ENVIRONMENTAL PROTECTION AGENCY

THE COMMONWEALTH OF MASSACHUSETTS

BOSTON HARBOR WATER QUALITY BASELINE

for the SDEIS on Boston Harbor Wastewater Facilities Siting

December 1984

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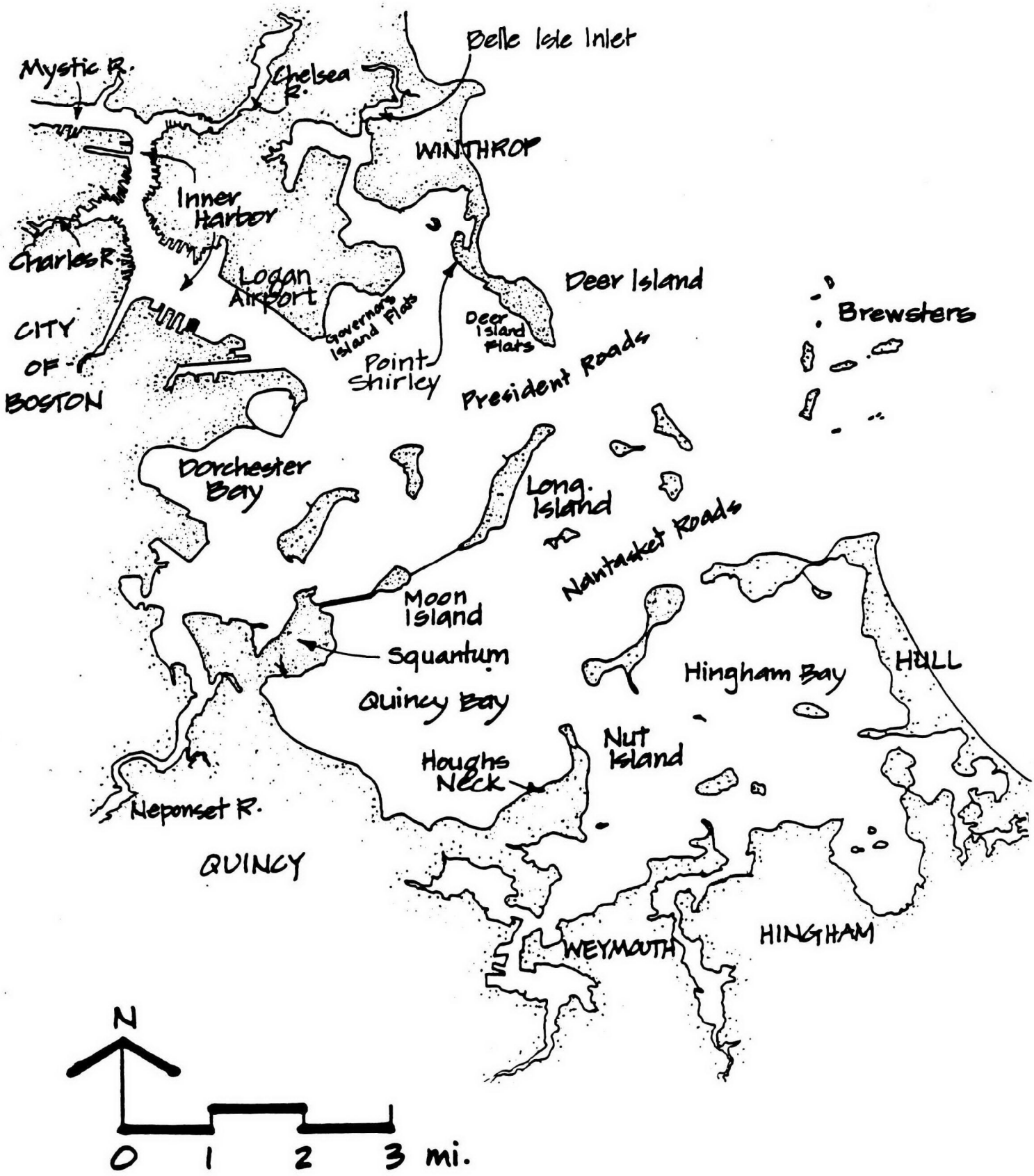
THE MAGUIRE

Place Names in and around Boston Harbor



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BOSTON HARBOR WATER QUALITY BASELINE

