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# MINUTES OF THE FOURTH ECORISK ADVISORY BOARD MEETING
# NAVY INSTALLATION RESTORATION PROGRAM
# NAVAL EDUCATION & TRAINING CENTER (NETC)
# NEWPORT, RHODE ISLAND

**June 28, 1995**

HALLIBURTON NUS CORPORATION
CONTRACT NO. N62472-90-D-1298
CONTRACT TASK ORDER NO. 0173

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## MINUTES OF THE FOURTH ECORISK ADVISORY BOARD MEETING

**JUNE 28, 1994**

The fourth meeting of the Ecorisk Advisory Board for Naval Education and Training Center sites was held in Building 1 of the Naval Education & Training Center in Newport, Rhode Island, on June 28, 1995, to discuss outstanding issues related to the off-shore ecological risk assessment to be performed for the Derecktor Shipyard. Attachment A presents a list of meeting attendees. Attachment B includes the meeting handouts. Attachment C presents discussion of the recommended resolutions to issues which were left outstanding at the conclusion of this meeting. The minutes of the meeting, are presented below, followed by the three attachments.

**OPENING REMARKS AND INTRODUCTION - Stephen S. Parker, Halliburton NUS Corporation**

The board members were introduced, and new members were noted:

Bob Krivinskas will be replacing Debbie Carlson as Northdiv's RPM for the NETC.

Shannon Behr will be Northdiv's technical point of contact for the NETC off-shore ecorisk projects.

Andrea Helmstetter (SAIC) is now acting as the QA officer for the NETC off-shore ecorisk projects.

- Christopher Kincaid (URI GSO) was introduced as a physical oceanographer for the Derecktor Shipyard project.

An update of recent events was presented: USEPA Comments on the Draft Final Work Plan and Addenda A through C were received and responded to. RIDEM Comments on Addenda B & C were received; responses will be forthcoming.

**DRAFT ADDENDUM B - PLAN FOR OFF-SHORE ECORISK ASSESSMENT FOR DERECKTOR SHIPYARD - Dr. James Quinn, URI Graduate School of Oceanography**

The outline of the Draft Work Plan Addendum for Derecktor Shipyard was presented, and the location of the site relative to the other study areas at the NETC was presented.

A summary of data collected in 1993 and 1994 studies performed in Coddington Cove was presented, which indicated contaminants in the deeper sediments (greater than 20 cm) and in samples collected nearer to the Derecktor Shipyard shoreline and piers.

*Cornell Rosiu (CDM) and Bob Krivinskas (Northdiv) both inquired about the locations of outfalls and their sources.*

Dr. Quinn and Stephen Parker responded that there were several outfalls above the water line in the area designated as the "dead zone" and these may be storm water outfalls or outfalls from floor drains. Other known outfalls were described, but it was clarified that all the outfalls and underground systems would be mapped as a part of the On Shore SASE Investigation which will be performed concurrently with the off shore ecorisk assessment.

Dr Quinn described the use of chemical markers in core sections, and that good chemical markers from 1960 and 1970 exist and can thus measure the sedimentation rates in various types of environments. Other markers exist back to the turn of the century and can be used to further date contaminant sources.

*Susan Svirsky (USEPA) asked if the core samples taken in 1993 and 1994 were just collected to refusal, and followed up by asking if the project team planned on taking deeper cores as a part of the ecological risk study.*

> Dr. Quinn replied that the 1993 and 1994 cores were taken by a diver pushing the core tube into the sediment, and a core from up to 35 cm in length was recovered - sample sections were taken to a maximum depth of 31 cm.
>
> Core samples for chemical analysis from this study were originally proposed to be collected to a depth of 1 meter using a piston core rig. (However, following subsequent discussions, vibracoring equipment to a depth of 10 feet was proposed - see page 4 of these minutes.)

*Susan Svirsky (USEPA) asked if any core samples taken in 1993 and 1994 were in the dead zone.*

> Dr. Quinn replied that both Stations 1 and 10 (1993) were taken from the dead zone.

The conclusions of the 1993 and 1994 studies were presented as described in slide #11 of the handout (Attachment B).

**ASSESSMENT AND MEASUREMENT ENDPOINTS - Dr. Greg Tracey, SAIC**

Dr. Tracey presented a list of preliminary contaminants of concern, based on prior data from Dr. Quinn's off-shore studies and a 1994 property assessment report prepared by TRC for Building 42 (immediately upgradient of the "dead zone").

*Susan Svirsky (USEPA) asked for clarification that this list would not encompass the analyte suite, and that these COCs only be considered as objectives.*

> Dr. Tracey responded that the latter was the case, and that samples will be analyzed for the analyte suite developed for the NOAA status and trends program. Other contaminants found will be considered and included if necessary.

There were no other questions on the development of the list of contaminants of concern, and Dr. Tracey continued his presentation with the proposed receptors of concern. He pointed out that winter flounder are not likely to be found in enough numbers for tissue analysis.

*Susan Svirsky (USEPA) asked if there was a surrogate species planned for low availability of winter flounder (besides Fundulus).*

> Dr. Tracey responded that the only fish that might be available is "cunner", which is a territorial reef-dwelling fish.

Assessment and measurement endpoints were reviewed and discussed.

*Susan Svirsky (USEPA) asked if the project team could evaluate direct effects of tissue concentrations on the organisms themselves as a measurement endpoint.*

> Dr. Tracey responded that this could be done, and attempts have been made with the Allen Harbor study. Ms. Svirsky asked if it could be addressed as it goes, depending on availability of data.

*Ms. Svirsky pointed out that PAHs are an exceptional problem at this site and, therefore, an enzyme induction test (mixed function oxidase [MFO] assay) and neoplasia studies might be appropriate.*

Dr. Tracey responded that the neoplasia studies are included, but the MFO assay was not. Ms. Svirsky continued with the point that there is a lot of data of MFO assays for *Fundulus*, and the EPA is concerned with how effects of PAHs will be detected in the measurement endpoints. There was additional discussion, and finally the issue was left open due to the unknown availability of *Fundulus* in the study area, the availability of MFO data on surrogate species, and the cost of performing the tests.

Following the meeting Dr. Tracey reviewed this outstanding issue and reported his findings to the Navy. The MFO test can be performed on cunner, assuming the reference stations be used as internal control. This will provide the data requested by the agency. A summary of the life history of cunner is presented in Attachment C.

Exposure point measurements were reviewed, and Dr. Tracey presented a description of the need and approach for measurement of sewage pathogens. As a part of this presentation, many points were raised:

*Dr. Tracey pointed out that the study area may be highly impacted by contaminants, nutrients, and pathogens from outfalls of the sewage treatment plants at Newport and Jamestown.*

*Dr. Cornell Rosiu stated that the shellfishing ban is due to the presence of pathogens, not nutrients, and asked if it is reasonable to assume that contaminants move together with pathogens.*

Dr. Tracey indicated that it is, and that Dr. Quinn's studies show a direct correlation of coprostanol and *Clostridium*. Water circulation in Narragansett Bay was discussed, and a post-meeting review of records show that general circulation in the bay is counter clockwise (south to north) in the east passage, past Coddington Cove.

*Chris Deacutis stated that it is important to note that there is a concern of pathogens in storm water runoff, not only combined sewer overflows (CSOs) and plant outfalls.*

*Bob Richardson indicated that the dilution factors in the east passage should be evaluated. Mr Richardson also indicated that dye studies have been performed at the Newport sewage treatment plan outfalls, and that the studies results can be acquired from the Treatment Plant. Mr. Richardson stated that the shellfishing ban is not due to the outfalls, but a result from non-point sources.*

There was general disagreement on the relevance of the use of pathogens as indicators because of unspecific and multiple sources other than the Newport Sewage Treatment Plant. A suggestion was made to evaluate overall impacts of nutrient and pathogens by use of analysis for BOD and COD. The issue was left open, and the Navy stated that they would revisit the issue and submit an adjusted approach as a part of the minutes of this meeting.

Following the meeting, this issue was discussed among the project team members, and it was decided that a new approach would be proposed. The new approach would consist of the measurement of BOD/COD and SOD (sediment oxygen demand) at the sediment-water interface, at eight stations plus the two reference stations. In addition, pathogens will be analyzed only in the tissue of undepurated deployed mussels.

**LOCATION OF SAMPLE STATIONS - Dr. Greg Tracey, SAIC**

Figure B4-1 was presented, which depicts the sample collection locations:

*Susan Svirsky (USEPA) asked where the diversity analysis will be done.*

Dr. Tracey responded that benthic diversity analysis will be done at all surface sample stations with the exception of #15, where markedly different sediment characteristics exist.

*A general request was made to correct the sample numbering scheme to reduce confusion.*

It was later agreed to number stations consecutively: Stations 1-12 are 1993 stations, Stations 13-24 are 1994 stations, and stations 25-41 will be 1995 stations. The figure will be adjusted accordingly.

*Chris Deacutis asked if one additional sample in the "dead zone" is enough to adequately characterize the conditions in that area. He also stated that he would support a tiered approach for the dead zone investigation.*

The subsequent discussion revealed that the on shore study (outfall investigation) will support the findings of the testing in this zone. An additional diver-video survey would be appropriate to document updated conditions in this area.

The concern was noted and an additional surface sediment sample station was added (with all analytical parameters), and a core station was added (surface and two depth intervals) thus totaling 2 stations from the 1993 study, one core station (surface and depth) for 1995 and one surface station for 1995.

*A general comment was raised about the possible disposal of sandblast grit from the piers to the cove, and would the proposed six deep cores (to one meter depth) adequately characterize the vertical extent of contamination.*

The Navy stated that in addition to the sampling for the ecological risk assessment, an attempt will be made to further determine the nature and extent of contaminants in the cove, and in so doing, a series of up to 15 cores was proposed to a depth of 10 feet below the sediment surface. Six of these cores will replace the 1-meter cores previously scoped for chemical analysis. Samples from 50 cm and 100 cm depths will be collected from these six core stations, shown on figures 2-4 (attached). The additional cores will be spatially distributed throughout the cove to ground-truth the geophysical study. In general, these cores will be sampled for TOC and grain size distribution, but the sampling plan will remain flexible to allow chemistry analytical samples if the 100 cm samples do not reach the historical contaminant distribution of concern.

*Chris Deacutis stated that the Rhode Island Department of Economic Development is interested in redeveloping this area as a port, and may carry out dredging operations in the future. He supported continuation of chemical sampling into these deeper cores, so that the State may have an indication as to what may be involved in future dredging projects in this area.*

The sample collection discussion continued by addressing the target surface sediment sample depth. The target depths for McAllister Point Landfill study were reviewed, and after much discussion, it was determined that a target depth for the Derecktor Shipyard/Coddington Cove Study area of 0-20 cm would be appropriate because of the nature of the sediments, and the species of concern. Agreement on this target depth for chemical and toxicity analyses was made clear and supported by all representatives of the regulatory parties present.

*Susan Svirsky asked about the locations of the reference stations; were they the ones used for Allen Harbor, and what data is available for these stations.*

Dr. Tracey showed the locations of the reference stations, Potter Cove and Castle Hill Cove. These have not been sampled before, but other adequate reference stations for Coddington Cove are not available. There are no apparent problems with point sources based on PCBs and PAHs, although some impacts may be present from historic sewage outfalls and ship maintenance activities by the Coast Guard.

*Susan Svirsky requested an additional mussel deployment in the "dead zone".*

The Navy agreed that this would be appropriate.

*Susan Svirsky asked if the coverage of biota samples was adequate, and specifically pointed out that there was no lobster sample scoped for the southeastern area of the cove.*

Some discussion of this issue ensued, and the Navy stated that the distribution of the biota samples would be revisited, and a rationale for their location will be presented as is shown on Table B4-1 for the sediment sample stations.

Following the meeting, Dr. Tracey discussed the sample distribution with Ms Svirsky, and a redistribution of biota sample stations was prepared this redistribution is shown in Attachment C.

*Bob Richardson stated that he did not agree with the use of pore water analysis for metals, and suggested the use of an elutriate test instead. This would be more realistic because of the potential for resuspension.*

Dr. Tracey recognized that pore water analysis is generally preferred because bioavailability and toxicity issues, but since the target surface sediment sample depth will be 0 to 20 cm, bioavailability may no longer be the main consideration. Thus it was agreed that the elutriate test for metals would be performed in lieu of the pore water test, provided AVS/SEM analysis would not be compromised.

*Susan Svirsky stated for the record that the USEPA generally does not support the use of sediment elutriate test within Superfund in lieu of the pore water analysis, but the substitution would be acceptable in the case of Derecktor Shipyard.*

**HYDROGRAPHIC SURVEY AND PHYSICAL OCEANOGRAPHY STUDY - Chris Kincaid, Associate Professor, URI GSO**

Dr. Kincaid presented the approach for a hydrographic survey which will show patterns of water flushing in and around Coddington Cove. The hydrographic and physical oceanography studies will determine probable sediment transport patterns and the relationships of the velocity of currents with the types of sediments in different areas of the cove.

*Chris Deacutis asked if a transect line could be extended into the "dead zone" to identify flushing characteristics in this area.*

Dr. Kincaid agreed that this would be appropriate, and would do it.

CLOSING REMARKS - Stephen S. Parker, Halliburton NUS Corporation

A summary of upcoming deliverable dates was reviewed for the Work Plans and Addenda. It was noted that regulatory concurrence for Addendum B is projected for August 30, and sampling is likely to begin before that date due to the seasonal window of opportunity which will be closing at the end of the summer. It was agreed that only the field activities which are not in controversy will be performed prior to regulatory concurrence.

There were five issues left outstanding at the meeting that may need to be addressed with the regulatory agencies. These are:

- Redistribution of the biota sample collection stations.
- Performance of SEM/AVS on sediment and relationship to metals analysis on elutriate.
- BOD/COD and SOD Data collection for determination of potential anoxic conditions in the "dead zone"
- Performance of an additional diver video survey in the so-called "dead zone" to provide updated information.
- Use of cunner as surrogate species in place of *Fundulus* as a pelagic receptor of concern, and performance of MFO tests in cunner.

The meeting was concluded, and it was stated that the outstanding issues would be discussed by the Navy and the project group, and additional recommendations would be forthcoming with the meeting minutes.

The meeting was adjourned at 1:30 P.M.

# ATTACHMENT A

# LIST OF ATTENDEES

EAB meeting - Derecktor Shipyard — 6/28/95

Attendance

| Person | affiliation/phone |
| --- | --- |
| Hector Laguette | HNUS/ 508-658-7899 |
| Steve Parker | HNUS /508-658-7899 |
| Bob Richardson | RI DEM /401-277-6519 |
| Chris Deacutis | RIDEM /401-277-3165 |
| Jim Quinn | GSO/URI 401-792-6219 |
| Chris Kincaid | GSO /URI 401 792 6571 |
| Paul Kulpa | RIDEM / 401-277-3872 |
| Andrea Helmstetter | SAIC / 401-782-1900 |
| SHANNON BEHR | NORTHNAVFACENGCOM / 610-595-0567 X183 |
| Kymberlee Keckler | USEPA / (617) 573-5777 |
| GREG TRACEY | SAIC 401 782-1900 |
| Mary Pothier | CDM / (617) 742-2659 |
| Cornell Rosiu | CDM / 617-252-8000 |
| BOB KRIVINSKAS | NORTHDIV ENVIRO (610) 595-0567 X134 |
| TODD BOBER | " " X160 |
| DEBBIE CARLSON | NORTHDIV-RPM 610-595-0567 x147 |
| Susan C. Svirsky | USEPA (617) 573-9649 |
| Brad Wheeler | Navy |

# ATTACHMENT B

# PRESENTATION HANDOUTS

ADDENDUM B:

DRAFT

# PLAN FOR OFFSHORE ECOLOGICAL RISK ASSESSMENT

FOR

DERECKTOR SHIPYARD
NAVAL EDUCATION AND TRAINING CENTER
NEWPORT, RHODE ISLAND

**24 March 1995**

**PROJECT NAME:** Offshore Ecological Risk Assessment for Derecktor Shipyard

**PROJECT REQUESTED BY:** Halliburton NUS Corporation

**PROJECT MANAGER:** Dr. James Quinn, GSO/URI

**PRINCIPAL INVESTIGATORS:** Dr. James Quinn, GSO/URI
Dr. John King, GSO/URI
Dr. Gregory Tracey, SAIC

**QUALITY ASSURANCE OFFICER:** Ms. Andrea Helmstetter, SAIC

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5.0 EXPOSURE ASSESSMENT

6.0 ECOLOGICAL EFFECTS ASSESSMENT

7.0 RISK CHARACTERIZATION

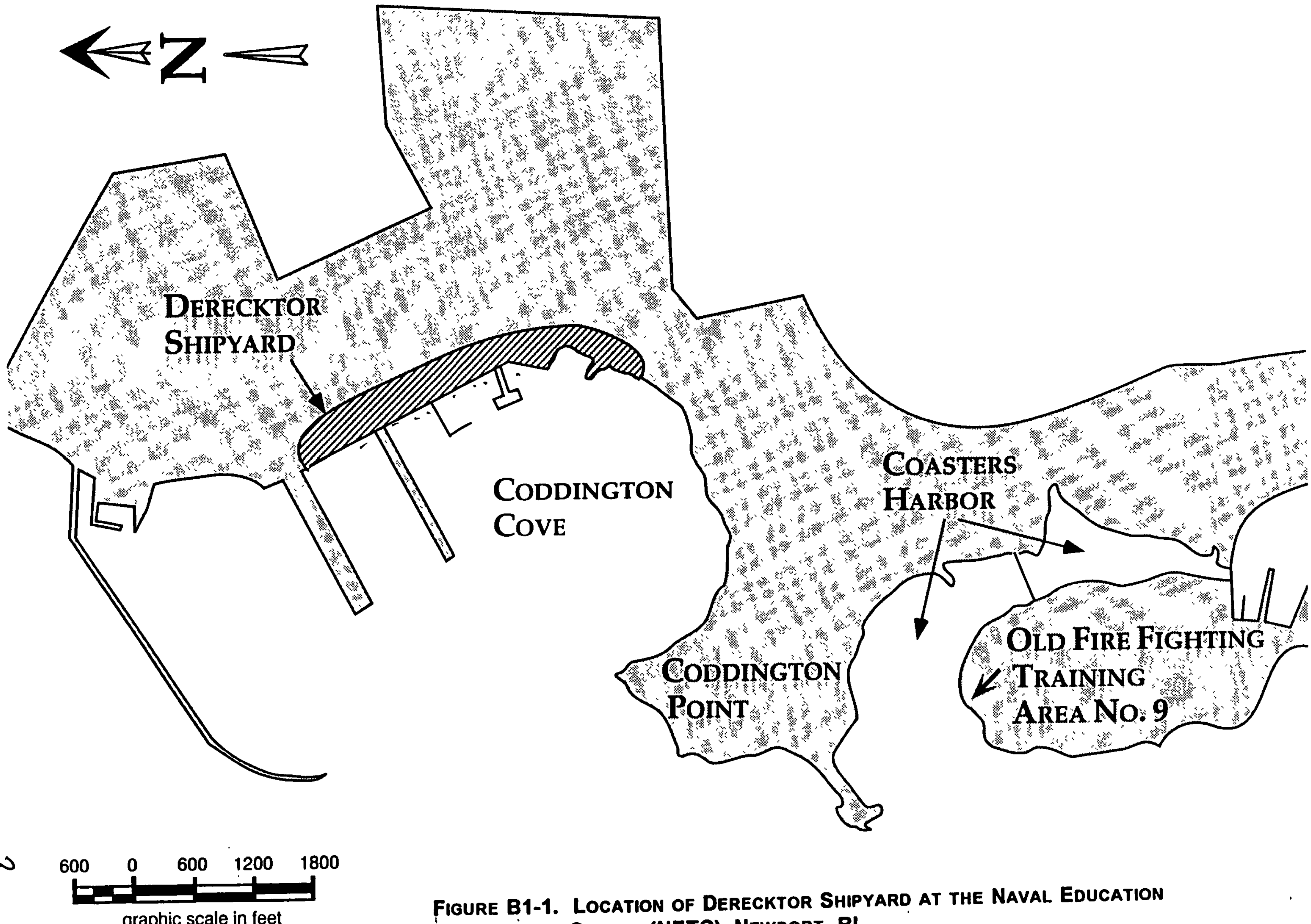


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**Figure B1-1. Location of Derecktor Shipyard at the Naval Education and Training Center (NETC), Newport, RI.**

