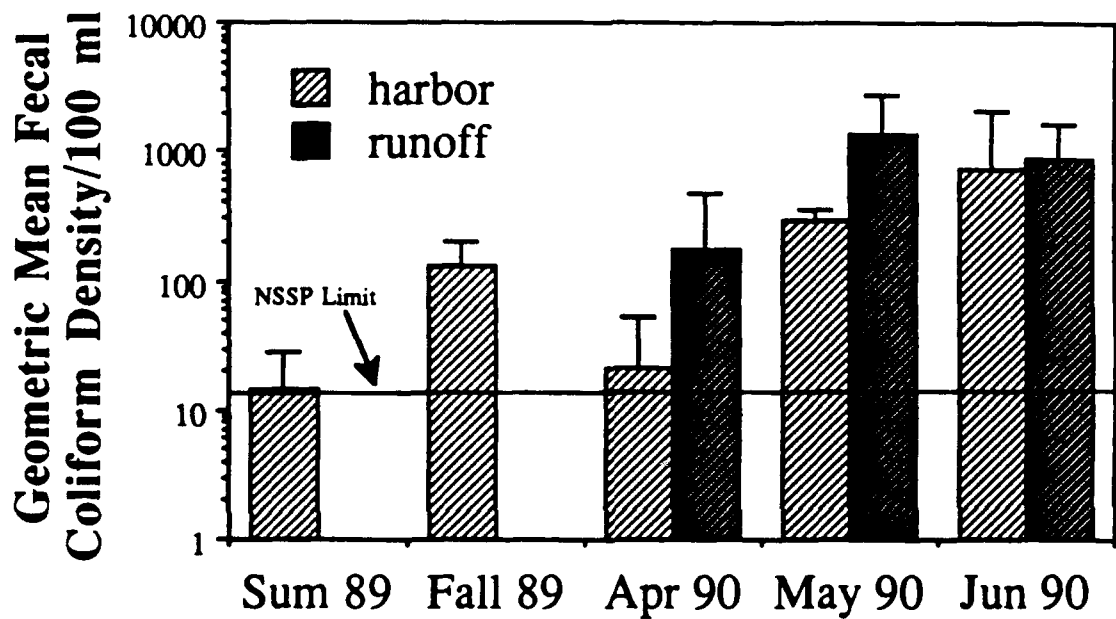
% AMPHIPOD MORTALITY
or
% Sea Urchin Reproductive Impairment



TOXICTY TO DEPLOYED MUSSELS



Fecal Coliform Densities in Allen Harbor



PHASE III (in progress)

Ecological risks from landfill contaminants were quantified by performing dose-response, laboratory bioassays of material collected from landfill seeps, landfill sediments, and extracts of sediments and soils collected from the landfill.

Varying concentrations of landfill media were exposed to benthic and water column species to determine the exposure-response relationships for chronic and acute endpoints.

The resulting data will be used to develop an exposure-response risk model for Allen Harbor.