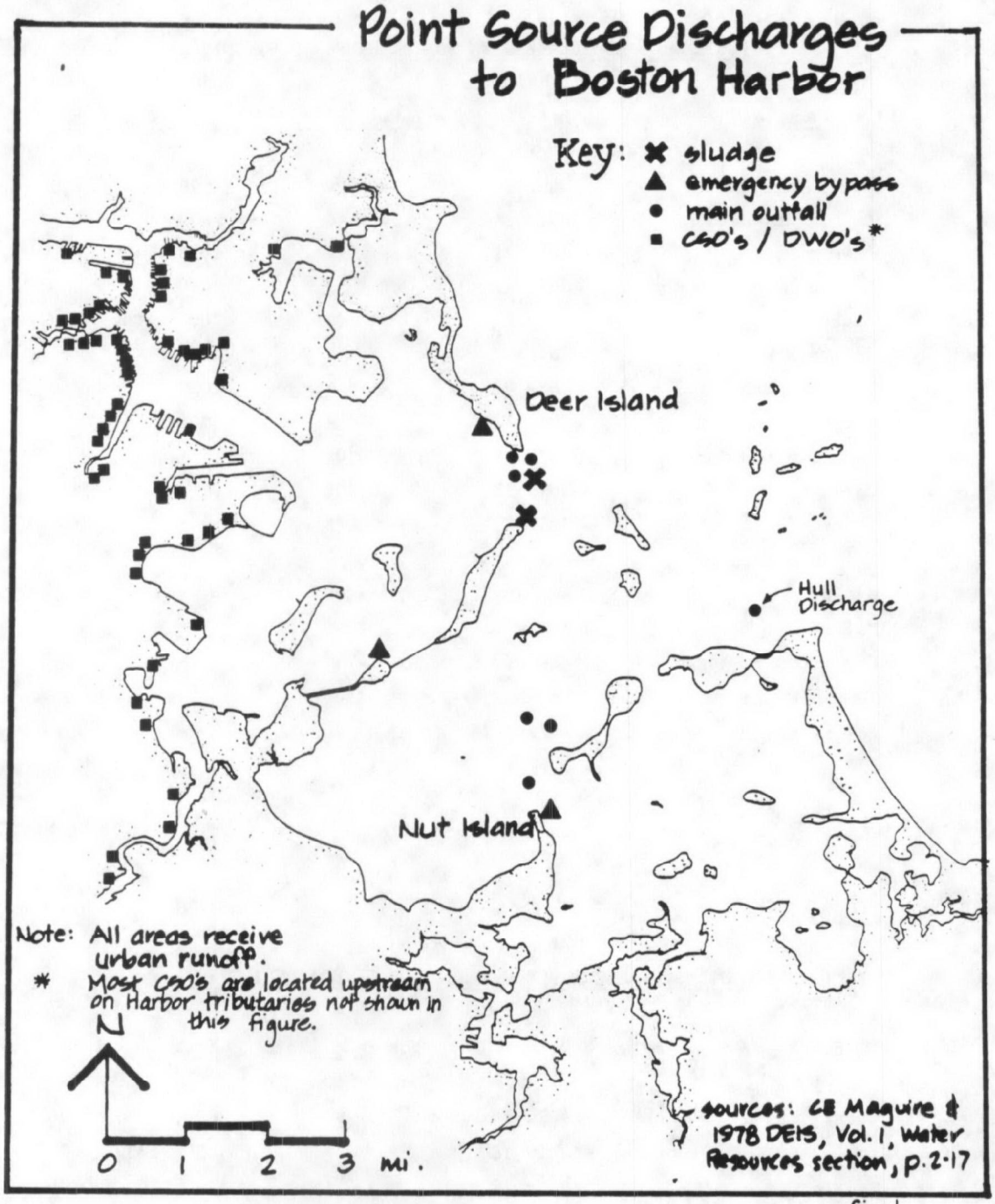
Point Source Discharges to Boston Harbor
Key: sludge
emergency bypass
main outfall
CSO's / DWO's*
Deer Island
Hull Discharge
Nut Island
Note: All areas receive urban runoff.
* Most CSO's are located upstream on Harbor tributaries not shown in this figure.
N
0 1 2 3 mi.
Sources: CE Maguire & 1978 DEIS, Vol. I, Water Resources section, p. 2-17