CONCLUSIONS OF THE ONSHORE INVESTIGATION

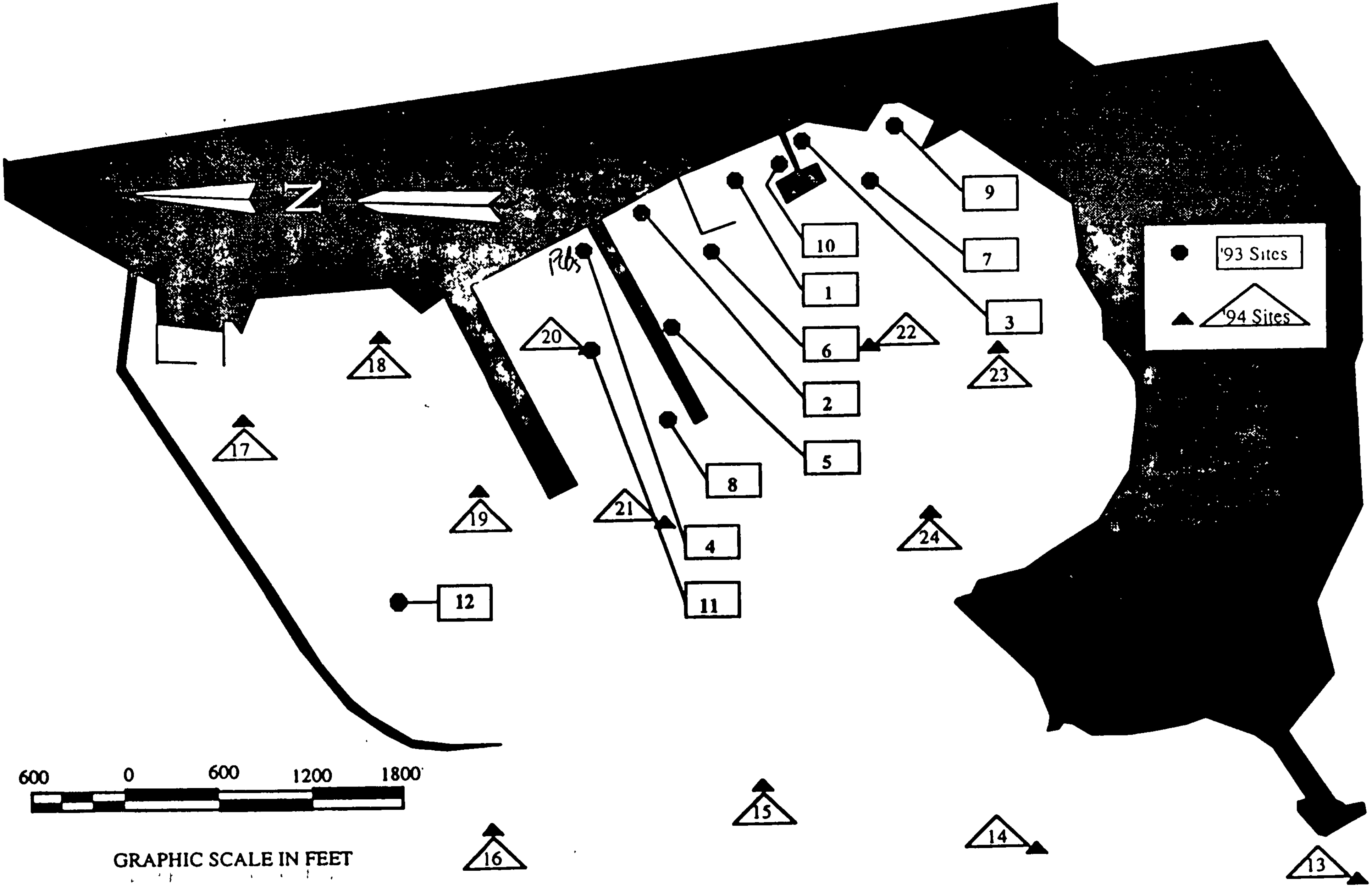
- The Derecktor operations generated large quantities of hazardous wastes.

- Housekeeping and hazardous material handling practices at the facility were poor.

- Waste materials were known to be disposed of on the property.

- Releases of hazardous material to the ground in the hazardous waste storage area (North Waterfront) is suspected but has not been confirmed.

- The primary pathways for contaminants to migrate from the site would be through the storm drain system and groundwater flow. Coddington Cove would be the primary receptor of contaminants through these pathways.




# Figure 1. Coddington Cove Site Locations

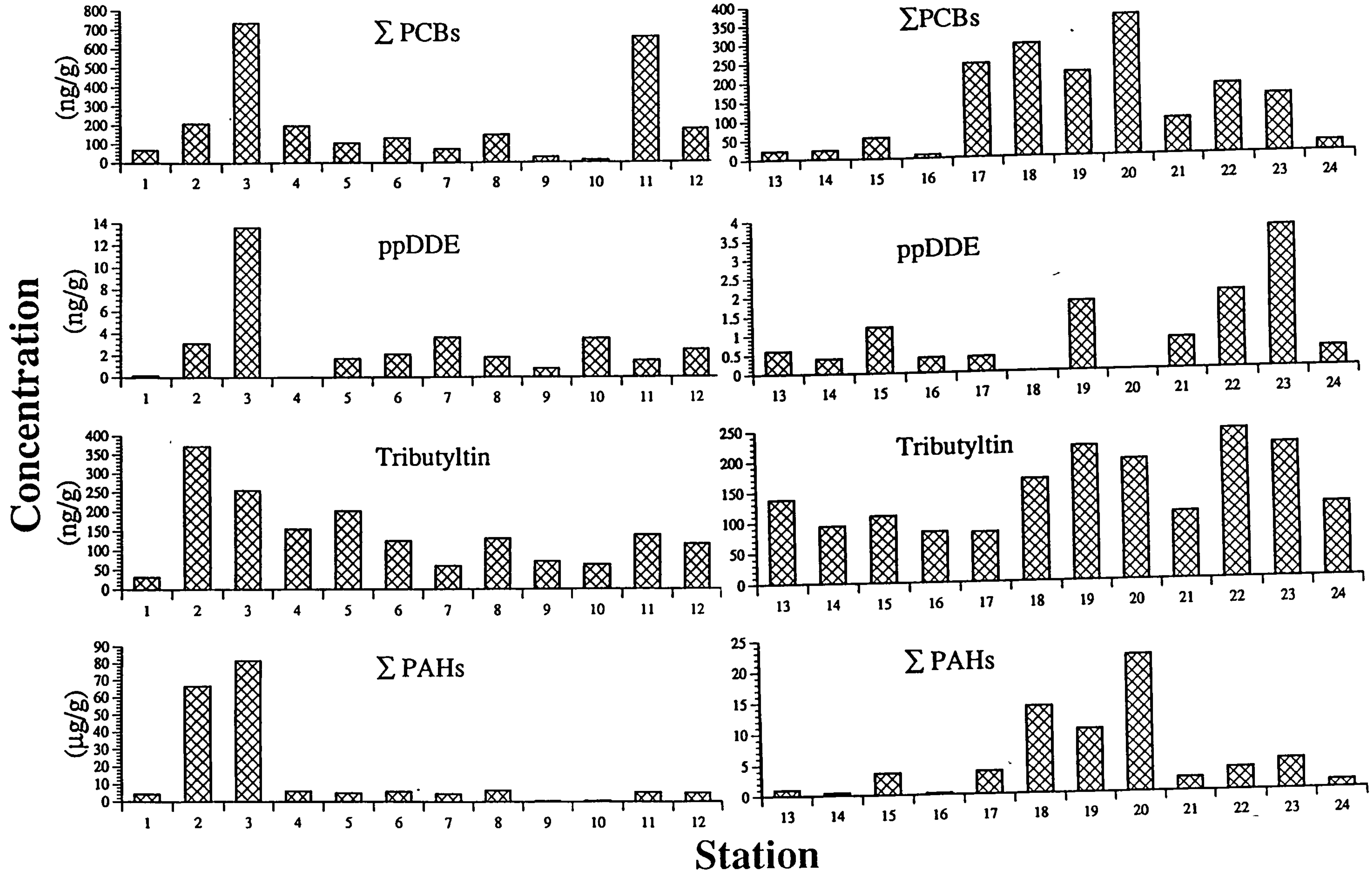
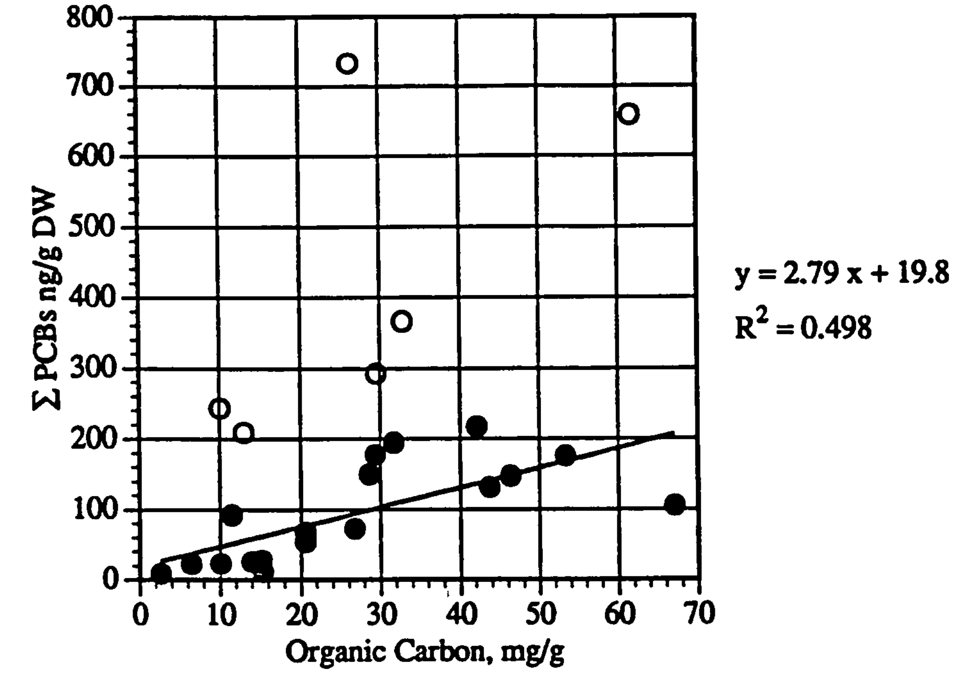



Figure 3. Concentrations of Organic Contaminants in Surface Sediments.



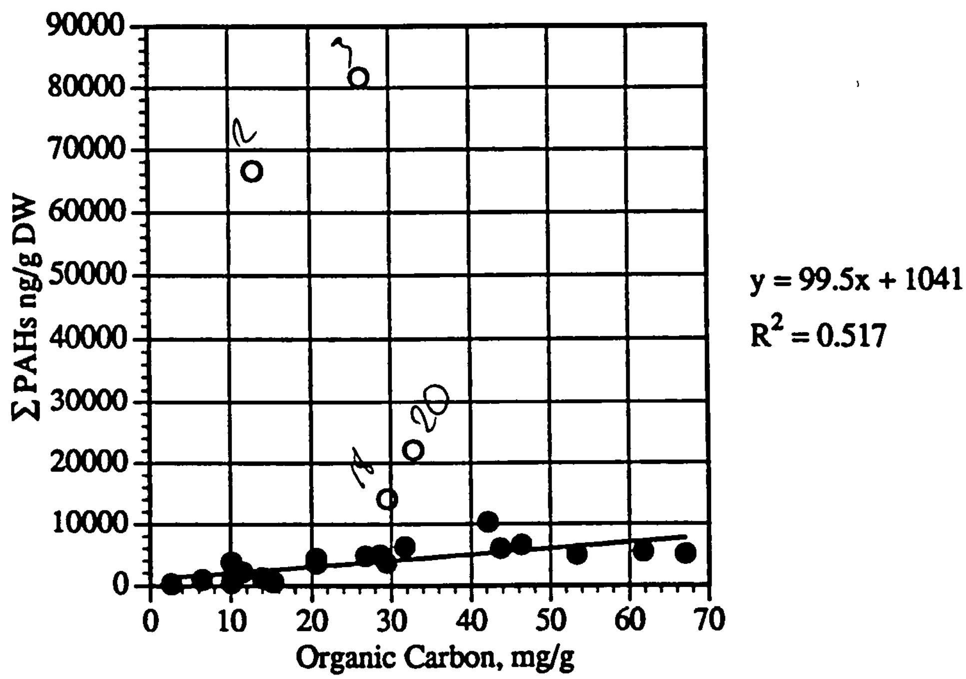




Figure 4. Plot of Organic Contaminants in Surface Sediments versus Organic Carbon.

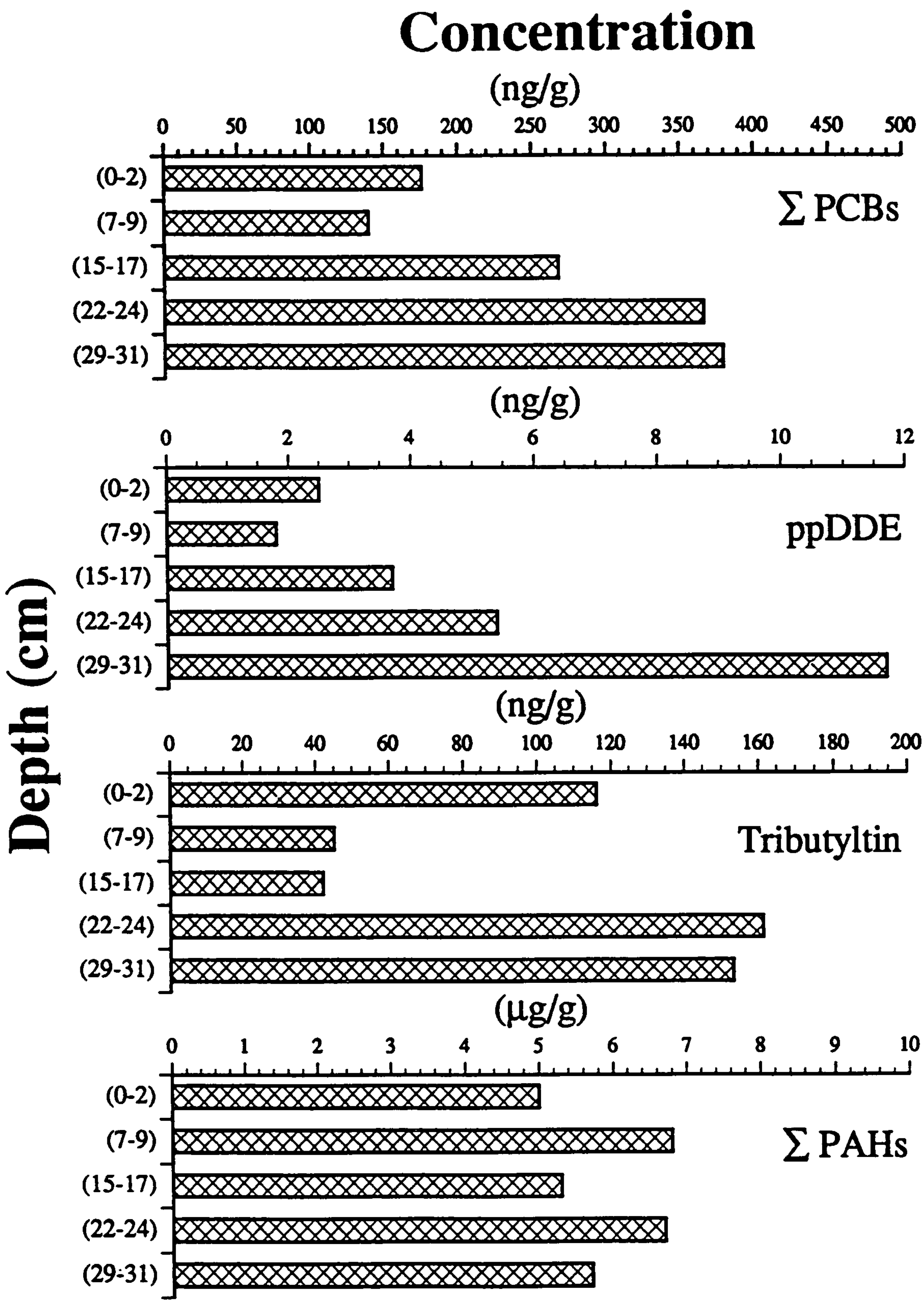
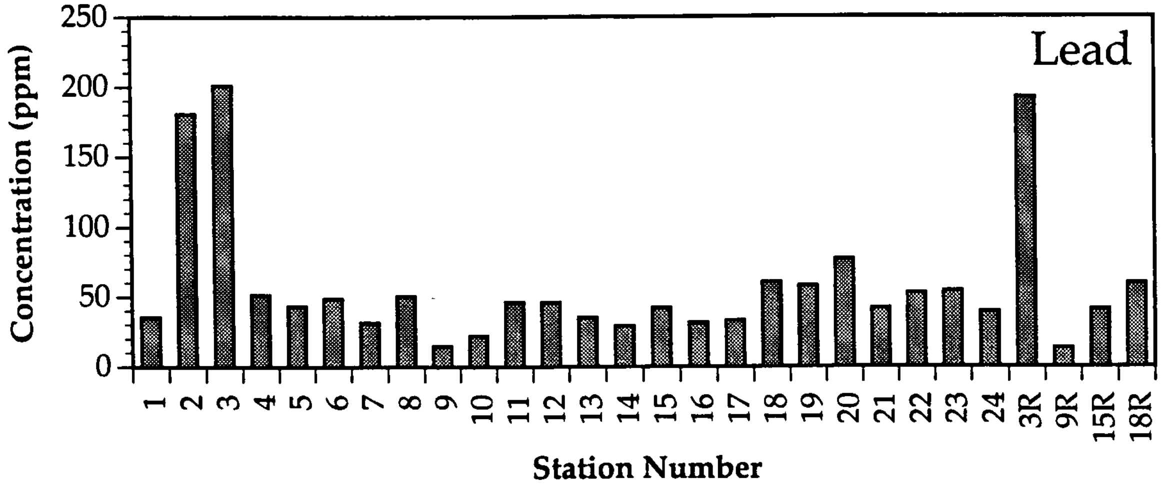
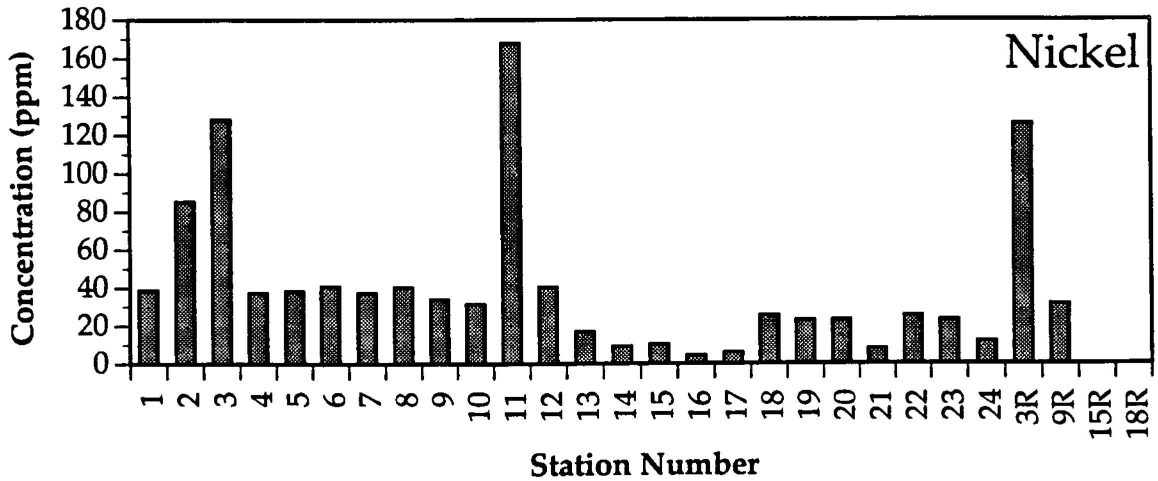
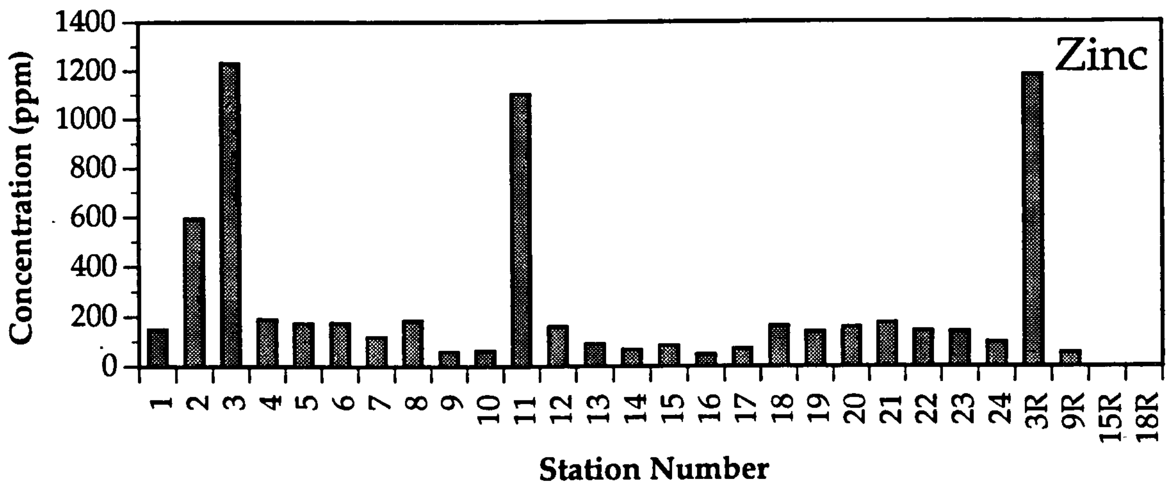



Figure 7. Concentrations of Organic Contaminants in Station 12 Sediment Core.