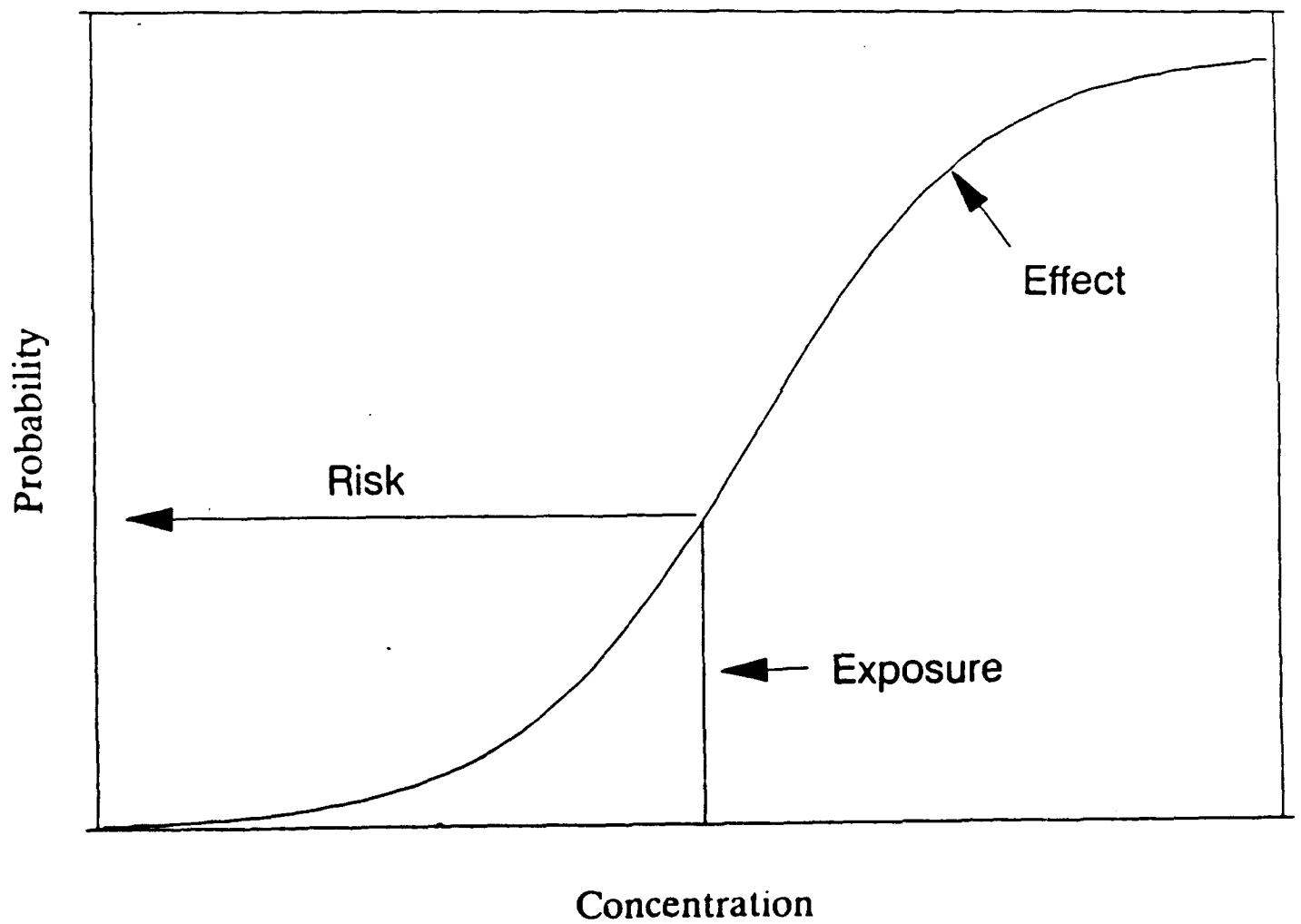
Long Term Monitoring Plan

- Identify variables and parameters for long-term monitoring of ecosystem health
- Long-term monitoring strategy will provide continuous verification of ecosystem health and safety for use in the Risk Management Plan for Allen Harbor.

QUANTIFICATION OF ECOLOGICAL RISK: ALLEN HARBOR PHASE III

EXPOSURE MEDIUM	SPECIES	ENDPOINTS
Seep Water	<i>Arbacia</i> (sea urchin)	Fertilization, Larval Growth Development, Survival
	<i>Mysidopsis</i> (mysid shrimp)	Chronic Mortality, Growth, Reproduction
	<i>Champia</i> (red alga)	Reproduction
	<i>Mulinia</i> (coot clam)	Acute Mortality, Development
	<i>Menidia</i> (silverside)	Chronic Mortality, Growth
Sediments	<i>Ampelisca</i> (Amphipod)	Acute Mortality
	<i>Cyprinodon</i> (sheepshead)	Chronic Mortality, Growth
	<i>Mulinia</i> (coot clam)	Acute Mortality, Development
Sediment or Landfill Extracts	<i>Arbacia</i> (sea urchin)	Fertilization, Larval Growth Development, Survival
	<i>Mulinia</i> (coot clam)	Acute Mortality, Development
	<i>Photobacterium</i>	Acute Mortality