fig. 1

TABLE 1

POSTING OF MDC BEACHES IN BOSTON HARBOR DURING 1982

Beach	Date	Total Coliform	Fecal Coliform
Tenean-Middle	June 30	2920	590
Constitution-Bath	July 14	0	600
Revere	July 21	-	1000
Malibu	July 21	-	810
Malibu	July 22	-	2000, 1060, 1550
Tenean North	July 21	-	26800
Tenean North	July 22	-	2050
Wollaston-Milton	July 21	-	11200
Constitution-North	July 28	4500	-
Carson	July 28	100	-
Tenean-North	July 29	485	-
Wollaston-Milton	August 4	10000	-
Carson	August 11	1200	-
Malibu	August 11	2680	-
Constitution-North	August 18	710	-
Tenean-North	August 18	1300	-
Wollaston-Milton	August 18	70	-

Source: EG&G, 1984, p. 199

TABLE 2

POSTING OF MDC BEACHES IN BOSTON HARBOR DURING 1984

Beach	Date	Total Coliform	Fecal Coliform
Constitution	July 18	-	2600, 5000, 4500
Wollaston	July 18	-	1030, 1230, 7600
Tenean	July 25	-	450, 510, 510
Tenean	July 27	-	600, 520, 440
Tenean	July 28	-	600, 1090, 310
Tenean	August 8	-	8000, 8000, 8000
Malibu	August 8	-	8000

Source: MDC Sewerage Division Beach Report 1984 Postings.

1. EXECUTIVE SUMMARY

A. Objectives

This water quality baseline has been prepared in support of the Supplemental Draft Environmental Impact Statement (SDEIS) on Siting of Wastewater Treatment Facilities for Boston Harbor. This report describes existing water quality in Boston Harbor as it relates to harbor uses, resources, and marine life. As such, this report serves two purposes:

1. Physical, chemical, and biological characteristics of the harbor are provided as a "baseline" to be used in comparative evaluation of the impacts of options presented in the SDEIS.

2. An issue-oriented summary of water quality problems in Boston Harbor is presented, providing a harbor-wide context for evaluation of the SDEIS options and their water quality impacts.

The water quality impacts of the SDEIS alternatives do not affect the treatment plant siting decisions which are the focus of this EIS. This is because water quality impacts are common among all secondary treatment alternatives and among all primary treatment alternatives. Also, the selection of an effluent discharge (outfall) site is relatively independent of the treatment plant site. The MDC's proposal for upgraded primary treatment (301(h) waiver application) calls for a discharge nine miles off Deer Island into Massachusetts Bay. The MDC Nut Island Site Options Study's preferred option for secondary treatment calls for discharge to President Roads. The water quality impacts of secondary treatment alternatives are discussed in section 11.3 of the SDEIS (Volume 2). The water quality impacts of primary treatment with a discharge nine miles off Deer Island will be presented in EPA's decision document on the 301(h) waiver application and summarized in the Final EIS on treatment plant siting.

This baseline was developed using the most recent water quality sampling data collected by the Massachusetts Division of Water Pollution Control (DWPC). Sediment and biologic data presented are from the MDC's recent 301(h) Waiver Application. These data sets have the advantage of presenting conditions over wide areas of the harbor while ensuring a degree of consistency in the methods of sampling and laboratory analysis. The EPA's computerized Boston Harbor data base was also reviewed to check the extent to which DWPC and MDC sampling results compare favorably with the data base. Generally, these data sets compare well.

B. Findings

1. Harbor Uses: Boston Harbor's most significant uses in economic terms are as a shipping port, and an aesthetic amenity of considerable real estate value. Its recreation and commercial fishing value is also significant, even though chronic water pollution has resulted in closure of half of the harbor's shellfish beds and periodic closure of area beaches.

2. Water Quality: Even though most waters in Boston Harbor meet the water quality standards established by the Massachusetts DWPC, Harbor waters have higher concentrations of pollutants than are found offshore in Massachusetts Bay. Water quality around the outer harbor islands and in Hingham Bay is the highest in the harbor. In contrast, the waters in the northern area of the Harbor (north and west of Long Island) often have the highest concentrations of pollutants. Inner Harbor waters (northwest of Castle Island) and other near shore waters frequently fail to meet minimum water quality standards. Periodic sewer overflows result in near shore violations of standards in Dorchester and Quincy Bays, and in Belle Isle Inlet.