**Concentrations of Selected Metals (Total Digestion) from Surface Sediments in Coddington Cove**



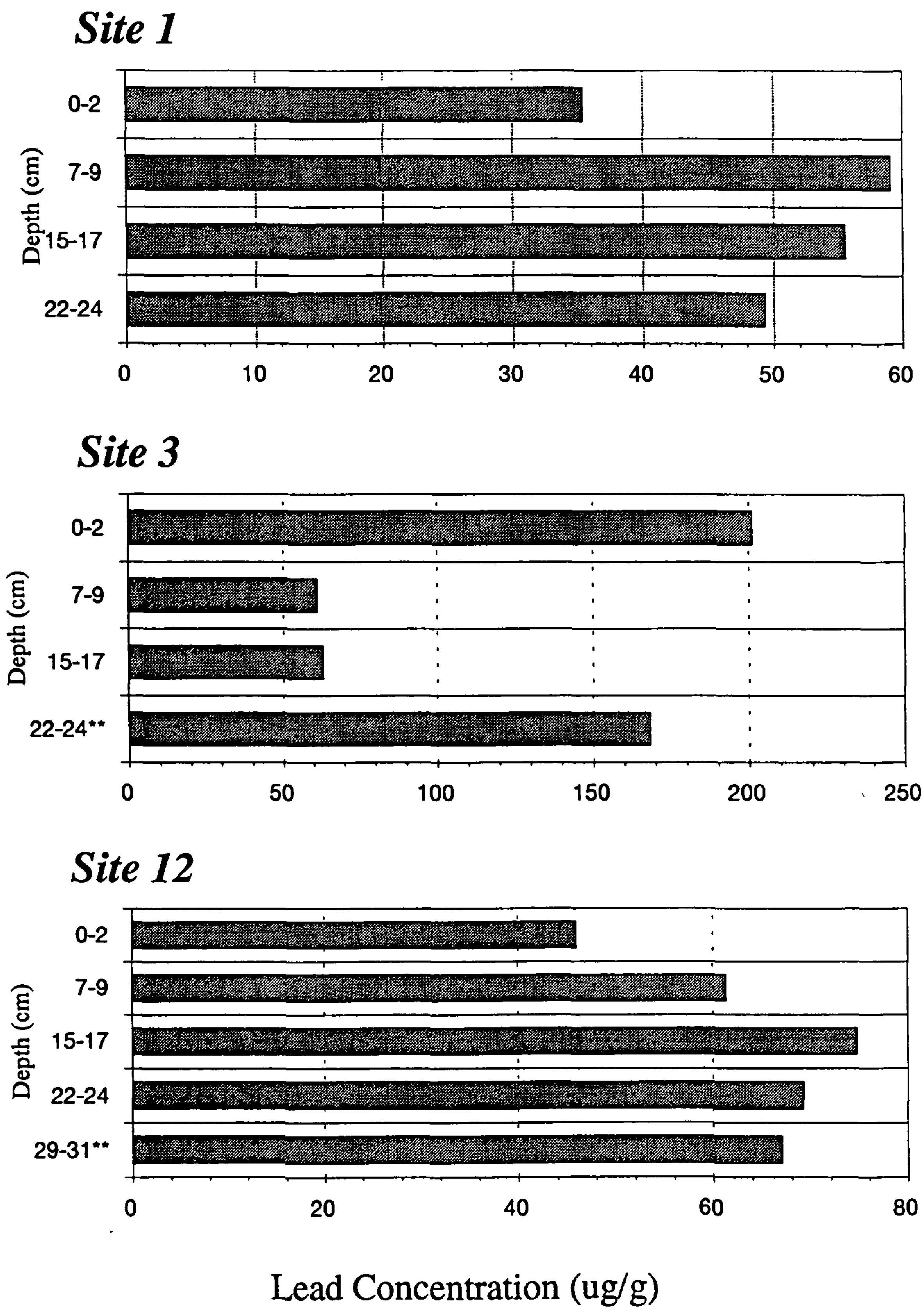



Figure 2.3.5.27 : Metals concentrations (total digestion) vs. depth in Coddington Cove Sediment cores.

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CONCLUSIONS

1. The levels of organic components and trace metals from primarily anthropogenic origin are very high in Coddington Cove surface sediments relative to concentrations typical of lower Narragansett Bay sediments. In addition, the concentrations of many of the contaminants found at a few of the cove stations are similar to or exceed values found in the Providence River.

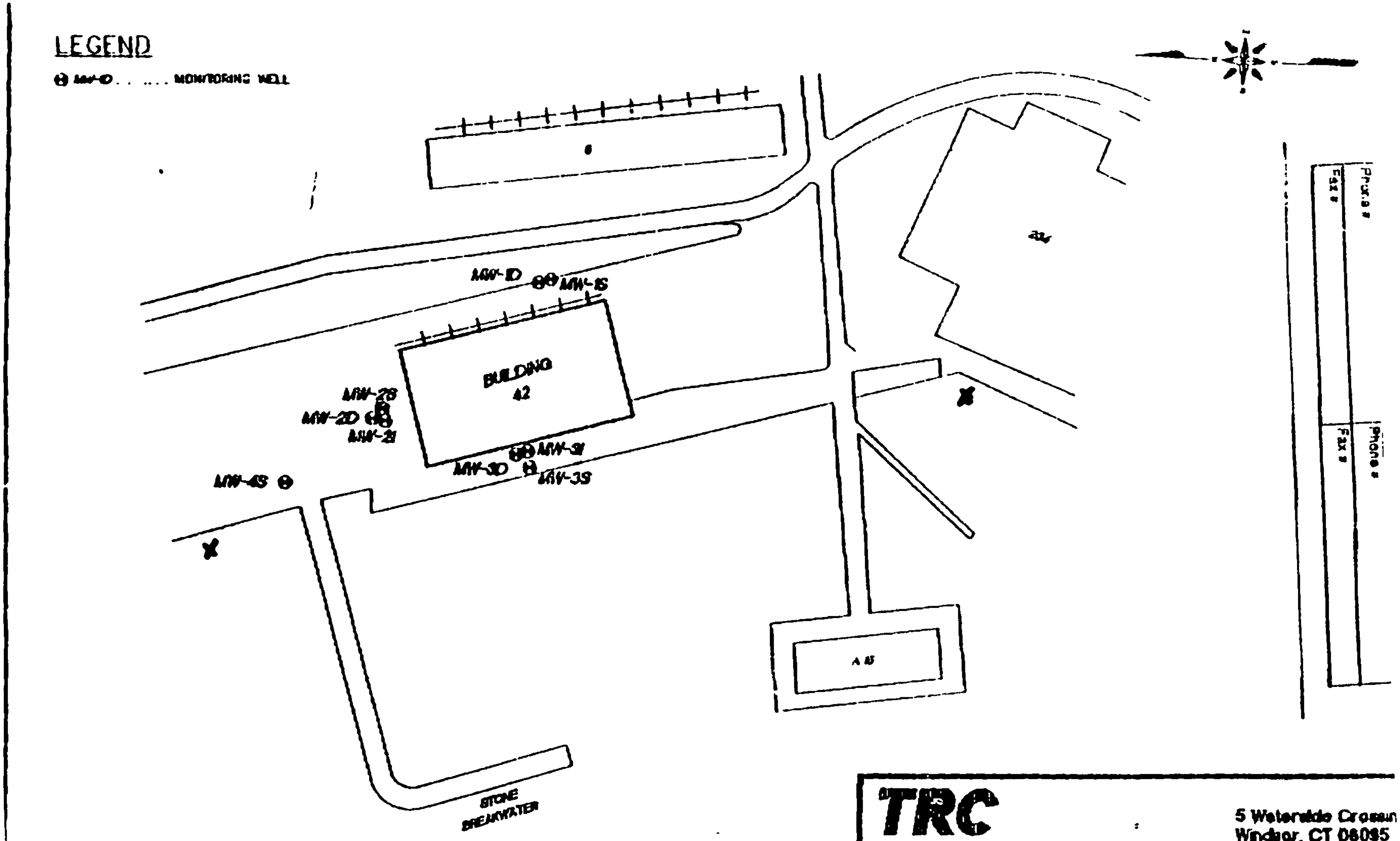
2. Elevated concentrations of the ΣPCBs and ΣPAHs were found in the one clam sample of sufficient size for analysis. These values are similar to those in clams from the upper Bay and the Providence River.

3. The spatial distribution of organic contaminants and trace metals in the surface sediments of Coddington Cove, after normalization for lithologic variations, indicates that the primary sources for many of these components are the series of outfall pipes from the former Derecktor Shipyard (e.g. stations 1 to 4) and/or piers for shipping activity (e.g. stations 11 and 20).

4. The maximum concentrations of ΣPCBs, ΣPAHs, nickel, lead, and zinc observed in Coddington Cove sediments exceed the NOAA Effects Range-Medium (ER-M) guidelines.

5. The acid volatile sulfide (AVS) concentrations observed in Coddington Cove sediments are relatively high and are significantly higher than the sum of the concentrations of the simultaneously extracted metals (SEM). The results of these studies indicated that the potential for biological effects from exposure to trace metals in the sediments of Coddington Cove is significantly lower under present conditions than would be predicted by comparison of the concentration data with NOAA guidelines.

6. High concentrations of organic and trace metal contaminants are found in sediment core sections down to 31 cm depth. Based on an estimated sedimentation rate of about 1 cm/yr., the elevated contaminant levels could extend down to 50-60 cm in depth. In some cases, subsurface maxima in concentrations suggest higher anthropogenic inputs to the cove in the past relative to the present time.




GRAPHIC SCALE

200 0 100 200 400

( IN FEET )
1 inch = 200 ft.

.\19810010\FIG3-1D

TRC
TRC Environmental Corporation
5 Waterside Crossing
Windsor, CT 06095
(203) 289-8631

DERECKTOR SHIPYARD
NAVAL EDUCATION AND TRAINING CENTER
NEWPORT, RHODE ISLAND

FIGURE 3-1
MONITORING WELL LOCATION MAP

**TABLE B2-1. PRELIMINARY DERECKTOR SHIPYARD GROUNDWATER COCs[1]**

| CONSTITUENT | WQC (ug/L) Acute | WQC (ug/L) Chronic | Max. Conc. (ug/L) | Hazard Quotient Acute | Hazard Quotient Chronic |
|---|---|---|---|---|---|
| Arsenic | 69 | 36 | 240 | **3.5** | **6.7** |
| Chromium | 1100 | 50 | 430 | 0.4 | **8.6** |
| Copper | 2.9 | 2.9 | 442 | **152.4** | **152.4** |
| Lead | 220 | 8.5 | 455 | **2.1** | **53.5** |
| Nickel | 75 | 8.3 | 540 | **7.2** | **65.1** |
| Zinc | 95 | 86 | 1190 | **12.5** | **13.8** |

[1] TRC, 1993

TABLE B2-2. PRELIMINARY DERECKTOR SHIPYARD SOIL COCs

| | Effects Range[2] | | Max. Conc.[2] | Hazard Quotient | |
|---|---|---|---|---|---|
| CONSTITUENT | Low (ER-L) | Median (ER-M) | | Low (ER-L) | Median (ER-M) |
| | | | | | |
| PAHs | | | | | |
| Benzo(a)anthrac | 261 | 1600 | 830 | **3.2** | 0.5 |
| Benzo(a)pyrene | 430 | 1600 | 920 | **2.1** | 0.6 |
| Chrysene | 384 | 2800 | 850 | **2.2** | 0.3 |
| Fluoranthene | 600 | 5100 | 1100 | **1.8** | 0.2 |
| Phenanthrene | 240 | 1500 | 770 | **3.2** | 0.5 |
| Pyrene | 665 | 2600 | 2700 | **4.1** | 1.0 |
| | | | | | |
| Metals | | | | | |
| Arsenic | 8.2 | 70 | 22.5 | **2.7** | 0.3 |
| Cadmium | 1.2 | 9.6 | 0.56 | 0.5 | 0.1 |
| Chromium | 81 | 370 | 31 | 0.4 | 0.1 |
| Copper | 34 | 270 | 550 | **16.2** | **2.0** |
| Lead | 46.7 | 218 | 380 | **8.1** | **1.7** |
| Mercury | 0.15 | 0.71 | 0.14 | **0.9** | 0.2 |
| Nickel | 20.9 | 51.6 | 68 | **3.3** | **1.3** |
| Silver | 1 | 3.7 | 0 | 0.0 | 0.0 |
| Zinc | 150 | 410 | 1200 | **8.0** | **2.9** |

[1] TRC, 1993

[2] PAH units = ppb: metals units = ppm



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| Table B2-3. Preliminary offshore sediment CoCs. | | | |
|---|---|---|---|
| | Maximum | | |
| Constituent | Concentration[1] | ER-L | HQ |
| 2-Methylnaphthalene | 53.4 | 70 | **0.8** |
| Acenaphthene | 192.9 | 16 | **12.1** |
| Acenaphthylene | 867.2 | 44 | **19.7** |
| Anthracene | 3360.0 | 85.3 | **39.4** |
| Benzo(a)anthracene | 10600.0 | 261 | **40.6** |
| Benzo(a)pyrene | 4710.0 | 430 | **11.0** |
| Chrysene | 6390.0 | 384 | **16.6** |
| Dibenz(a,h)anthracene | 1460.0 | 63.4 | **23.0** |
| Fluoranthene | 13600.0 | 600 | **22.7** |
| Fluorene | 858.8 | 19 | **45.2** |
| Naphthalene | 16.0 | 160 | 0.1 |
| Total PCBs (Sum of Congeners x 2) | 733.3 | 22.7 | **32.3** |
| Phenanthrene | 4890.0 | 240 | **20.4** |
| Pyrene | 10100.0 | 665 | **15.2** |
| | | | |
| Total Polycyclic Aromatic Hydrocarbons | 81700.0 | 4022 | **20.3** |
| | | | |
| p,p'-DDE | 13.6 | 2.2 | **6.2** |
| | | | |
| Arsenic | -- | 8.2 | -- |
| Cadmium | 1.0 | 1.2 | **0.8** |
| Chromium | 195.0 | 81 | **2.4** |
| Copper | 262.3 | 34 | **7.7** |
| Lead | 201.1 | 46.7 | **4.3** |
| Mercury | -- | 0.15 | -- |
| Nickel | 167.9 | 20.9 | **8.0** |
| Silver | 13.8 | 1 | **13.8** |
| Zinc | 1231.4 | 150 | **8.2** |

[1] Quinn et al., 1994



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## TABLE B2-4. PROPOSED DERECKTOR SHIPYARD OFFSHORE COCs*

| CONSTITUENT | Maximum Onshore HQ | Maximum Offshore HQ |
|---|---|---|
| <u>PAHs</u> | | |
| Benzo(a)anthracene | **3.2** | **40.6** |
| Benzo(a)pyrene | **2.1** | **11.0** |
| Chrysene | **2.2** | **16.6** |
| Fluoranthene | **1.8** | **22.7** |
| Phenanthrene | **3.2** | **20.4** |
| Pyrene | **4.1** | **15.2** |
| 2-Methylnaphthalene | | **0.8** |
| Acenaphthene | | **12.1** |
| Acenaphthylene | | **19.7** |
| Anthracene | | **39.4** |
| Fluorene | | **45.2** |
| Naphthalene | | 0.1 |
| Dibenz(a,h)anthracene | | **23.0** |
| Total Polycyclic Aromatic Hydrocarbons | | **20.3** |
| p,p'-DDE | | **6.2** |
| Total PCBs (Sum of Congeners x 2) | | **32.3** |
| <u>Metals</u> | | |
| Arsenic | **6.7** | – |
| Cadmium | 0.5 | **0.8** |
| Chromium | **8.6** | **2.4** |
| Copper | **152.4** | **7.7** |
| Lead | **53.5** | **4.3** |
| Mercury | **0.9** | – |
| Nickel | **65.1** | **8.0** |
| Silver | 0.0 | **13.8** |
| Zinc | **13.8** | **8.2** |
| Total Butyltins | ** | |

* bolded values = HQ's > 0 7

**special contaminant of concern

Table B2-2. Target ecological systems/species/receptors of concern for Derecktor Shipyard.

| Habitat | Ecological System/Species/Receptor of Concern |
| --- | --- |
| Pelagic | blue mussel (*Mytilus edulis*)[1]<br>mummichog (*Fundulus* spp.)<br>winter flounder (*Pseudopleuronectes americanus*)[2] |
| Epibenthic | blue mussel[3]<br>lobster (*Homarus americanus*) |
| Benthic | hard shell clam (*Mercenaria mercenaria*)<br>soft shell clam (*Mya arenaria*)<br>benthic community |
| Avian Predator | osprey (*Pandion haliaetus*)<br>herring gull (*Larus argentatus*)<br>red-breasted merganser (*Mergus serrator*)<br>great blue heron (*Ardea herodias*) |

[1]surrogate for pelagic species when collected from mid-upper water column (e.g. mooring floats)
[2]present abundances of this species do not permit their collection for this study.
[3]representative of epibenthic species when collected from bottom substrate.

Table B2-3. Assessment and measurement endpoints

| Assessment Endpoint | Receptor of Concern | Measurement Endpoint |
|---|---|---|
| Habitat Quality | Critical habitats | Spatial distribution of habitats |
| Sediment Quality | Infaunal receptors<br>Epifaunal receptors | o Bulk sediment toxicity to amphipods (10-day mortality)<br>o Pore water toxicity to sea urchin gametes (sperm cell test)<br>o Benthic community structure (diversity, numbers)<br>o Abundance and condition of target receptor species |
| Water Quality | Pelagic receptors<br>Epifaunal receptors | o Abundance and condition of indigenous mussels<br>o Water toxicity to sea urchin gametes (sperm cell test)<br>o Abundance and condition of target receptor species |
| Status of Natural Resources | Resource species | o Abundance and condition of target receptor species<br>o Abundance and condition potential prey species<br>o Bioaccumulation and trophic transfer |

Table B2-4 Exposure point measurements for Derecktor Shipyard.

| Exposure Medium/ Receptor | Exposure Point Measurement |
|---|---|
| Sediment | o Bulk sediment and pore water chemistry<br>o Redox potential discontinuity<br>o Geotechnical characteristics (*e.g.*, grain size, water content)<br>o Ammonia<br>o Organic carbon<br>o SEM/AVS<br>o Pathogen abundance[1] |
| Water | o Water column chemistry (deployed mussel tissue residues)<br>o Dissolved oxygen, ammonia concentration<br>o Hydrographic parameters (temperature, salinity)<br>o Pathogen abundance[1] |
| Biota | o Tissue chemistry<br>o Pathogen abundance[1] |

[1]Total/fecal coliforms, male-specific bacteriophage, *Clostridium perfringens*

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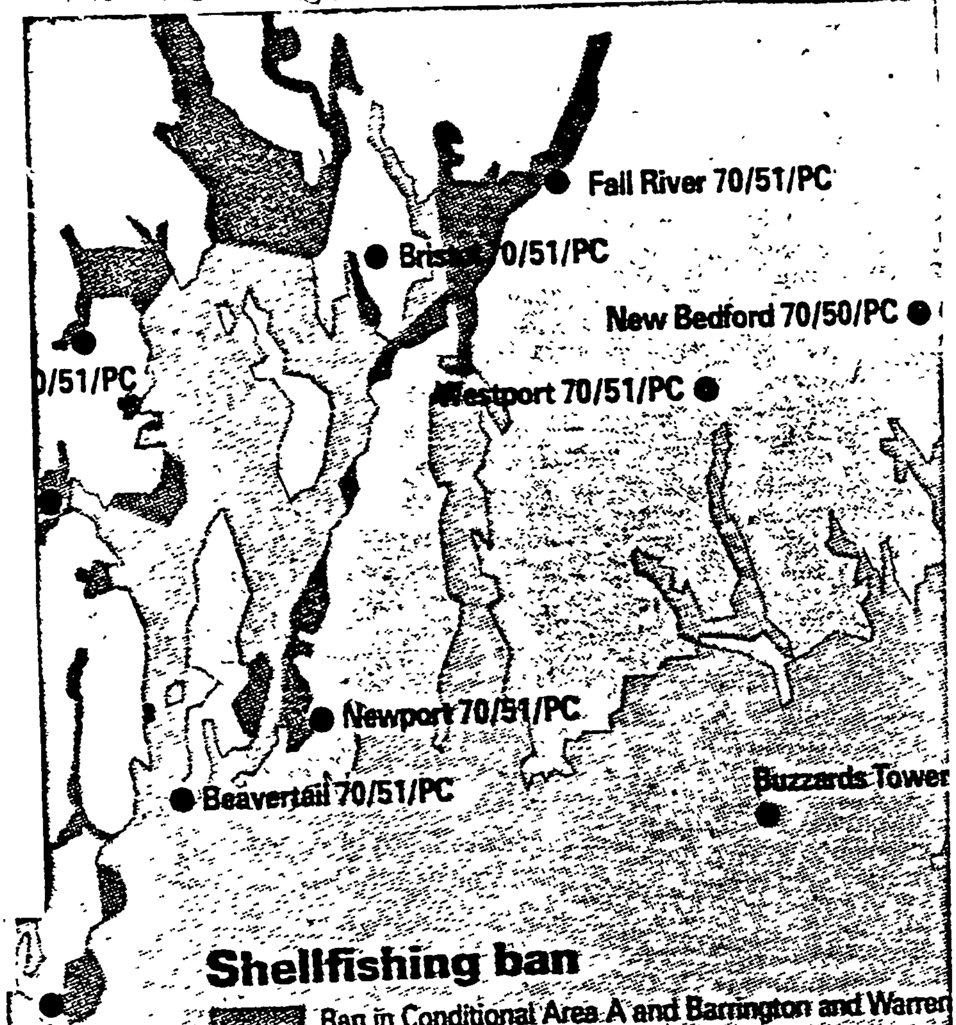


## Shellfishing ban

Ban in Conditional Area A and Barrington and Warren Rivers until sunrise Monday, July 3. Greenwich Bay closed for management reasons until Dec. 13. For up-to-date information call 277-2900 or 1-800-256-6500.