Exposure-Response Risk Model



DISCUSSION

ASSESSMENT OF RISK FOR ALLEN HARBOR

COMPARISON WITH OTHER NARRAGANSETT BAY STATIONS

Qualitative Evaluation

- ++ High Risk Potential
 + Moderate Risk Potential
 -- Low Risk Potential

Allen Harbor versus Narragansett Bay

	Subtidal							Intertidal		
	AH	TTN	MV	NJ	PC	GB	ERLN	AH	CC	MP
Amphipod Toxicity	-	-	-	-	-	-		-	-	-
SCE	+		+							
Metabolic Cooperation	-		-							
Sea Urchin Fertilization	+	+	+							
Development	+	+	+							
Quahog Condition	+	-	-	-	-	-				
Mytilus SFG	+	+	+				-			
Phagocytic Index	-						-			
Pathology	-		-	-	-	-		+	+	+
Coliforms	+	+								
PCBs	+		+	-	+	-		-	-	-
PAHs	-		-	-	-	-		-	+	-
Pesticides	-		-	-	-	-		-	-	-
Sterols	-		-	-	-	-		-		
VOCs	-		-							
Metals	-		-	-	-	-		-	-	-
Butyltin	-		-					+	+	-

RISK QUOTIENTS DERIVED FROM SEDIMENT BENCHMARK CONCENTRATIONS

$$\text{Risk Quotient} = \frac{\text{Expected Environmental Concentration}}{\text{Toxic Benchmark Concentration}}$$

Where the Toxic Benchmark Concentration is defined as:

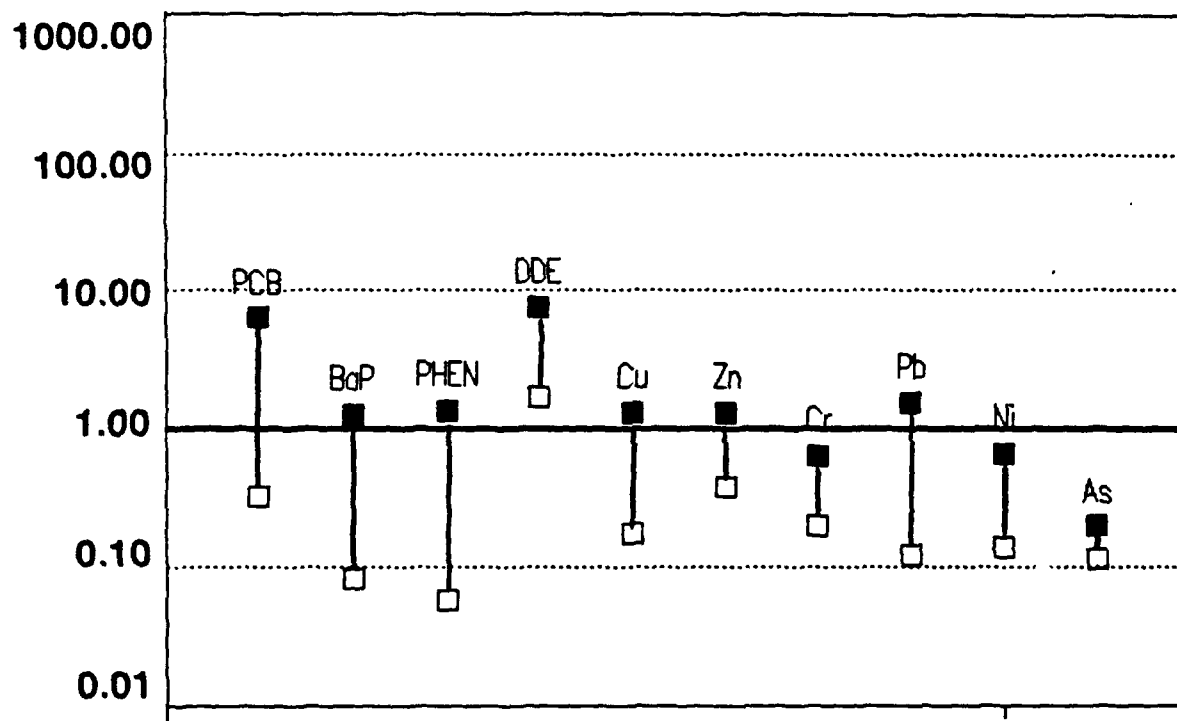
Effects Range Low (ER-L) the concentration below which only 10% of observed toxicological effects have occurred (Long and Morgan 1990).

Apparent Effects Threshold (AET) the concentration above which statistically significant toxicological effects have always occurred (PTI 1988).