3. Marine Life: Boston Harbor supports a diverse community of marine organisms. However, the composition of benthic communities in the Inner Harbor, Deer Island/Governors Island Flats and Dorchester Bay is indicative of environmental stress. Fin erosion is found in winter flounder populations throughout the harbor. Toxic chemicals in harbor sediments are thought to contribute to the incidence of this disease, although this has not been verified. A recent study by the National Marine Fisheries Service has found cancerous lesions in the tissues of winter flounder from Boston Harbor. Given the incidence of finfish and shellfish cancers reported for other marine waters receiving industrial wastes, and the levels of carcinogens in discharges to the harbor, it is expected that the incidence of cancers in Boston Harbor fish populations is greater than in populations from less polluted waters (J. Harschbarger, Smithsonian Institution Registry of Tumors in Lower Animals, pers. comm). Toxic chemicals, such as heavy metals, polychlorinated biphenyls (PCBs), and pesticides, are found in the tissues of flounder and lobster caught throughout the Harbor and even outside the harbor. The few samples taken showed that concentrations of these toxics do not exceed FDA limits for human consumption. However, the concentration of PCBs in several samples approached the FDA limits.

C. Harbor Uses

Boston Harbor is the largest seaport in New England and the eleventh busiest in the nation in terms of total trade. (O'Brien & Gere, 1981, V.II. p. 3-29). Shipping in Boston Harbor accounted for over $2 billion in foreign trade during 1978; the principal imports and exports being petroleum products and scrap iron, respectively (O'Brien & Gere, 1981, V.II. p. 3-30).

Urbanization along 180 miles of shoreline and the drumlin topography around Boston Harbor afford many striking views of the

harbor and its islands. Cumulatively, these views impart a significant value to residential and commercial properties. The proximity of dense residential development around Boston to the harbor beaches, island parks, fishing and boating facilities is also of significant economic value. "Over three million people in the greater Boston area live within 25 miles of the Harbor, and in Boston alone, there are over 200,000 people who live within walking distance of the Harbor and the rivers entering the Harbor". (O'Brien & Gere, 1981, V.II. p. 3-29).

The most significant harbor uses which are impaired or precluded by poor water quality are swimming and shellfishing. The quality of water in the Inner Harbor is such that DWPC designated uses do not include swimming or other primary contact recreation. Recently, the posting of Boston Harbor beaches was a regular summer occurrence during and after rainfall events which trigger combined sewer overflows in East Boston, Dorchester Bay, and the Inner Harbor (Table 1, Figures 1 and 2). Table 2 shows that relatively few beach postings occurred during the summer of 1984. Mechanical failures at both Nut Island and Deer Island wastewater treatment plants occasionally result in raw sewage discharges. Progressive deterioration in these plants' treatment capacity has dramatically increased the occurrence of such bypassing events in recent years. Treatment plant discharges, sewer overflows and urban runoff have all been implicated as sources of bacterial pollution which leads to beach posting.

Shellfish beds cover about 4,600 acres of Boston Harbor (Lipman, DEQE, c. 1983). Over half of this area is closed to shellfishing because of bacterial contamination of overlying waters (Figure 3). In the remaining beds, shellfish may only be harvested by licensed master diggers who must transport the shellfish to the Commonwealth's depuration plant where shellfish are cleansed prior to sale. The recent annual harvest from these beds (mostly softshell clams) has been valued between $5 and $6 million; the potential annual value from closed beds has been estimated to be $4 million (Lipman, DEQE, c. 1983). Overflows and bypasses of raw sewage, poorly treated wastewater from treatment facilities, and storm drainage have all been implicated

as sources of bacterial contamination in shellfishing areas. Sewer overflows and treatment plant bypassing reported to DEQE often results in closure of affected areas to shellfishing (Harrington, DEQE, pers. comm.). Commercial lobster fishing in Boston Harbor is apparently not affected by harbor pollution.

Floating sewage, oil, grease, and debris impair the visual quality of Boston Harbor from many vantage points. These surface plumes are particularly evident after rains which overtax sewer and treatment plant capacity. Such plumes are a chronic occurrence near main sewer overflow points, such as Moon Island, and many points in the Inner Harbor. Tidal flushing in the outer harbor appears to quickly disperse locally obnoxious plumes.