Figure 3. Geometric Mean Densities of Microbial Indicators in WWTPs

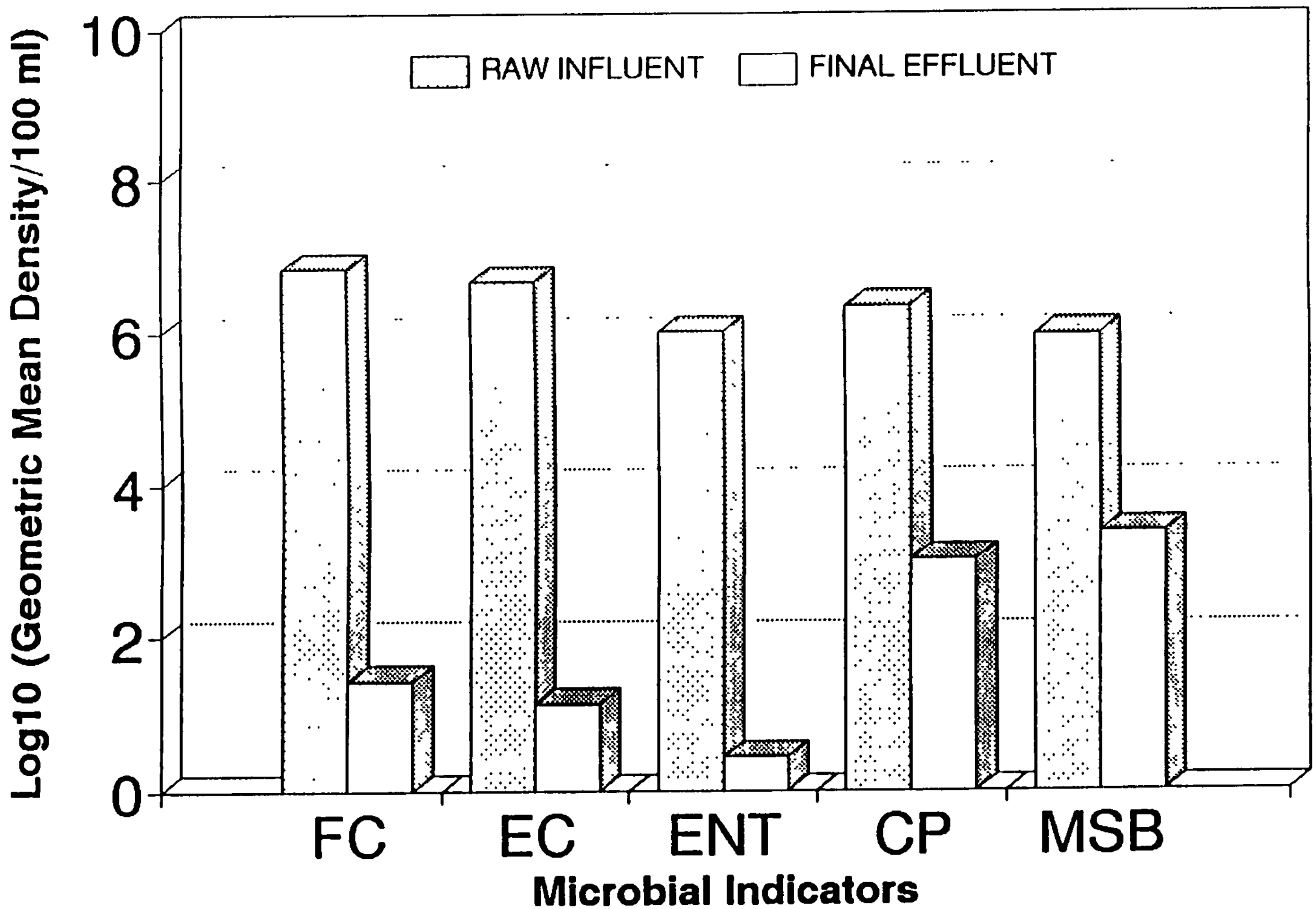


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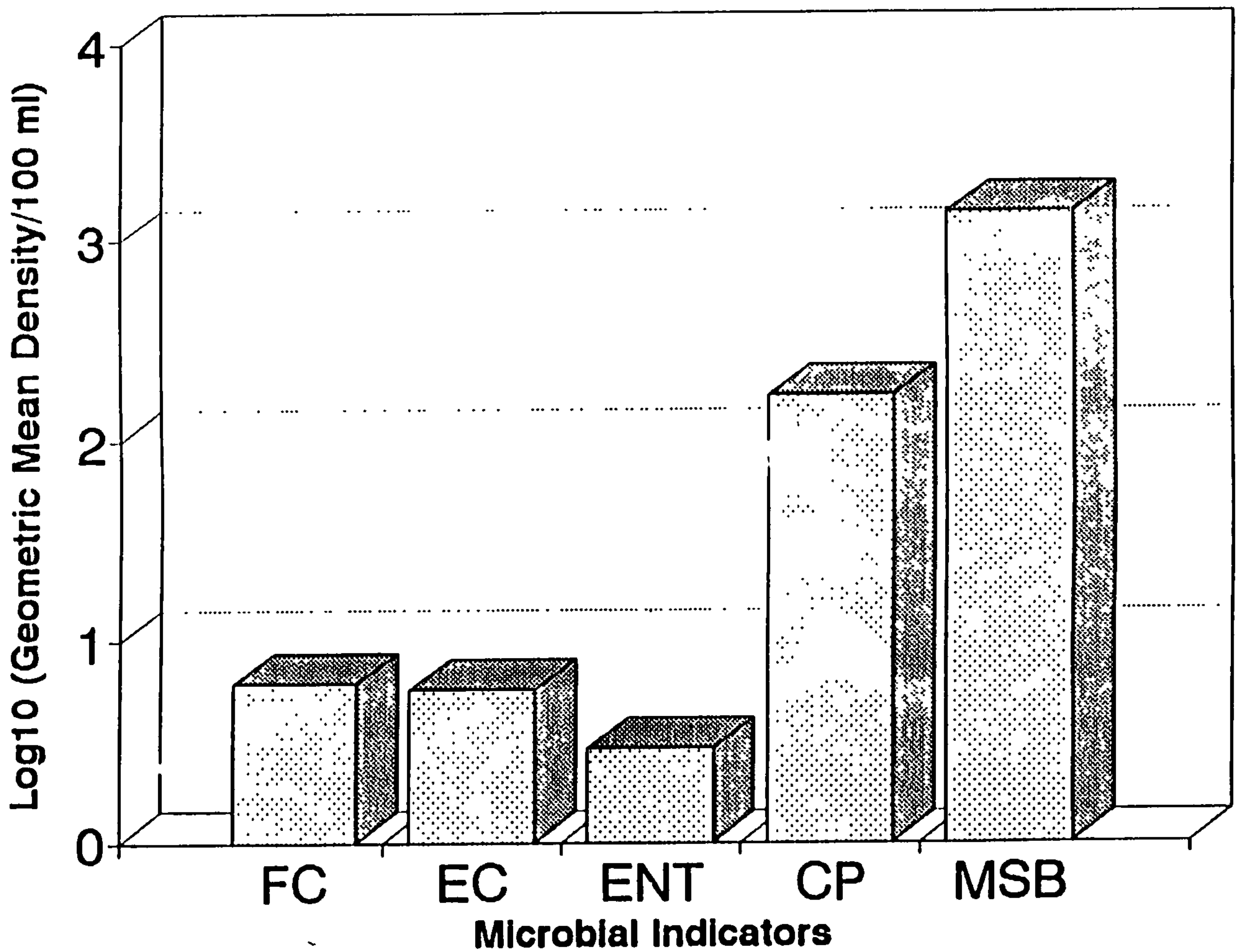
Figure 6. Geometric Mean Densities of Microbial Indicators in Receiving Waters



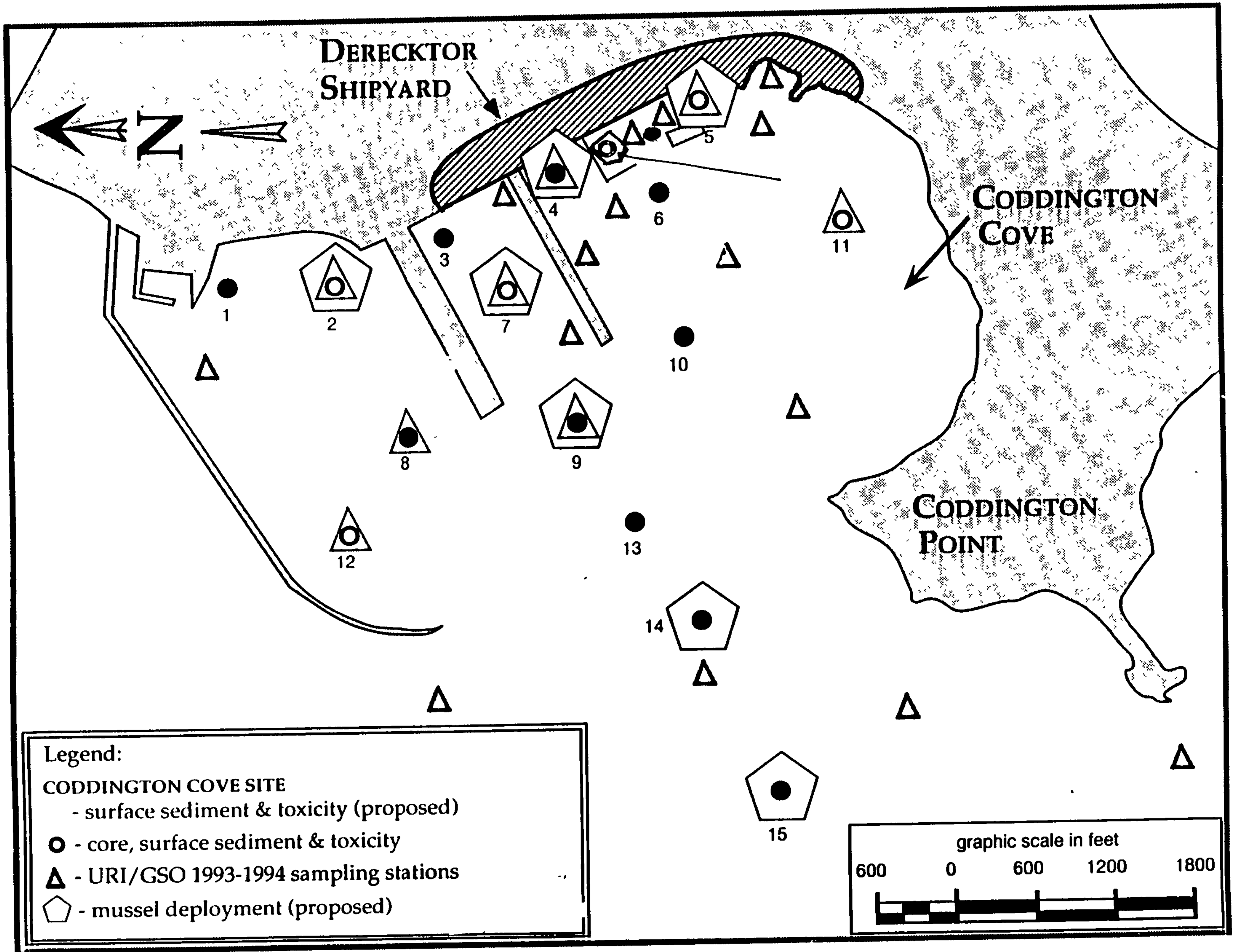



FIGURE B4-1. PROPOSED PHASE II URI/SAIC SAMPLING LOCATIONS.

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Table B4-1. Proposed stations and rationale for selection. Refer to Figure B4-1 for station locations.

| Rationale for Selection | Station Numbers |
|---|---|
| A. SURFACE SAMPLING STATIONS | |
| 1. High metals, high PCBs (GSO) | 7 |
| 2. High metals, high PCBs and high PAHs (GSO) | 2, 4, 5, 8 |
| 3. Eliminate data gap near contaminated station (GSO) | 1, 3, 6, 10 |
| 4. Eliminate data gap (GSO) | 11, 12 |
| 5. Stations needed to define environmental gradient (GSO) | 9, 13, 14, 15 |
| 6. Reference stations Potter Cove Jamestown | 16, 17, 18 |
| B. DEEP CORE SAMPLING STATIONS | |
| 1. High metals, high organics (GSO) | 2, 5, 7 |
| 2. Establish historical trends and determine contaminant accumulation (GSO) | 11, 12 |

## Table B4-2. NETC Derecktor Shipyard Sample Collection and Analysis Summary

| | | | | | Bioassay (a) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| MATRIX | LOC | STA | Chemistry (a) | Geo-technical | Mussel Deployment | MICRO | AMP | DIV | CI | ARB |
| SEDIMENT | CC | 1' | G | G | | G | G | | | G |
| | CC | 2 | G,C | G,C | | | G | | | G |
| | CC | 3 | G | G | | | G | | | G |
| | CC | 4 | G | G | | | G | | | G |
| | CC | 5 | G,C | G,C | | G | G | | | G |
| | CC | 6 | G | G | | | G | | | G |
| | CC | 7 | G,C | G,C | | G | G | | | G |
| | CC | 8 | G | G | | | G | | | G |
| | CC | 9 | G | G | | G | G | | | G |
| | CC | 10 | G | G | | | G | | | G |
| | CC | 11 | G,C | G,C | | | G | | | G |
| | CC | 12 | G,C | G,C | | | G | | | G |
| | CC | 13 | G | G | | G | G | | | G |
| | CC | 14 | G | G | | | G | | | G |
| | CC | 15 | G | G | | G | G | | | G |
| | PC | S1 | G | G | | | G | | | G |
| | PC | M1 | G | G | | G | G | | | G |
| | CH | S1 | G | G | | G | G | | | G |
| | CH | M1 | G | G | | G | G | | | G |
| TISSUE | CC | 1 | BM,DBM,LOB | | | BM | | D | DBM, MF, HN | |
| | CC | 2 | BM, MF | | X | | | D | DBM, MF, HN | |
| | CC | 3 | BM,(DBM) LOB | | | BM | | D | DBM, MF, HN | |
| | CC | 4 | BM, MF, LOB | | X | | | D | DBM, MF, HN | |
| | CC | 5 | BM,(DBM) MF, LOB | | X | BM | | D | DBM, MF, HN | |
| | CC | 6 | HC, MF | | | | | D | DBM, MF, HN | |
| | CC | 7 | HC, MF | | X | HC | | D | DBM, MF, HN | |
| | CC | 8 | HC | | | | | D | DHC | |
| | CC | 9 | HC, LOB | | X | HC | | D | DHC | |
| | CC | 10 | HC (DHC) | | | | | D | DHC | |
| | CC | 11 | HC, DHC | | | | | D | DHC | |
| | CC | 12 | HC, DHC, LOB | | | HC | | D | DHC | |
| | CC | 13 | LOB | | | | | D | DHC | |
| | CC | 14 | LOB | | X | | | D | DHC | |
| | CC | 15 | HC, LOB | | X | HC | | • | DHC | |
| | PC | S1 | BM, MF | | | BM | | D | DHC | |
| | PC | M1 | HC | | | HC | | D | DHC | |
| | PC | D1 | LOB | | | | | D | DHC | |
| | CH | S1 | BM,MF | | | BM | | D | DBM | |
| | CH | M1 | HC,LOB | | | HC | | D | DHC | |

**CODES:**

G = Grab sample
C = Piston Core
AMP = Amphipod Test
ARB = Arbacia Test
Micro = Sewage Pathogens
MD = Mussel Deployment
PC = Potter Cove, Jamestown

CI = Bivalve Condition Index
CH = Castle Hill (So Aquidneck Island)
BM = Blue Mussel, DBM = Depurated Blue Mussel
HC = Hard Clam, DHC = Depurated Hard Clam
LOB = Lobster
MF = Mummichog Fish
D = Community Structure Analysis
CC = Coddington Cove, NETC

[a] Biota samples for Chemistry and biology dependent on availability
• Sample excluded due to atypical sediment charcteristics (coarse sand)