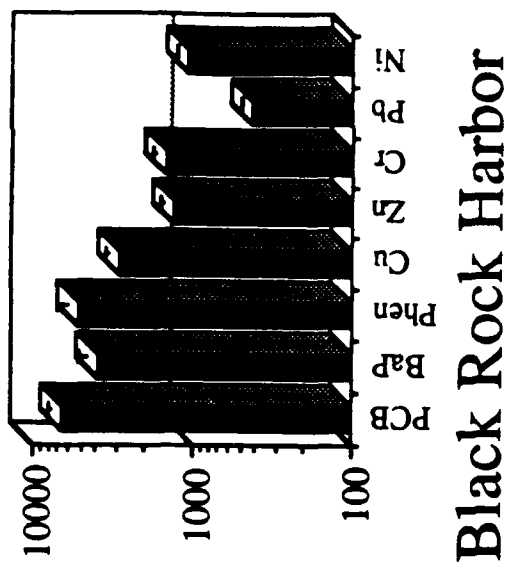
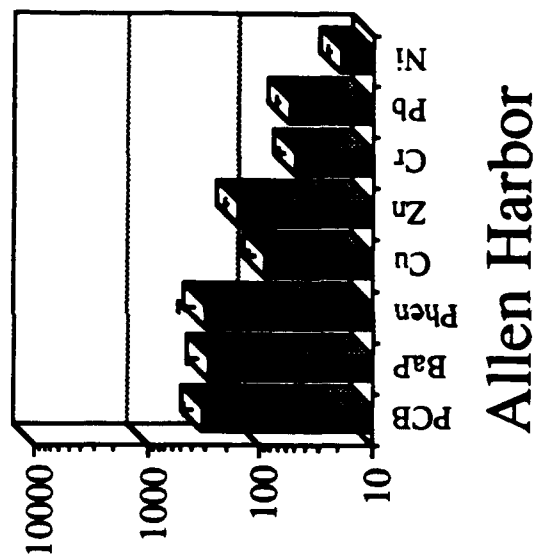
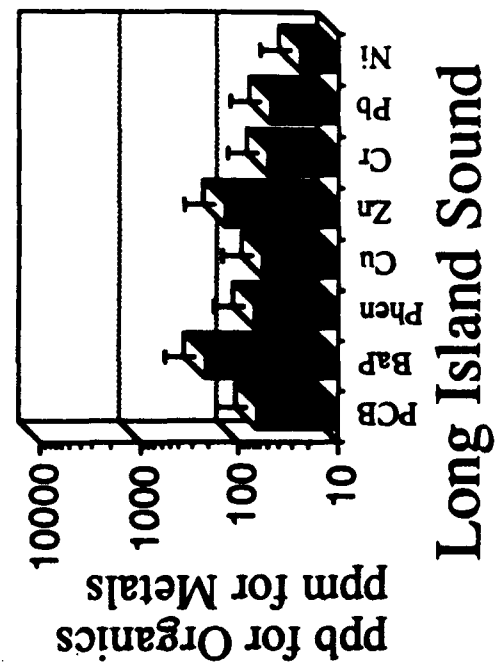
Risk Quotients (RQ) were determined for ER-L (Most Conservative) and AET benchmark concentrations for the mean concentration of contaminants measured in Allen Harbor sediment.

$RQ \geq 1.0$	High Risk
$0.1 \leq RQ < 1.0$	Moderate Risk
$RQ < 0.1$	Low to No Risk