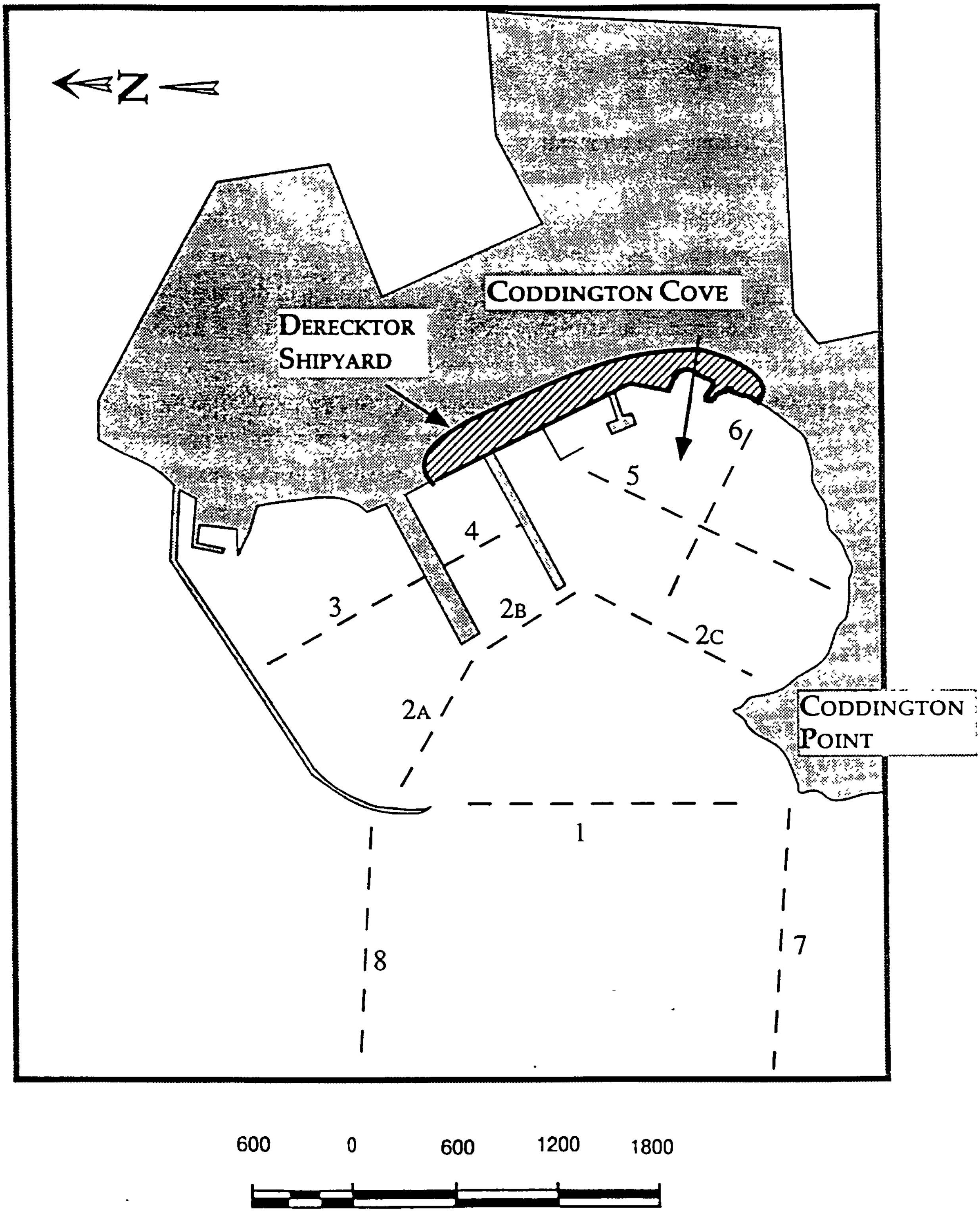
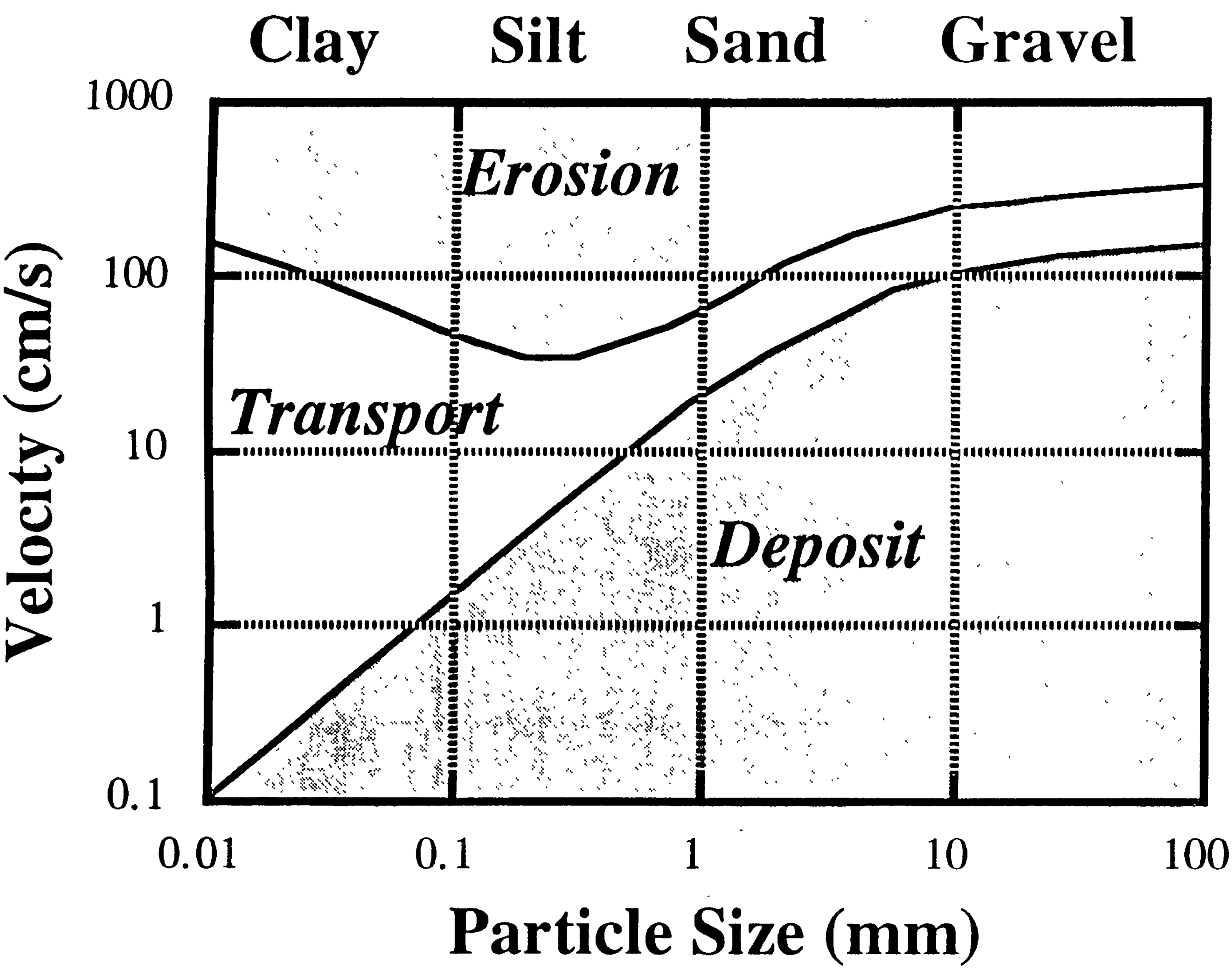



**Figure B4-2: Derecktor Shipyard ERA hydrographic survey lines.**



Clay
Silt
Sand
Gravel
Erosion
Transport
Deposit
Velocity (cm/s)
1000
100
10
1
0.1
0.01
0.1
1
10
100
Particle Size (mm)

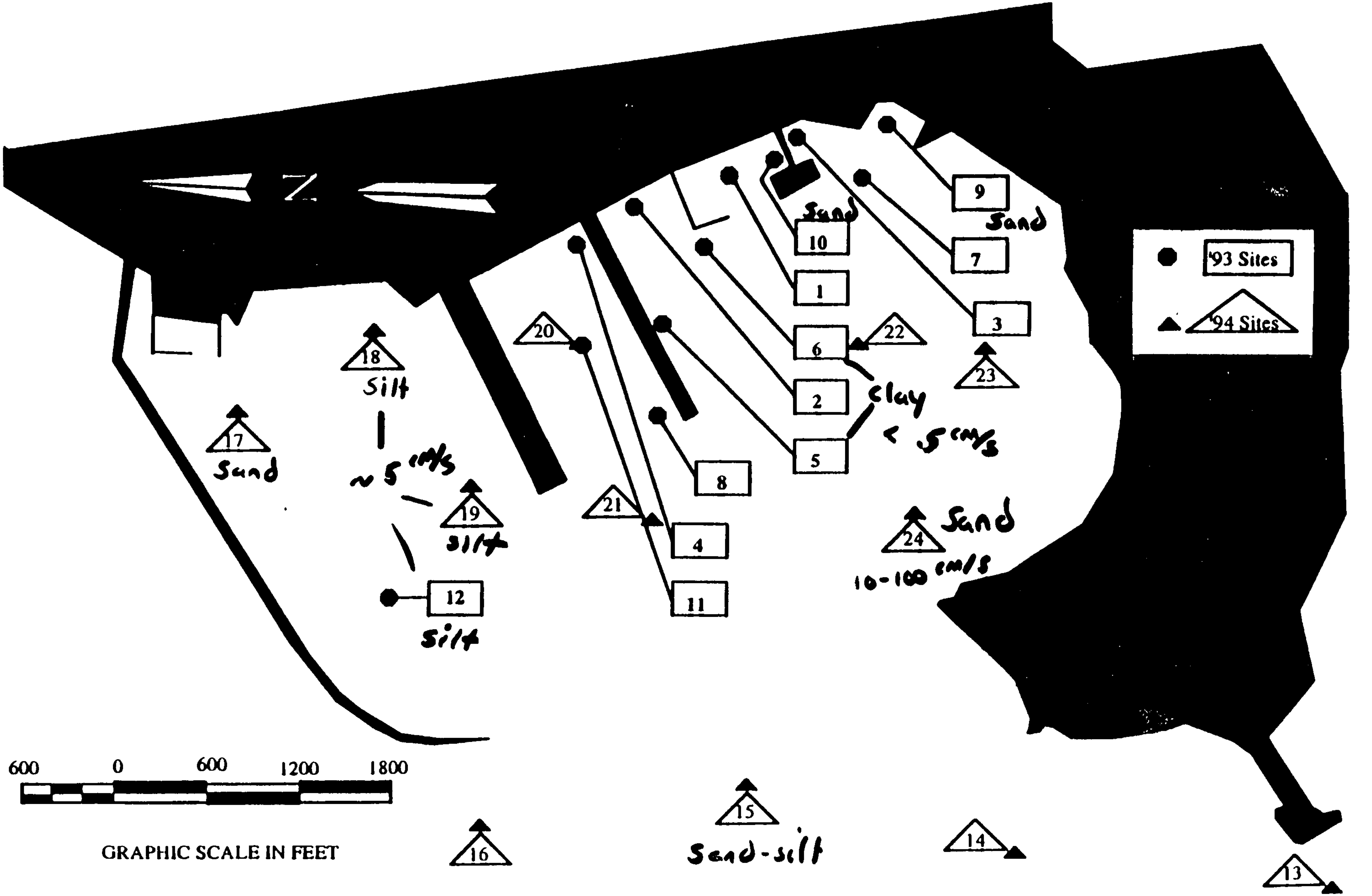



Figure 1. Coddington Cove Site Locations

Bay mean ~ 30 cm/sec ; Velocities are Transport-Deposition Thresholds

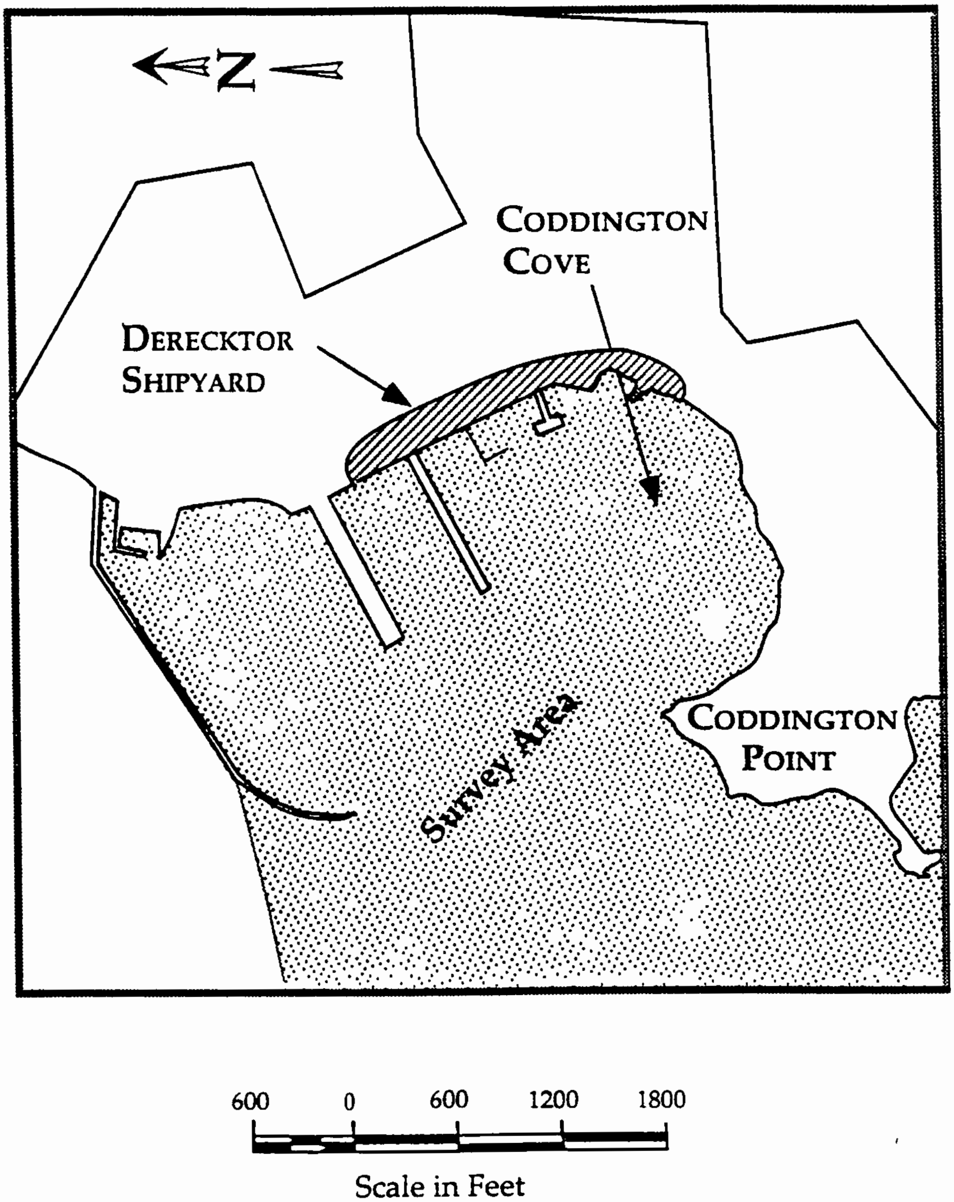



**FIGURE B4-3. DERECKTOR SHIPYARD ERA GEOPHYSICAL SURVEY AREA**

# UPCOMMING SUBMITTALS

# NETC ECORISK AND RELATED STUDIES

## OFF SHORE ECORISK WORK PLAN

- Responses to RIDEM Comments to Addenda B & C: **June 30, 1995**
- Final Off Shore Master Work Plan and Addenda A - McAllister Point: **July 30, 1995**
- Draft Final Addenda B - Derecktor Shipyard and C - Old Fire Fighting Training Area: **July 30, 1995**
- Regulatory Concurrence on Addenda B & C: **August 30, 1995**
- Final Addenda B and C: **September 30, 1995**

## SASE WORK PLAN AND ON SHORE STUDIES

- Responses to Comments to the Draft SASE Work Plan: **July 30, 1995**
- Draft Final SASE Work Plan: **September 15, 1995**
- Regulatory Concurrence: **October 15, 1995**
- Final SASE Work Plan: **November 15, 1995**

# ATTACHMENT C

# DISCUSSIONS ON OUTSTANDING TECHNICAL ISSUES

To: Bob Krivinskas, NORTHDIV
From: Greg Tracey, SAIC
Subject: Revised Sampling Plan Proposal and Justification
Date: 10 July 1995

As a result of issues raised by EPA and RIDEM at the EcoRisk Advisory Board (ERAB) meeting of 28 June, additional information and clarification on our sampling plan for Derecktor shipyard was distributed to EPA (Susan Svirsky) and RIDEM (Bob Richardson) for review and comment. A summary of these issues as well as revised sampling maps and rationale are provided below. Both EPA and DEM have indicated concurrance with the changes.

**Issue Resolutions**

1. *Fish target species selection.* The habitat in the vicinity of McAllister Pt and potentially Coddington Cove does not appear to support mummichog populations. We have had some success, however, in collecting small, 5-20 cm cunner (*Tautogolabrus adspersus*). Based on the Bigelow and Schroeder description (attached), this species would appear to be a suitable substitute for mummichogs as a target species for candidates for exposure/effects assessment, i.e. they are omnivorous, territorial, bottom dwellers, and amenable to conventional collection techniques.

2. *Biota sampling distribution.* A revised sample redistribution was agreed upon which required elimination of depurated bivalve samples in favor of other samples to provide better sample coverage without greatly expanding the overall sample numbers. (Depurated bivalve data is now less necessary given that there now exists an extensive data set on depurated and non-depurated bivalves for both Allen Harbor and McAllister Point. These data provide the necessary information to extrapolate results for non-depurated samples to depuration values when necessary.) It was acknowleged that there is uncertainty as to whether indigeneous biota will be available at the selected locations, and as with other studies, we would intend to relocate stations so as to be sure that the best, most extensive database is available.

A sampling and analysis summary of chemistry and biota sampling by station is included in Table 1. In the paragraphs below, maps for sampling of each target receptor are discussed along with separate justification for each. The distribution of sediment sampling locations investigated during the URI (1994) study is shown in Figure 1. The following discussion describes the location of biota sampling for the Derecktor Shipyard ERA. In each case, the biota sampling location is paired with a sediment sampling location (closed and open circles) so as to allow exposure-response relationships to be investigated.

- *Epibenthic Receptors (Indigenous Blue mussels).* Natural populations of blue mussels *(Mytilus edulis)* will be collected at harbor front stations 25-29 to characterize long-term exposure and effects on epibenthic populations in the immediate vicinity of Derecktor Shipyard. In addition, 3 additional samples will be collected shoreward of stations 35, 36 and URI (1994) station 24, to characterize the nearshore environment where epibenthic scavengers and birds may have more active feeding (Fig. 2). (These latter stations replace depurated blue mussel samples). The environment above the sediment water interface is entirely artificial, consisting of docks/piers and concrete abutments. Collections will be made at low tide by hand-picking of specimens off the structures. Collections of indigenous mussels are also planned for intertidal areas at the two reference sites.

- *Infaunal/epibenthic Receptors (Hard Shell Clams).* Natural populations of hard shell clams *(Mercenaria mercenaria)* will be collected at offshore stations 31-36 and 38 to characterize long-term exposure and effects on infaunal/epibenthic populations in Coddington Cove away from the immediate vicinity of Derecktor Shipyard water front (Fig. 3). One additional station will be attempted in the "dead zone" area, and if unsuccessful, will be relocated to the vicinity of station 30. No depuration bivalve samples will be performed. Collections of hard shell clams are also planned for deep areas at the two reference sites.

- *Fish populations.* Natural populations of mummichogs and/or cunner (pending approval) will be collected at harbor front stations 26, 28, 29, 31 and 34 as well as shoreward of stations 35 and 36, to characterize the nearshore environment where avian predators may have more active feeding (Fig. 4). Collections of fish are also planned for intertidal areas at the two reference sites.

- *Epibenthic scavengers.* Natural populations of the american rock lobster (*Homarus americanus*) are planned for 9 stations in Coddington Cove + 2 reference sites (Fig. 5). Traps will be deployed at harbor front stations 25, 27, 28, 29; at central Coddington Cove stations 33, 35 and 36, and at Outer Coddington Cove stations 38 and 39. Collections of lobsters are also planned for intertidal areas at the two reference sites.

- *Pelagic Exposure pathways.* Blue mussels will be deployed at 1 m above bottom at 8 stations in Coddington Cove and at 2 reference sites (Fig. 6). The strategy is to characterize harbor front water quality conditions via stations 26 , 28, 29 and between the new "dead zone" stations 40 and 41 as well as the gradient in water quality extending out of the harbor via stations 31, 33, 38 and 39. (The figure shows station 40 as the site; precise locationing will depend on logistical considerations such as vessel traffic, etc). Mussel deployments are also planned for deep areas at the two reference sites.

*3. Fate and transport investigations.* Fate and transport issues at Derecktor Shipyard include potential impacts of hypoxia and contributions of contaminants and nutrients from sources out of Coddington Cove. Specific attention will be merited to the "dead zone" along the water front, with the objective that the results of the study be able to conclusively implicate or rule out Navy-related contaminant input as the primary stressor to this area. Because weight of evidence must support this conclusion and that hypoxia impacts are a plausible alternative hypothesis to contaminant impacts as the primary effects mechanism, water circulation and oxygen dynamics studies are required.

The preferred approach is to augment standard $O_2$ measurements in Coddington Cove (done in conjunction with mussel deployments) with the data necessary to model $O_2$ concentrations under various scenarios (particulary water tempearture and stratification) so as to provide a more comprehensive assessment that could otherwise be provided by point estimates. These data will include estimates of flushing/residence times within the various harbor areas derived from the circulation study, and water (BOD/COD) and sediment (SOD) oxygen demand measurements at selected sediment sampling locations (stations 26, 30-33, 35 and reference sites; Table 1).

Sediment core samples will be taken at each station and incubated with overlying site water at bay temperature ($\sim$20-22 °C) and low light (15-30 $\mu$E $m^{-2}$ $s^{-1}$). Time series oxygen measurements are taken to develop a curve of $O_2$ uptake for the station. Similarly, water samples are taken at 10 day intervals over a month at each SOD station. Data on oxygen demand as well as salinity distributions and residence time will be entered into the EPA WASP model to calculate/predict water column (surface/bottom) $O_2$ concentrations.

The Newport outfall dye study model and other existing data will be reviewed to assess inputs from the Newport CSO as a potential source of BOD to Coddington Cove. Analyses of waters, sediments and indigenous biota for pathogens will not be performed because of the difficulties in interpretation. However, measurement of tissue pathogen concentrations in deployed mussels will continue. The proposed deployment strategy for mussels being near outfall pipes along the waterfront as well as along a gradient extending from the harbor front outward towards Narragansett Bay will provide data to support this assessment.

Circulation studies will be conducted as proposed, from which contour maps of water velocities for characterization of sediment transport potential across the cove will be derived. Geophysical surveys and point estimate chemistry and grain size measurements will allow the construction of maps depicting soft sediment distribution across the harbor and with depth. From these data, characterization of contaminated sediment distribution and transport potential will be elucidated.

*4. Depth of sediment sampling.* Sampling for chemistry and toxicity testing at "surface" sediment sampling sites will consist of a composite the top 20 cm of sediment. Because typical grab samplers (e.g. Van Veen, Smith-MacIntyre, Ponar) will not sample to this depth, it will be necessary to take multiple short core samples (approximately 3-5) to obtain the required volumes for testing purposes. The material from each core will be combined and mixed aboard ship, after which the composited material will be subsampled to obtain the sample material for various analytical fractions (organics, metals, sediment toxicity, elutriate toxicity and chemistry, grainsize/TOC).

*5. Elutriate testing.* Elutriate toxicity testing will be performed and will be substituted for the pore water measurement. Analysis of elutriate water chemistry will be substituted for porewater chemistry in order to keep the exposure-effects data paired. In addition, organics on elutriate water would be possible since sufficient volumes are more easily generated. The elutriate test SOP will be submitted under separate cover. Sea urchins are among the recommended species, (although the Greenbook lists west coast species). hence testing will use our local species, A*rbacia punctulata*.

*6. MFO/P450 measurements.* Because extensive PAH bioaccumulation in fish is not typically observed (detoxification mechanisms breakdown and eliminate PAHs as they are accumulated), an indicator of PAH exposure other than tissue residues is required for the exposure assessment.

One such indicator is known as P450 activity. The cytochrome P450 system includes several families of heme proteins, enzymes, that catalyze detoxification reactions with foreign compound substrates. During these reactions, apolar (lipid-soluble) chemicals are converted to more water-soluble and readily excreted metabolites. This is accomplished through biotransformation involving oxidation by several monooxygenase reactions which are catalyzed by the cytochrome P450 system. In the environment, teleosts are exposed to aromatic contaminants such as PCBs, dioxins, and aromatic hydrocarbons, capable of inducing hepatic cytochrome P450 monooxygenase activity. The response of this enzyme system is well established in both freshwater and marine fish exposed to a variety of contaminants has been evaluated in a number of laboratory and field studies (see Table 2). Results from these studies have indicated that this enzyme system responds rapidly, at very low levels of exposure, and is highly correlated with contaminant level in the environment.

Based on this information, P450 would appear to be a valuable exposure indicator for fish collected in the Derecktor Shipyard ERA. Thus, the measurement of P450 responses in fish collected at the same stations as those collected for chemical analysis will be attempted. The data will be used cytochrome P450 measurements will be made on fish to infer PAH detoxification activity and also suggest potential adverse effects due the metabolic "overhead" of detoxification (reducing reproductive output, for example). The fish will be collected in conjunction with those collected for tissue residue and condition assessments.

**P450 References for Table 2.**

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Lindstrom-Seppa, P., Korytko, P.J., Hahn, M.E. & Stegeman, J.J. *Aquatic Toxicology*, **28**, 147-167, 1994.

## Dereckt r Shipyard Risk Assessment Sample Collection/Chemical Analysis Summary

| Sample ID | | Sediment Chemistry* | | | Tissue Chemistry* | | | | | Geotechnical | | Water | | Bioassay | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | STATION | Bulk Sediment | | Elutriate | Indig | Deployed | Hard | Lobster | Fish | | | BOD/COD | DO/NH4/ | | | | | | | |
| SITE | NO. | SUR | BOT | SUR | Mussel | Mussel | Clam | | | GS | TOC | SOD | TSS/CHL | HN | DIV | P450 | MICRO | AMP | CI | Elutriate |
| CC | 24 | | | | 1 | | | | | | | | | | | | | | | |
| CC | 25 | 1 | | 1 | 1 | | | 1 | | 1 | 1 | | | 1 | 1 | | | 1 | 2 | 1 |
| CC | 26 | 1 | 2 | 1 | 1 | 1 | | | 1 | 3 | 3 | 1 | 3 | 1 | 1 | 1 | 1 | 1 | 3 | 1 |
| CC | 27 | 1 | | 1 | 1 | | | 1 | | 1 | 1 | | | 1 | 1 | | | 1 | 2 | 1 |
| CC | 28 | 1 | | 1 | 1 | 1 | | 1 | 1 | 1 | 1 | | 3 | 1 | 1 | 1 | 1 | 1 | 4 | 1 |
| CC | 29 | 1 | 2 | 1 | 1 | 1 | | 1 | 1 | 3 | 3 | | 3 | 1 | 1 | 1 | 1 | 1 | 4 | 1 |
| CC | 30 | 1 | | 1 | | | | | | 1 | 1 | 1 | | 1 | 1 | | | 1 | 0 | 1 |
| CC | 31 | 1 | 2 | 1 | | 1 | 1 | | 1 | 3 | 3 | 1 | 3 | | 1 | 1 | 1 | 1 | 3 | 1 |
| CC | 32 | 1 | | 1 | | | 1 | | | 1 | 1 | 1 | | 1 | 1 | | | 1 | 1 | 1 |
| CC | 33 | 1 | | 1 | | 1 | 1 | 1 | | 1 | 1 | 1 | 3 | 1 | 1 | | 1 | 1 | 3 | 1 |
| CC | 34 | 1 | | 1 | | | 1 | | 1 | 1 | 1 | | | | 1 | | | 1 | 2 | 1 |
| CC | 35 | 1 | 2 | 1 | 1 | | 1 | 1 | 1 | 3 | 3 | 1 | | | 1 | 1 | | 1 | 4 | 1 |
| CC | 36 | 1 | 2 | 1 | 1 | | 1 | 1 | 1 | 3 | 3 | | | 1 | 1 | 1 | | 1 | 4 | 1 |
| CC | 37 | 1 | | 1 | | | | | | 1 | 1 | | 3 | | 1 | 1 | 1 | 1 | 0 | 1 |
| CC | 38 | 1 | | 1 | | 1 | 1 | 1 | | 1 | 1 | | 3 | | 1 | | 1 | 1 | 3 | 1 |
| CC | 39 | 1 | | 1 | | 1 | | 1 | | 1 | 1 | | | | 1 | | | 1 | 2 | 1 |
| CC | 40 | 1 | | 1 | | 1 | | | | 1 | 1 | | 3 | | 1 | | 1 | 1 | 1 | 1 |
| CC | 41 | 1 | 2 | 1 | | | 1 | | | 3 | 3 | | | | 1 | | | 1 | 1 | 1 |
| JPC | 1 | 1 | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 3 | | 1 | 1 | 1 | 1 | 5 | 1 |
| CHC | 1 | 1 | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 3 | | 1 | 1 | 1 | 1 | 5 | 1 |
| T0 | | | | | | 1 | | | | | | | | | | | 1 | | | |
| TOTAL. | | 19 | 12 | 19 | 10 | 11 | 10 | 11 | 9 | 31 | 31 | 8 | 30 | 9 | 19 | 9 | 11 | 19 | 49 | 19 |

| | |
|---|---|
| Group Totals | 101 |
| QA/QC | 20 |
| Total. | 121 |

JPC = Potter Cove, Jamestown
CC = Coddington Cove, NETC
CHC = Castle Hill (So Aquidneck Island)

GS = Grain Size
TOC = Total organic carbon

*Chemistry analytes described in URI and SAIC, 1994

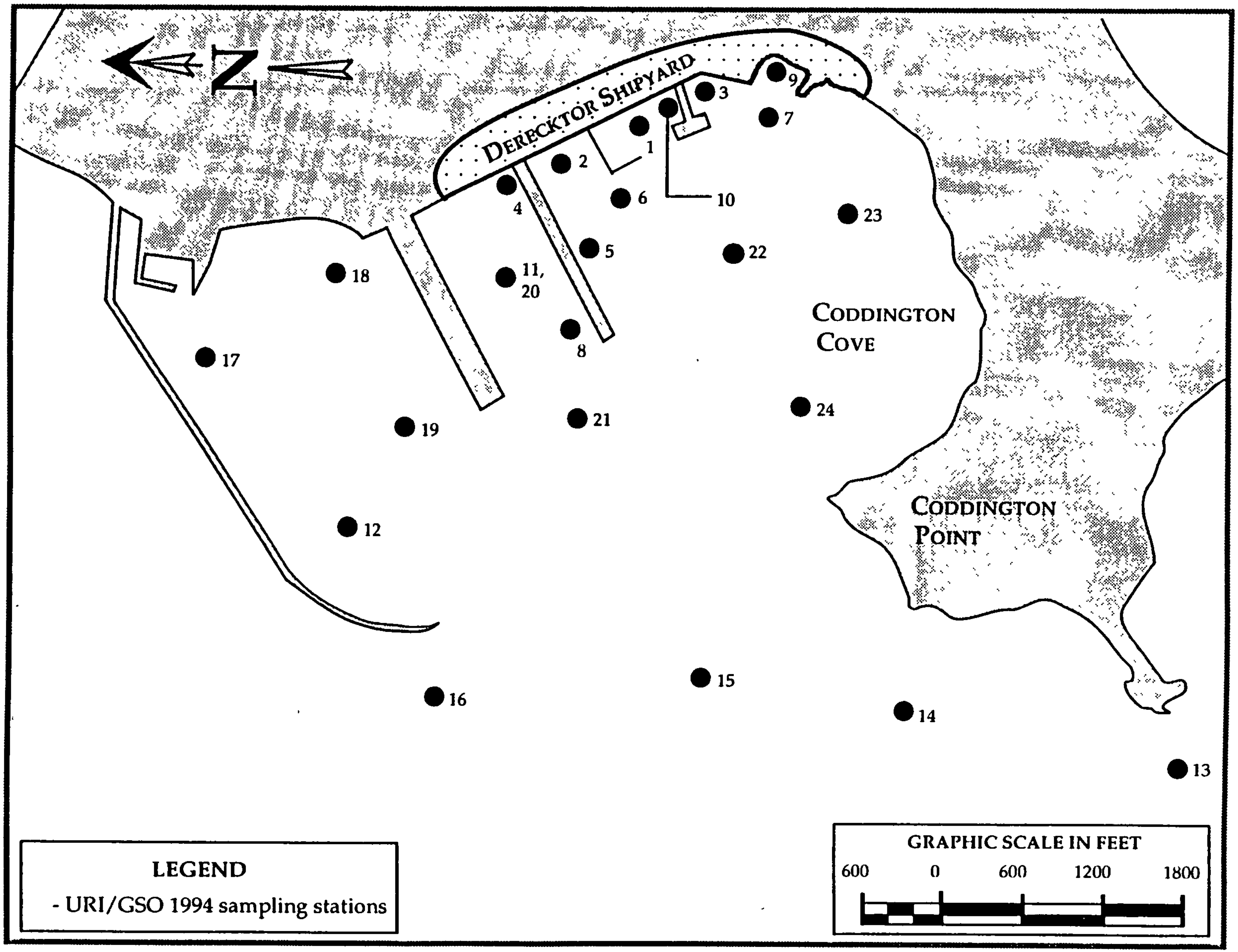
BOD/COD = Water column biological/ chemical oxygen demand
SOD = Sediment oxygen demand
DO/NH4 = Dissolved oxygen/ammonia
TSS/CHL = Total suspended solids/ Chlorophyll a

Micro = Sewage Pathogens in Mussel Tissue
DIV = Community Structure Analysis
P450 = Cytochrome P450 assay
AMP = Amphipod Test
CI = Bivalve Condition Index
Elutriate = Elutriate test with Arbacia

**Table 2. List of fish species which have been used in P-450 evaluations.**

| Common Name | Scientific Name | Citation | |
|---|---|---|---|
| Starry Flounder | *Platichthys stellatus* | Collier et al., 1989, | Stein et al , 1992 |
| Rock Sole | *Lepidopsetta bilineata* | Varanasi et al., 1990 | Stein et al., 1992 |
| English Sole | *Parophyrys vetulus* | Collier et al., 1989, 1991 | Stein et al , 1992 |
| Winter Flounder | *Pseudopleuronectes americanus* | Collier et al., 1989 | Monosson and Stegeman, 1991 |
| White Perch | *Morone americana* | Collier et al., 1989 | |
| Atlantic croaker | *Micropogonias undulatus* | Collier et al., 1989 | |
| White croaker | *Genyonemus lineatus* | Collier et al., 1989 | |
| Yellowfin sole | *Limanda aspera* | Varanasi et al., 1990 | |
| Flathead Sole | *Hippoglossus elassodon* | Varanasi et al., 1990 | |
| Pacific halibut | *Hippoglossus stenolepis* | Varanasi et al , 1990 | |
| Dolly Varden | *Salvelinus malma* | Varanasi et al., 1990 | |
| Rainbow trout | *Oncorhynchus mykiss* | Haasch et al., 1992, 1993 | van der Weiden, 1992 |
| Largemouth bass | *Micropterus salmoides* | Haasch et al., 1992, 1993 | |
| Killifish | *Fundulus heteroclitus* | Haasch et al., 1992, 1993 | |
| Atlantic cod | *Gadus morhua* | Goksor and Husoy, 1992 | Goksoyr et al. 1994 |
| Mirror carp | *Cyprinus carpio* | van der Weiden et al., 1993 | van der Weiden, 1992, 1994 |
| Fathead minnow | *Pimephales promelas* | Lindstrom-Seppa et al., 1994 | |
| Channel catfish | *Ictalurus punctatus* | Ronis et al., 1992 | |
| Rocky Mountain whitefish | *Prospium williamsoni* | Kloepper-Sams and Benton, 1994 | |
| Longnose sucker | *Catostomus catostomus* | Kloepper-Sams and Benton, 1994 | |
| Burbot | *Lota lota* | Kloepper-Sams and Benton, 1994 | |

Figure 1.


N
DERECKTOR SHIPYARD
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2
3
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6
7
8
9
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11,
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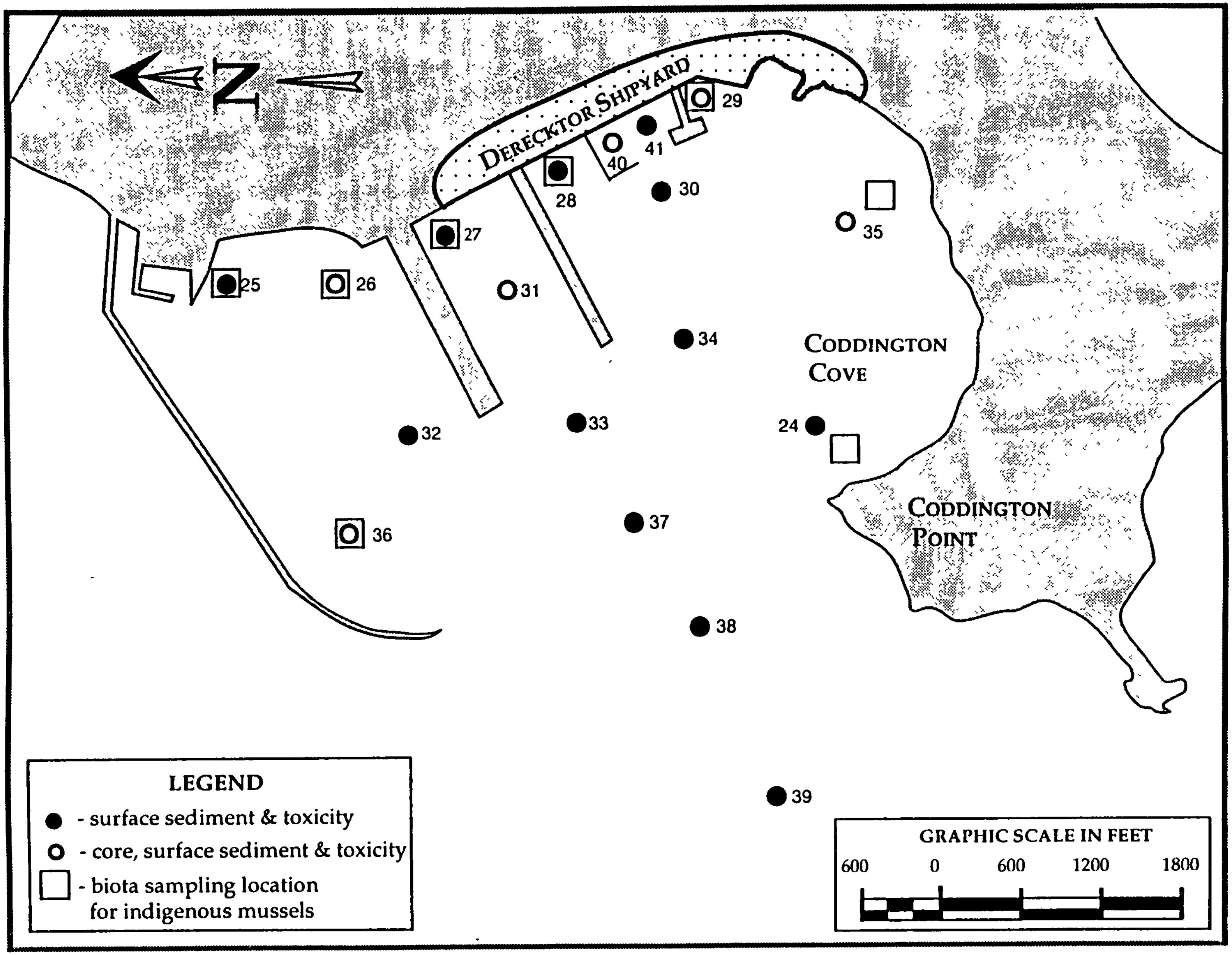
14
15
16
17
18
19
21
22
23
24
CODDINGTON
COVE
CODDINGTON
POINT
LEGEND
- URI/GSO 1994 sampling stations
GRAPHIC SCALE IN FEET
600
0
600
1200
1800

Figure 2.