Risk Quotients of Selected Contaminants in Allen Harbor



COMPARISON WITH OTHER NORTH EASTERN SITES



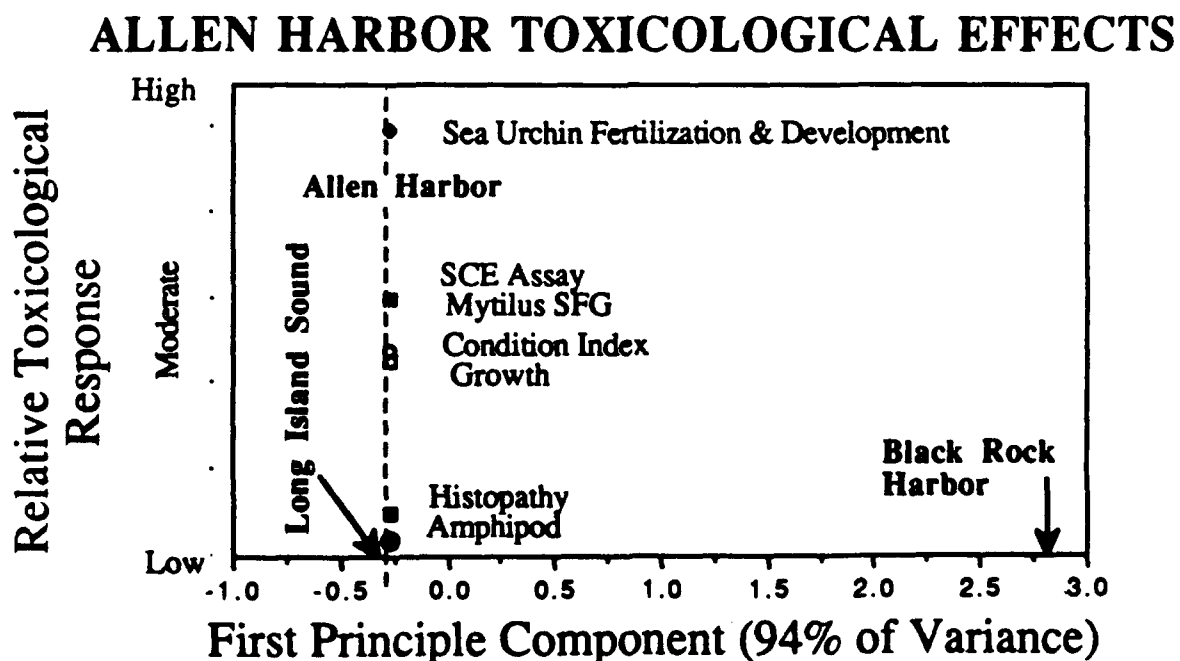
DEVELOPMENT OF EXPOSURE RESPONSE MODEL FOR RISK

An exposure response representation for Allen Harbor was obtained by plotting the relative toxicological response versus the value obtained from principal component analysis of the toxic chemical data.

Principal components were computed from the mean concentrations of PCB, BaP, PHEN, Cu, Zn, Pb, Cr, and Ni obtained for each station in Narragansett Bay (this study) and two other stations: a clean reference site in central Long Island Sound, and a heavily contaminated site in Black Rock Harbor, CT (Munns et al. 1988).

Principal components are linear combinations of the toxic chemical data constructed so that the first principal component will explain the maximum amount of variance in the independent variables (toxic chemical concentrations).

The principal component values for the Long Island Sound and Black Rock Harbor stations are shown for comparison.



SUMMARY AND CONCLUSIONS

- The study provides direct measures of environmental health, under true exposure conditions, using endpoints that have ecological significance.
- The approach can be used to identify the source and extent of problems and distinguish between hot spots and nonproblems.
- The risk assessment framework provides a context for developing an understanding of ecotoxicity that can be used to validate methodologies and establish ecological effects databases.
- Case studies are an effective approach for developing biologically-based models to assess risk.
- Ecological risk assessment and monitoring programs provide valuable information to facilitate site closure and determine how dirty a hazardous waste site actually is.

ACKNOWLEDGEMENTS

The work reported here was funded by the Assistant Commander for Environment Safety and Health of the Naval Facilities Engineering Command, Alexandria, VA and the USEPA Office of Research and Development, Washington, DC. The Authors wish to thank all those who contributed to this project:

Naval Facilities Engineering Command: Joe Kaminski, Ted Zagrobelny, and Elizabeth Wilkins;

Northern Division: Franco La Greca, Jim Szykman, Russ Fish, Jim Valenti, Al Haring, and Tom Schekels;

Naval Construction Battalion Center Davisville: Cmd. Bernard Murphy, Capt. Sam Saltoun, Lt. Don LaChance, Joe Guatieri, Louis Fayan, Odette Griffin, and Mathew Maliki;

EPA Environmental Research Laboratory Narragansett: Al Beck, Tim Gleason, Rich Pruell, George Gardner, Michele Redman, Randy Comeleo, Bettyanne Rogers, Bob Bowen, Warren Boothman, and Don Cobb;

University of Rhode Island: Jim Quinn and Pei Chang;

U.S. Food and Drug Administration: Virgil Carr;

Naval Ocean Systems Center: Peter Seligman, Jeff Grovhoug, Larry Gadbois, Laura Kear, Aldis Valkirs, Susan Cola, Bill Wild, and Sach Yamamoto.