N
DERECKTOR SHIPYARD
29
41
40
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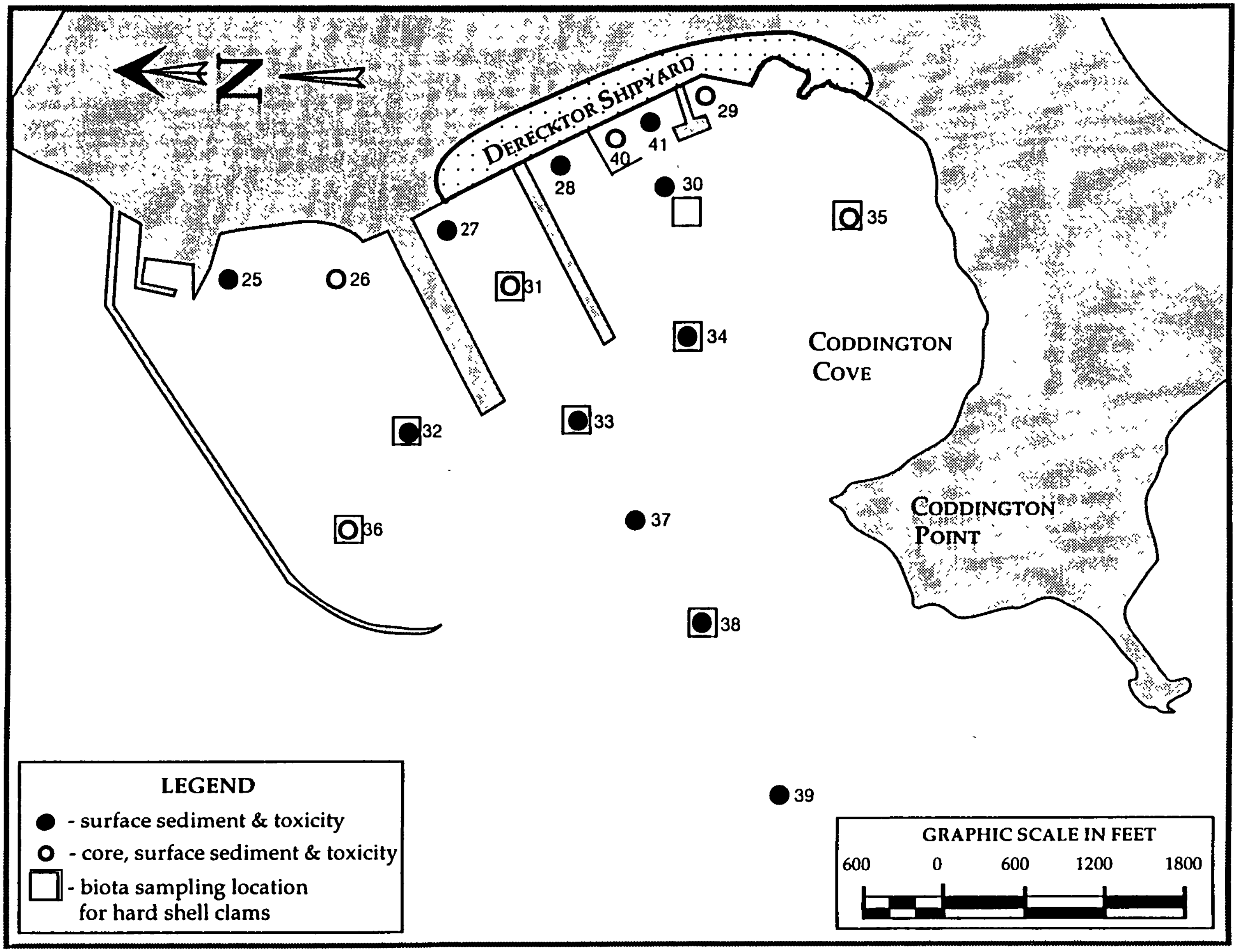
26
31
34
CODDINGTON
COVE
33
24
32
37
CODDINGTON
POINT
36
38
39
LEGEND
- surface sediment & toxicity
- core, surface sediment & toxicity
- biota sampling location
for indigenous mussels
GRAPHIC SCALE IN FEET
600
0
600
1200
1800

Figure 3


N
DERECKTOR SHIPYARD
25
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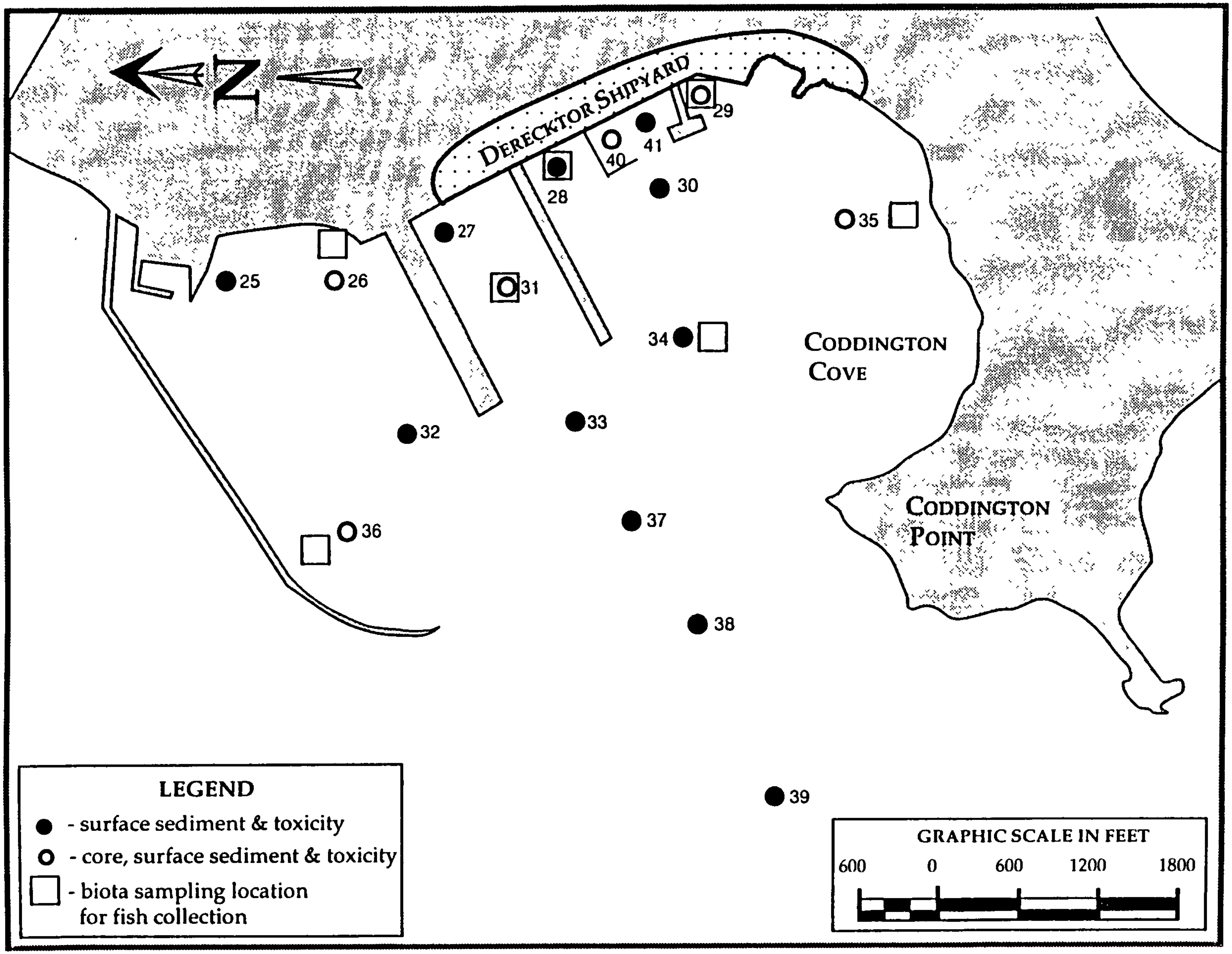
CODDINGTON COVE
CODDINGTON POINT
LEGEND
- surface sediment & toxicity
- core, surface sediment & toxicity
- biota sampling location for hard shell clams
GRAPHIC SCALE IN FEET
600
0
600
1200
1800

Figure 4.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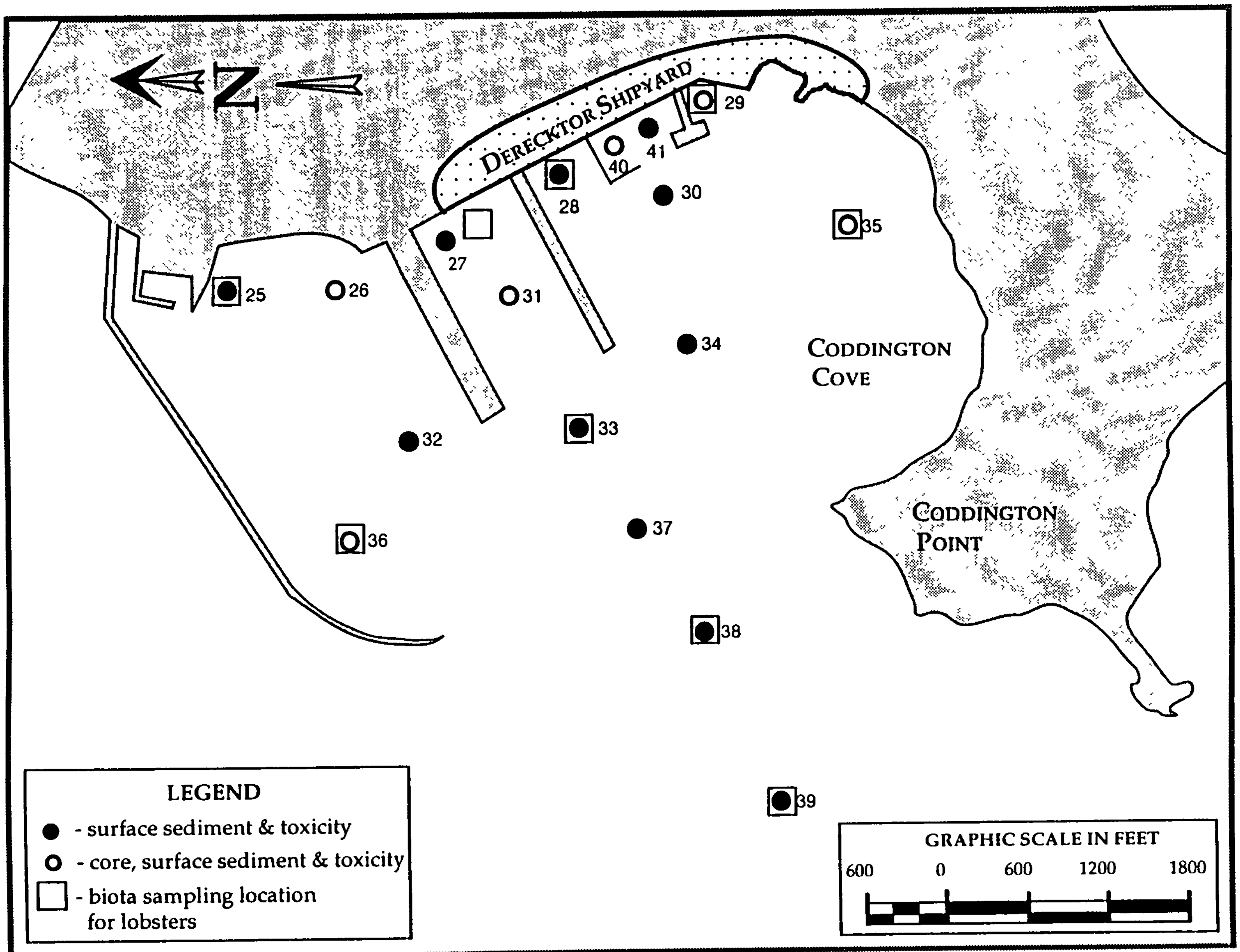
CODDINGTON COVE
CODDINGTON POINT
LEGEND
- surface sediment & toxicity
- core, surface sediment & toxicity
- biota sampling location for fish collection
GRAPHIC SCALE IN FEET
600
0
600
1200
1800

Figure 5.


N
DERECKTOR SHIPYARD
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CODDINGTON
COVE
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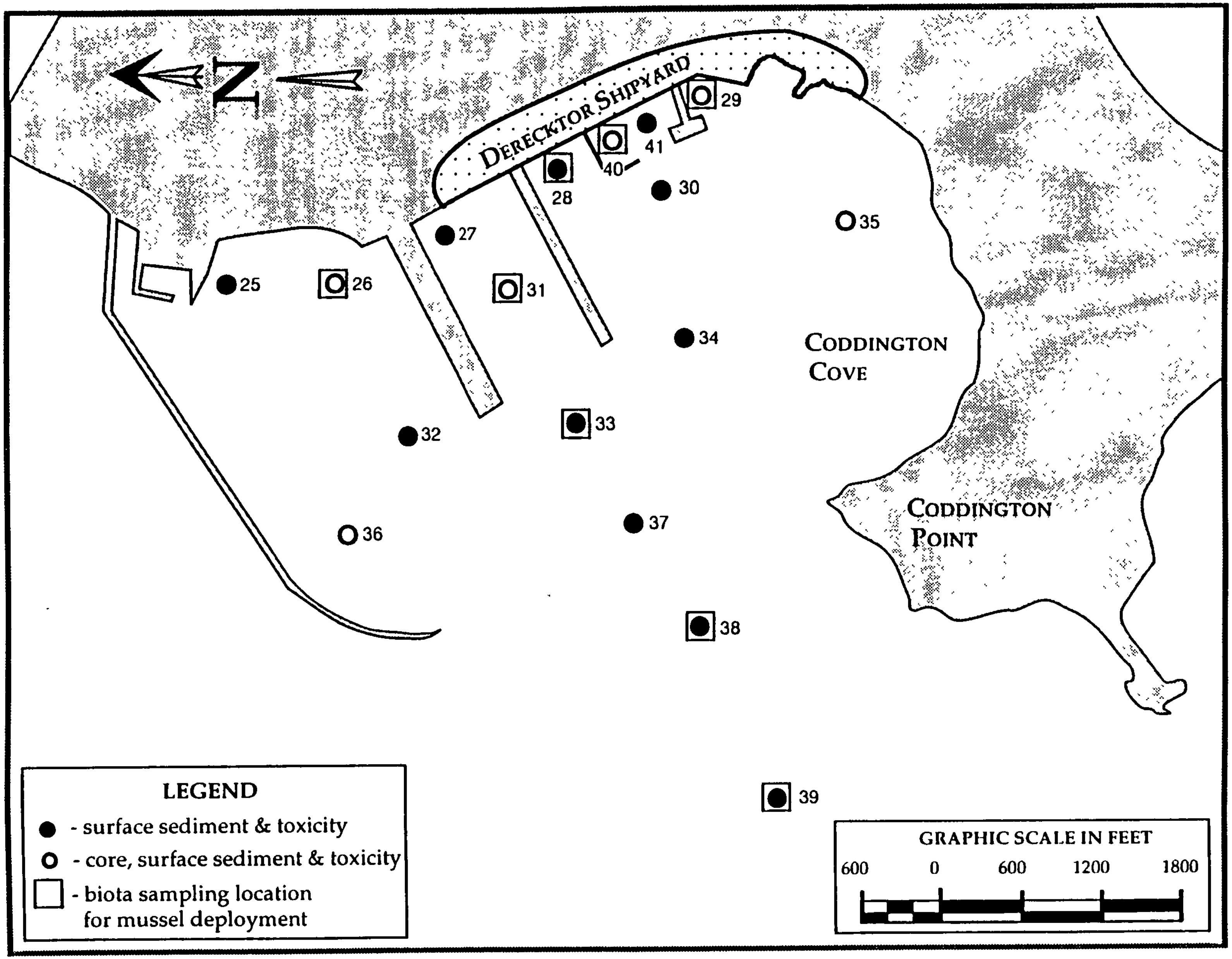
37
CODDINGTON
POINT
36
38
39
LEGEND
- surface sediment & toxicity
- core, surface sediment & toxicity
- biota sampling location
for lobsters
GRAPHIC SCALE IN FEET
600
0
600
1200
1800

Figure 6



N
DERECKTOR SHIPYARD
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37
38
39
40
41
CODDINGTON COVE
CODDINGTON POINT
LEGEND
- surface sediment & toxicity
- core, surface sediment & toxicity
- biota sampling location for mussel deployment
GRAPHIC SCALE IN FEET
600
0
600
1200
1800

spicuous respects in which the flying gurnard differs noticeably from its relatives, the sea robins, are that the first five or six rays of each pectoral, with their interconnecting membrane, form a separate fin, having no connection with the remainder of the pectoral except at the base; that the few lowermost rays of each pectoral fin are not separate, in the form of feelers, but are continuous with the remainder of the fin; that the first two spines of the dorsal fin are separate, that the bony armor covering the front and top of the head reaches rearward considerably beyond the origin of the dorsal fin on either side to end in a stout spine, that each gill cover [72] is extended rearward as a stout spine about as far as the axil of the pectoral fin, and that the scales are much larger and each armed with a short stout spine.

*Color.*—This is a very brilliant fish, varying widely in color; most of them are of some shade of brownish to greenish olive above, with the lower side paler, but marked irregularly with reddish salmon or salmon yellow. The winglike pectorals are variously marked with bright blue streaks near their bases, with blue spots and bars toward their tips. The caudal fin usually has about three brownish-red cross bars.

*Size.*—To about 12 inches.

*General range.*—Tropical to warm temperate latitudes of both coasts of the Atlantic; south to Brazil and north rather commonly to North Carolina on the American coast: a few to New York and the southern coast of Massachusetts in most years (in autumn [73]); recorded as a stray from Massachusetts Bay. A dried and hardened specimen that was found on the shore near Country Harbor, Nova Scotia, in September 1939, by Stanley McKinley, among the kelp and eel grass that had been washed ashore during the night, was thought by him (no doubt correctly) to have been carried north on the deck of some steamer from the south.[74]

*Occurrence in the Gulf of Maine.*—The only report of this warm-water fish from north or east of Cape Cod is of one said to have been taken in Massachusetts Bay.[75]

## THE CUNNER TRIBE, OR WRASSES. FAMILY LABRIDAE

Members of the cunner family have a single long dorsal fin, its forward part spiny, its rear part soft rayed, with no evident demarkation between the two. The ventral fins are located under the pectorals, and the caudal peduncle is very deep. The structure of the dorsal fin is sufficient of itself to distinguish them from all Gulf of Maine fishes except the scup, sea bass, rosefish, tilefish, or certain sculpins. And there is no danger of confusing a cunner or tautog with any of these, for their rounded tails and pectorals, and their general body-forms separate them at a glance from the thin-bodied, fork-tailed scup; their small mouths and the relative sizes of their fins are obvious distinctions between them and the sea bass tribe; their smooth cheeks and broad caudal fins separate them from the spiny-headed, narrow-tailed rosefish or from any sculpin; and they do not in the least resemble the tilefish with its broad mouth, adipose "fin" on the nape of its neck, concave tail fin, and pointed pectorals. Both the roof of the mouth and the floor of the throat (pharynx) is armed with a patch of conical or knoblike teeth in the cunner tribe. It is with these that they grind the hard-shelled mollusks and crustaceans on which they feed.

### KEY TO GULF OF MAINE CUNNERS

1. Gill covers scaly, snout somewhat pointed, dorsal profile of head rather flat..........Cunner, p. 473

   Gill covers largely naked, snout blunt, dorsal profile of head high-arched...............Tautog, p. 478

**Cunner** *Tautogolabrus adspersus* (Walbaum) 1792

Perch; Sea perch; Blue perch; Bergall; Chogset

Jordan and Evermann, 1896–1900, p. 1577.

*Description.*—The readiest field marks by which the cunner may be distinguished from its close relative, the tautog, are mentioned on page 479. It is moderately deep in body, moderately flattened sidewise, with a very deep caudal peduncle,

[72] Actually the preopercular bone.

[73] The most recent record from Woods Hole, of which we have heard, is of two taken there on November 24, 1948, from the deck of *Albatross III* while she was moored at the dock (Arnold, Copeia, 1949, p. 300).

[74] McKenzie, Proc. Nova Scotian Inst. Sci., vol. 20, 1940, p. 44.

[75] This specimen is now in the Museum of Comparative Zoology, to which it was transferred from the Boston Society of Natural History. There is no clue to its origin, except that it was taken many years ago.

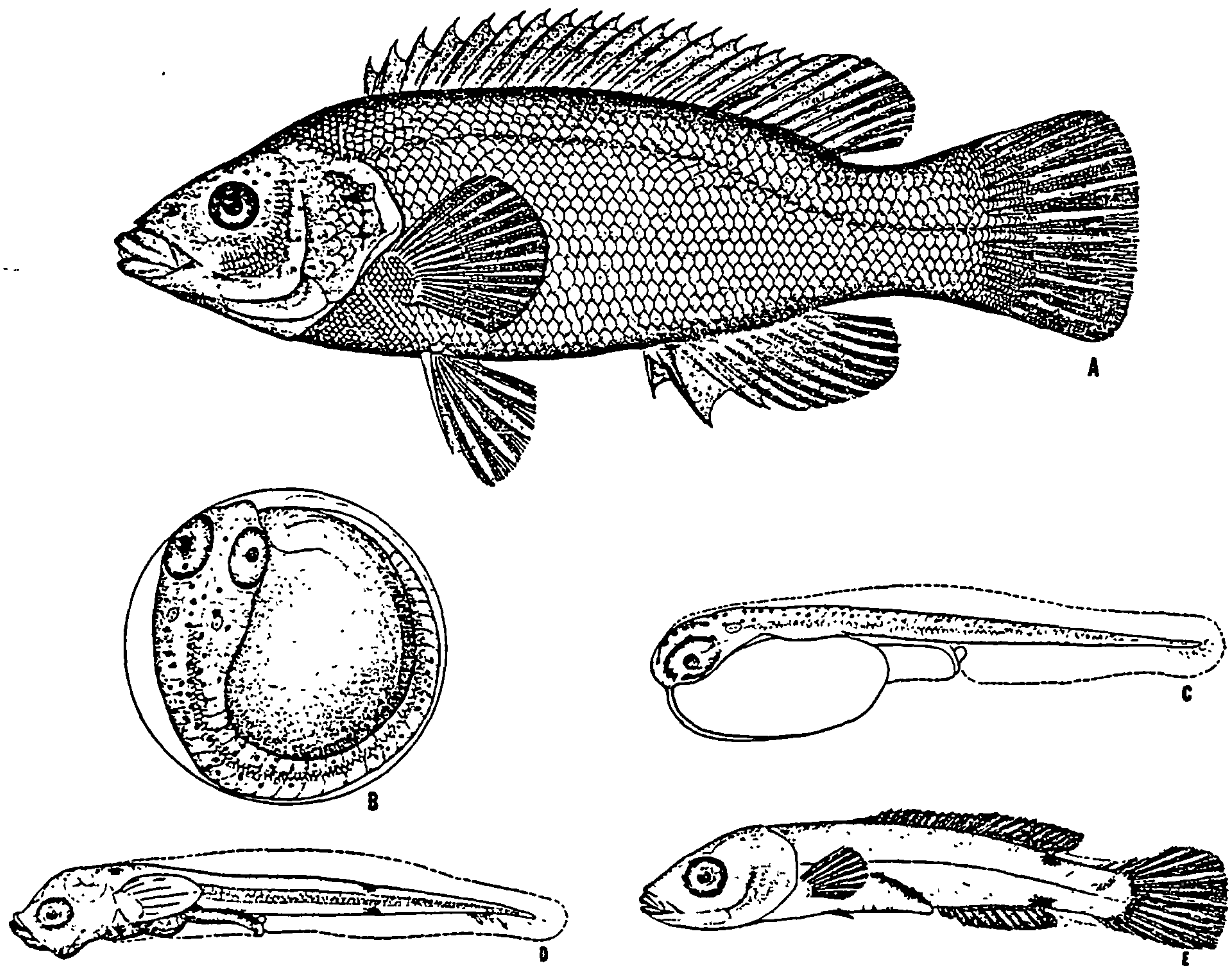


FIGURE 249.—Cunner (*Tautogolabrus adspersus*). A, adult, Woods Hole, Mass.; from Goode, drawing by H. L. Todd. B, egg; C, larva, newly hatched, 2.2 mm.; D, larva, 4.2 mm.; E, young, 8 mm. B–E, after Kuntz and Radcliffe.

flat-topped head (in the tautog the dorsal profile is high arched), small mouth at the tip of the snout, rather pointed nose, and protractile premaxillary bones. Its lips, too, are thinner than those of the tautog. It has several rows of conical teeth of various sizes in each jaw, the outer ones very stout. Its body and gill covers are covered with large scales (in the tautog there is a naked area in front of each gill opening), and its skin is so tough that the fish must be skinned before marketing. Its dorsal fin (about 18 spines and 9 or 10 soft rays) originates over the upper corner of the gill cover, i. e., a little in front of the pectoral fins, and runs back to the caudal peduncle. The first 4 or 5 rays of the dorsal fin are graduated, the others are of about equal lengths. The soft part is only a little more than one-third as long as the spiny part, and is rounded in outline. The rear margin of the caudal fin is slightly convex with rounded corners. The anal fin (3 stout spines and about 9 rays) originates under or behind the middle of the dorsal and corresponds to the soft part of the latter in outline. The ventrals stand under or a little behind the pectorals; both the ventrals and the pectorals are of moderate size, and the pectorals are rounded.

*Color.*—To describe the color of the cunner is to list all the colors of the bottoms on which it lives, for it is one of the most variable of fishes. As a rule the upper parts range from reddish brown (darker or paler) of a bluish cast to blue with brownish tinge, variously mottled with blue, brown, and reddish. Some fish, however, are uniform brown, while fish caught over mud bottom are often very deep sepia. In some situations they may be dull olive green mingled with blue, brown, or rust color. Some cunners are slaty, but reddish or rust tones are apt to prevail when they are living among red seaweeds about rocks. Cunners caught in deep water are often almost as red as the rosefish; on the other hand we have seen very pale ones, more or less speckled all over with blackish dots, over sandy bottom. The belly is invariably of a bluish cast, more or less vivid, sometimes whitish, sometimes dusky, sometimes little paler than the sides. Some cunners have the lips and lining of the mouth bright yellow. Young fry are more or less dark-barred and blotched.

*Size.*—In the Gulf of Maine adult cunners measure about 6 to 10 inches in length and weigh less than half a pound, and one a foot long is very large. But a few are caught up to 15 inches long, and as heavy as 2½ pounds.

*Habits.*—The cunner is chiefly a coastwise fish. In our northern waters they are the most plentiful from just below tide mark downward. They swarm among eel grass (*Zostera*) and about the piling of wharves and under floats in harbors. They also run up into the deeper salt creeks, small fish farther than larger ones, though we have never heard of one in water that is appreciably brackish; and young cunners are often found among eel grass and in rock pools. Southward, however, from New York or thereabouts, most of them keep to water at least 15 to 20 feet deep, hence somewhat farther out, depending on the topography of the coast line and of the bottom.

At the other extreme, they are common enough at 10 to 15 fathoms in the inner parts of Massachusetts Bay, and not rare as deep as 25 to 35 fathoms on the offshore ledges and banks, and we have taken them as deep as 70 fathoms on Georges Bank. But the great majority live within 5 or 6 miles of the shore. And while there are some on the offshore grounds, such as Stellwagen Bank, Jeffreys and Cashes Ledges, and even on Georges and Browns Banks where the otter trawls frequently pick up a few, we have never heard of a large catch of them made far out at sea, whether along southern New England or to the northward. Most of the cunners that are caught the deepest and the farthest offshore are large ones that have probably strayed thither, and finding good feeding, have remained.

As far as we know adult cunners never depart far from the bottom, or from the rocks about which they make their homes, nor do they school. Many, it is true, may live together, but they act quite independently of one another, simply congregating because the surroundings are attractive. Cunners, like other rockfish, spend much of the time resting quietly or swimming slowly among the bunches of Irish moss (*Chondrus*) and fronds of kelp, or in the open spaces among the eel grass (*Zostera*), wherever the latter has reestablished itself, always on the lookout for food.

Cunners are year-round residents, broadly speaking, wherever they are found. At the most, they may descend into slightly deeper water to pass the coldest months,[75] or they may desert the shoalest parts of certain enclosed bays in midsummer to escape the very high temperatures produced there as the sun strikes the flats at low tide. They have been described as hibernating in the mud during the winter, or at least as lying among eel grass or rocks in a more or less torpid state. But we find no positive evidence of this; on the contrary, practical fishermen, among them Capt. L. B. Goodspeed, to whom we are indebted for many notes, inform us that cunners are to be caught in abundance on precisely the same spots in winter as in summer. In fact a few are landed in Boston during the cold months, and the only reason more are not brought in then is that there is so little demand for them.

It has long been known that the cunner is vulnerable to very low temperatures. Hazards of this sort are more frequent south of Cape Cod, where the fish are more likely to be caught in very shoal water in a sudden freeze, than in the Gulf of Maine, where active mixing by the tide usually prevents the water from chilling to the danger point, except at the surface. However, this did take place in Massachusetts Bay in the winter of 1835, when cunners came ashore in quantities between Marblehead and Gloucester. And the failure of the cunners to produce young within the Bay of Fundy (p. 478) suggest that the lower thermal limit to their successful reproduction is about 55°–56°, though the young fry as well as the adults are at home in temperatures close to the freezing point of salt water. The upper

[75] Ambrose (Proc. and Trans., Nova Scotian Inst. Nat. Sc., vol. 2, No. 2, 1870, p. 93) describes the cunners as moving out of Saint Margaret Bay, Nova Scotia, in autumn, to return early in May

thermal limit, for the well being of the cunner, is something like 70°–72°, to judge from the distribution of the species.

Cunners are omnivorous. As a rule they find their livelihood browsing among seaweeds, stones, or dock piles, biting off barnacles and small blue mussels, with the fragments of which they are often packed full. They devour enormous numbers of amphipods, shrimps, young lobsters, small crabs, and other small crustaceans of all kinds; also univalve mollusks and the smaller bivalves, hydroids, and annelid worms. They sometimes eat small sea urchins, bryozoans, and ascidians, and they occasionally capture small fish such as silversides, sticklebacks, pipefish, mummichogs, and the fry of larger species. Finally, eel grass is often found in cunner stomachs besides the animal food. Small cunner fry taken at Woods Hole were found by Dr. Linton to have fed chiefly on minute crustacea such as copepods, amphipods, and isopods.

The cunner is a busy scavenger in harbors, congregating about any animal refuse, to feed on the latter as well as on the amphipods and other crustaceans attracted by the same morsels. They are also said to eat fish eggs, and no doubt feed to some extent on herring spawn. Our own belief is that cunners are always hungry, no matter what the stage of the tide.

The cunner spawns chiefly from late spring through early summer. The eggs are buoyant, transparent, 0.75 to 0.85 mm. in diameter, and they do not have an oil globule. Incubation occupies about 40 hours at temperatures of 70° to 72°, but it is probable that about 3 days are required for hatching in the cooler waters of the Gulf of Maine (55° to 65°). At hatching the larvae are about 2 to 2.2 mm. long, and at 15 mm. the young cunner is of practically adult form. On newly hatched larvae the pigment cells are scattered uniformly over head and trunk, but by the 3-mm. stage they have gathered into a pair of black spots, dorsal and ventral, about halfway between the vent and the base of the caudal rays, which are characteristic of the species. And these spots persist to about the 10- to 20-mm. stage. By the time the fry have grown to about 25 mm. they are as variable in color as their parents (it is on record that Louis Agassiz had 60 colored sketches of small cunners 3 to 4 inches long, of different hues, prepared at Nahant during a single summer).[76]

Fry of 1 to 1.2 inches have often been taken in August, and young fish up to 2 inches long in September in southern New England waters. Hence we may assume that Gulf of Maine cunners (probably hatched somewhat later) may average about 2 to 2½ inches by their first autumn, and 2½ to 2¾ inches by the following June when they are one year old, which Johansen [77] found true also of the earliest hatched fry in the southern side of the Gulf of St. Lawrence. The subsequent rate of growth has not been studied for the cunners of our Gulf. But Johansen's [78] age determinations for cunners of the Gulf of St. Lawrence make it likely that Gulf of Maine cunners 3 to 4 inches long are 2 years old; those of 4 to 5 inches 2 or 3 years old; those of 5 to 6 inches 3 years old; those of 6 to 7 inches 3 or 4 years old; those of 7 to 8 inches 4 or 5 years old; those of 8 to 9 inches 5 or 6 years old; those of 9 to 10 inches about 6 years old; and those of 10 to 11 inches 6 or 7 years old. But the relationship is complicated by the fact that female cunners run larger than males, so that males may be a year older than females of the same size.

Most of the cunners mature in their third summer (i. e., when 2 full years old) when 2¾ to 3½ inches long.

*General range.*—Atlantic coast of North America and the offshore banks, from Conception Bay, east coast of Newfoundland, and the western and southern parts of the Gulf of St. Lawrence,[79] southward in abundance to New Jersey, and occasionally as far as the mouth of Chesapeake Bay.

*Occurrence in the Gulf of Maine.*—The cunner is one of our most familiar fish, to be found all around the shore line of the Gulf. The Massachusetts Bay region is perhaps their chief center of abundance, and they are so numerous there in

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[76] The embryology and larval development and fry of the cunner have been described by Agassiz (Proc. Amer. Acad. Arts, Sci., N. Ser., vol. 9, 1882, p. 290, pls. 13 to 15); Agassiz and Whitman (Mem. Mus. Comp. Zool., vol. 14, No. 1, Pt. 1, 1885, p. 18, pls. 7–19, and Mem. Mus. Comp. Zool., vol. 40, No. 9, 1915, pls. 32–39); Kuntz and Radcliffe (Bull. U. S. Bur. Fish., vol. 35. 1918, p. 99, figs. 18–29); and more recently by Johansen (Contr. Canad. Biol., N. Ser., vol. 2, No. 17, 1925, pp. 440–450).

[77] Contrib. Canadian Biol., N. Ser., vol. 2, No. 17, 1925, p. 451.

[78] Johansen (Contrib. Canadian Biol., N. Ser., vol. 2, No. 17, 1925, pp. 451-455) worked out the age-length relationship for a large series of Gulf of St. Lawrence cunners by a study of their scales and otoliths.

[79] See Johansen, Contrib. Canadian Biol., Ser. 2, vol. 2, No. 17, 1925, pp. 5–6 [427–428]), for the distribution of the cunner in Canadian waters.

good years, along the rocky shores and around and over ledges, that no amount of fishing seems to have any effect on their numbers. Generally speaking, they are less numerous east of Casco Bay, and our experience has been that they are progressively less and less so eastward along the shore from Penobscot Bay toward the Bay of Fundy, but average larger. On the outer coast of Mount Desert, for example, it is unusual to catch one in the enclosed harbors (precisely the localities they frequent farther west and south), and most of those caught outside are very large. Thus we took many of 12 to 13 inches, averaging about 1½ pounds, near Baker's Island, off Northeast Harbor, in August 1922, and no small ones. But young fish in plenty, as well as adults, have been reported from Bluehill Bay, nearby,[80] where the water is warmer in summer.

Cunners are also taken, here and there, along the coast, eastward to the Grand Manan Channel, sometimes in numbers as in 1928, when so many were caught "about the rocks and in the coves to the south of West Quoddy," that they were reported in the press.[81] But they are so scarce ordinarily around Grand Manan and within Passamaquoddy Bay that only half a dozen large specimens had been taken there from the founding of the Biological Station at St. Andrews in 1906 down to the early 1920's.[82] And while the cunner is reported from Black River east of St. John, New Brunswick, it seems to be unknown farther in along the New Brunswick shore of the Bay of Fundy or in Chignecto Bay and Minas Basin at the head. But Annapolis Basin on the Nova Scotian side of the bay, harbors a few, while cunners of all sizes are so numerous in St. Mary Bay that this must be an important centre of reproduction and the source of the few large (i.e., old) ones that are caught farther up the Bay of Fundy. And they are reported along the western shore of Nova Scotia, as at Pubnico for example.

There are large cunners in small numbers on the offshore fishing grounds in our Gulf also, Stellwagen at the mouth of Massachusetts Bay, Cashes Ledge, and Georges and Browns Banks, as mentioned above (p. 475) in depths down to 50 fathoms or so. But it is not likely that they ever descend into the deep basins of the Gulf. Certainly our experimental trawlings have not yielded any there, 42 fathoms being the greatest depth at which we have known of a cunner taken anywhere in the inner parts of the Gulf.[83]

Extending our survey farther east and north, we find cunners reported as numerous all along the outer coast of Nova Scotia, including the many bays and inlets, also in the southern side of the Gulf of St. Lawrence from Cape Breton to the Gaspé Peninsula, including the shallow bays of Prince Edward Island and the shores of the Magdalen Islands, also up the west coast of Newfoundland as far as Bay of Islands. And they are to be expected at the heads of the bays along the south coast of Newfoundland for they have been taken in Conception Bay on the east coast. But this last is their most northerly known outpost on the Atlantic coast, and they have never been reported either from the estuary of the St. Lawrence or anywhere along the north shore of the Gulf of St. Lawrence.[84]

Cunners near Newport, Rhode Island, commence spawning by mid-May and June sees the chief production of eggs there and near Woods Hole, where most of the fish are spent after the first days of July, though eggs have been taken in abundance there until July 15, a few as late as August 15.[85] Probably spawning does not commence until June in the colder waters of our Gulf, but continues there through the later summer, for our towings have yielded many eggs, apparently of the cunner, in July and August. And the chief spawning season is about the same as this in the southern side of the Gulf of St. Lawrence, according to Johansen [86] and to Reid.[87]

Cunner eggs have been taken at our tow net stations along outer Cape Cod; near Race Point at the tip of the Cape; in Massachusetts Bay (where we have often towed them in great numbers in the tideways between the offlying ledges); and at the mouth of Penobscot Bay, as well as in sundry harbors. Blue Hill Bay inland from Mount Desert may be a breeding center, for small fry are reported there.[88] And eggs taken off

[80] Reported to us by Rear Adm. S. E. Morrison, U S. Navy.

[81] Boston Transcript for August 29, 1928.

[82] Johansen, Contrib Canadian Biol. N. Ser , vol 2, No. 17, 1925, p. 5 [427].

[83] One was trawled at this depth at the mouth of Massachusetts Bay (lat. 42°28′ N., long. 70°13′ W ) by the *Albatross II*, July 28, 1931.

[84] See Johansen, Contrib. Canadian Biol., N. Ser. 2, vol. 2, No. 17, 1925, pp. 5–6 [427–428] for an account of the status of the cunner in the Gulf of St. Lawrence, and around Newfoundland.

[85] Agassiz and Whitman, Mem. Mus. Comp. Zool., vol. 14, No. 1, 1885, p. 18, Kuntz and Radcliffe, Bull. U. S. Bur Fish., vol. 35, 1918, p. 99.

[86] Contrib. Canadian Biol., N. Ser., vol. 2, No. 17, 1925, p. 17 [439].

[87] Contrib. Canadian Biol. and Fish., N. Ser., vol. 4, No 27, 1929.

[88] By Rear Admiral S. E. Morrison, U S N.

Libbey Island prove that cunners spawn in diminishing numbers eastward along the Maine coast nearly to the mouth of the Bay of Fundy. It is doubtful, however, whether eggs produced along the coast east of Mount Desert yield more than a very small proportion of fry, nor do cunners breed successfully in the cold water of the Bay of Fundy, where no small ones are ever seen. However, the Bay is simply a gap in the breeding range, for St. Mary Bay is a productive nursery. Both eggs and larvae were taken at various localities along the outer coast of Nova Scotia by the Canadian Fisheries Expedition during the summer; and the shoal inshore waters in the southern side of the Gulf of St. Lawrence are a productive spawning area.[89]

Larval cunners and small specimens generally, like their eggs, are so closely confined to the coast line that it is impossible to represent the localities where we have taken them on a general chart of the Gulf; in fact, all our catches of 100 or more have been made either in harbors or at most not a couple of miles from land.[90] There may be some successful reproduction on Cashes and Jeffreys Ledges. But we have found no evidence, whether of eggs or of young fry, that the few large cunners that wander offshore to Georges Bank produce any young there.

*Variations in abundance.*—No evidence is available as to how much the cunners may vary in abundance from year to year, along the coasts of our Gulf as a whole. But they may do so widely at a given locality. Thus we found very few of them in 1950 along the Cohasset shore, on the southern side of Massachusetts Bay, where they are plentiful ordinarily. And they were so scarce there during the summer of 1951, that persons raking Irish Moss (*Chondrus*) reported seeing hardly a cunner around the rocks where many are to be seen in most summers, and another acquaintance who usually baits a lobster pot or two with cunners taken in a cunner trap caught only one occasionally in that way.

*Importance.*—The cunner was a favorite pan fish once. During the 1870's the annual catch of the small boats fishing out of Boston was estimated as not much short of 300,000 pounds, while the fact that 104,100 pounds of cunners were reported for Maine in 1889, 148,300 pounds in 1898, and 281,500 pounds in 1905, shows that the annual harvest was still considerable to that time. But the reported catch had fallen to 30,695 pounds for Maine by 1919, and to about 10,000 pounds for the entire coast line of Massachusetts, south as well as north of Cape Cod. And Maine reported only 10,000 pounds for 1928 and 1,735 pounds for 1929, while the only cunners reported for Massachusetts were 30 pounds and 45 pounds for those 2 years, respectively. From that time down to 1947, commercial catches of cunners have been reported for Maine in only 3 years out of the 14.[91]

The landings reported for Massachusetts during this period suggests ups and downs so erratic and so extreme[92] that we hesitate to place any dependence upon them further than that landings ranging from 3,100 pounds to 18,700 pounds (average 7,450 pounds) for the years 1944–1947 show that a small demand continues for cunners. And we can witness that sizeable ones are very good pan fish.

Although not regarded as a game fish, the cunner affords amusement to thousands of vacationists near our seaside resorts. And the number caught, of which no record is kept, is so considerable that this must be classed as a useful little fish from the recreational standpoint.

Probably more cunners are caught on bits of clam than on any other bait. But they will take snails broken from their shells, bits of crab, lobster, or pieces of sea worms (*Nereis*) almost as freely. And we have even caught a few while trolling near rocks, for mackerel, with a small spinner tipped with a bit of white fish skin. The little ones are a great nuisance, often stealing the bait as fast as it is offered, and because it is a small-mouthed fish, very small hooks are best.

## Tautog *Tautoga onitis* (Linnaeus) 1758

### BLACKFISH; WHITE CHIN

Jordan and Evermann, 1896–1900, p. 1578.

[89] See Johansen (Contrib. Canadian Biol., New Ser., vol. 2, No. 17, 1925, p. 18 [440], also Reid, Contrib. Canadian Biol. and Fish. N. Ser., vol. 4, No. 27, 1929.

[90] The precise records have been published elsewhere (Bull. Mus. Comp. Zool., vol. 58, 1914, p. 108, and vol. 61, 1917, p. 271).

[91] One hundred and seventy five pounds for 1933, 200 pounds for 1935, 45,300 pounds for 1938, an amount so large that we question its accuracy, especially since the entire catch was reported as made on "lines, trawl." No catch statistics are available for 1934, 1936, 1941, or 1942.

[92] Reported catches for Massachusetts jumped from 45 pounds for 1929 to 349,251 pouhds for 1931, dropped to 0 for 1932, 152 pounds for 1933 and 0 again for 1935; rose to 27,800 pounds for 1937; were 0 again in 1939; but 53,500 pounds in 1940.