D. Water Quality Standards

Waters in Boston Harbor are classified by the DWPC as class SA, SB, or SC (see Figure 4). These classes correspond to intended uses, but do not necessarily reflect the water's quality. Waters meeting the minimum water quality criteria for their class are suitable for the following designated uses (314 CMR 4.03):

> Class SA - Waters assigned to this class are designated for the uses of protection and propagation of fish, other aquatic life and wildlife; for primary and secondary contact recreation, and for shellfish harvesting without depuration in approved areas.
>
> Class SB - Waters assigned to this class are designated for the uses of protection and propagation of fish, other aquatic life and wildlife; for primary and secondary contact recreation, and for shellfish harvesting with depuration (Restricted Shellfish Areas).
>
> Class SC - Waters assigned to this class are designated for the protection and propagation of fish, other aquatic life and wildlife, and for secondary contact recreation.

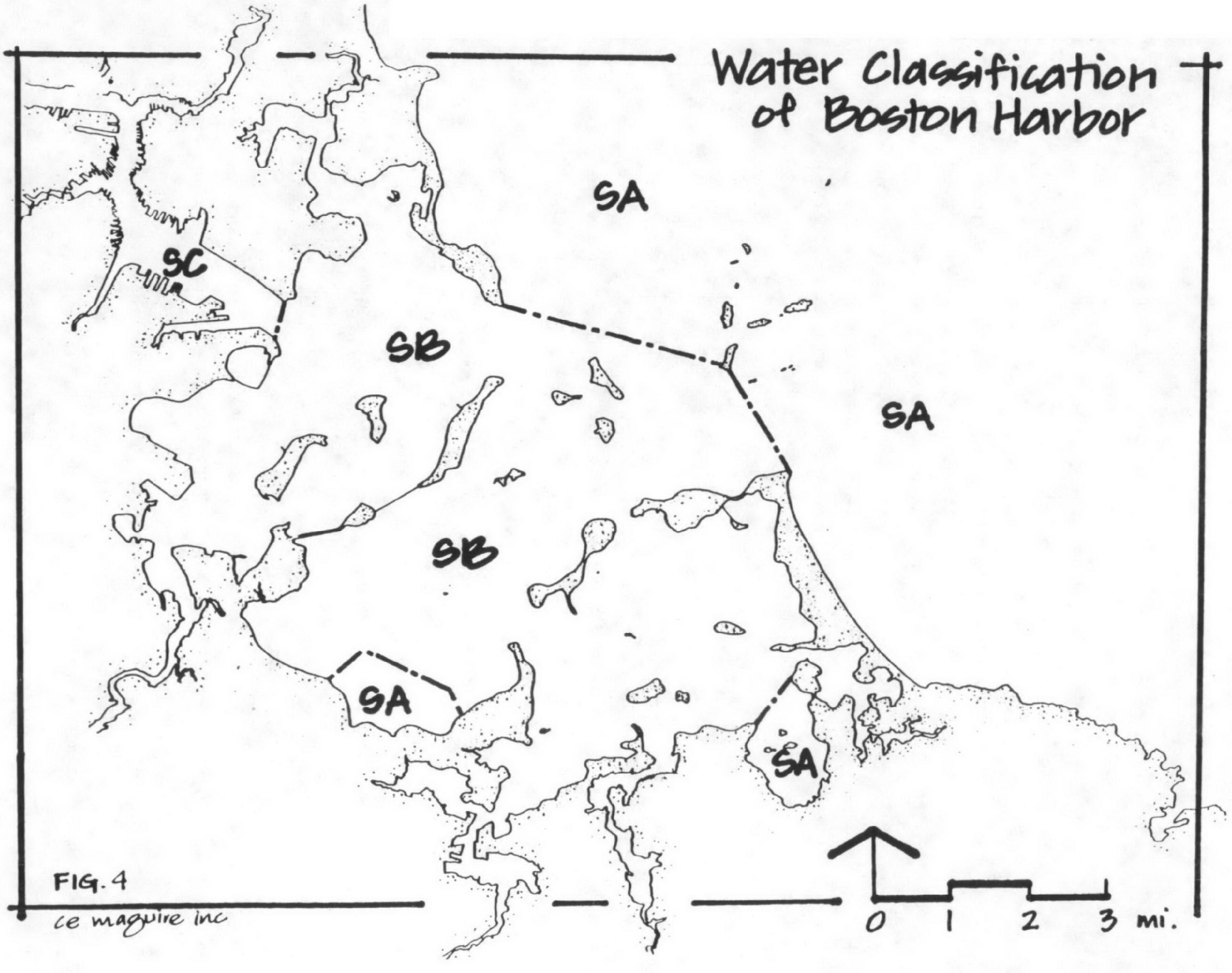

FIG. 4

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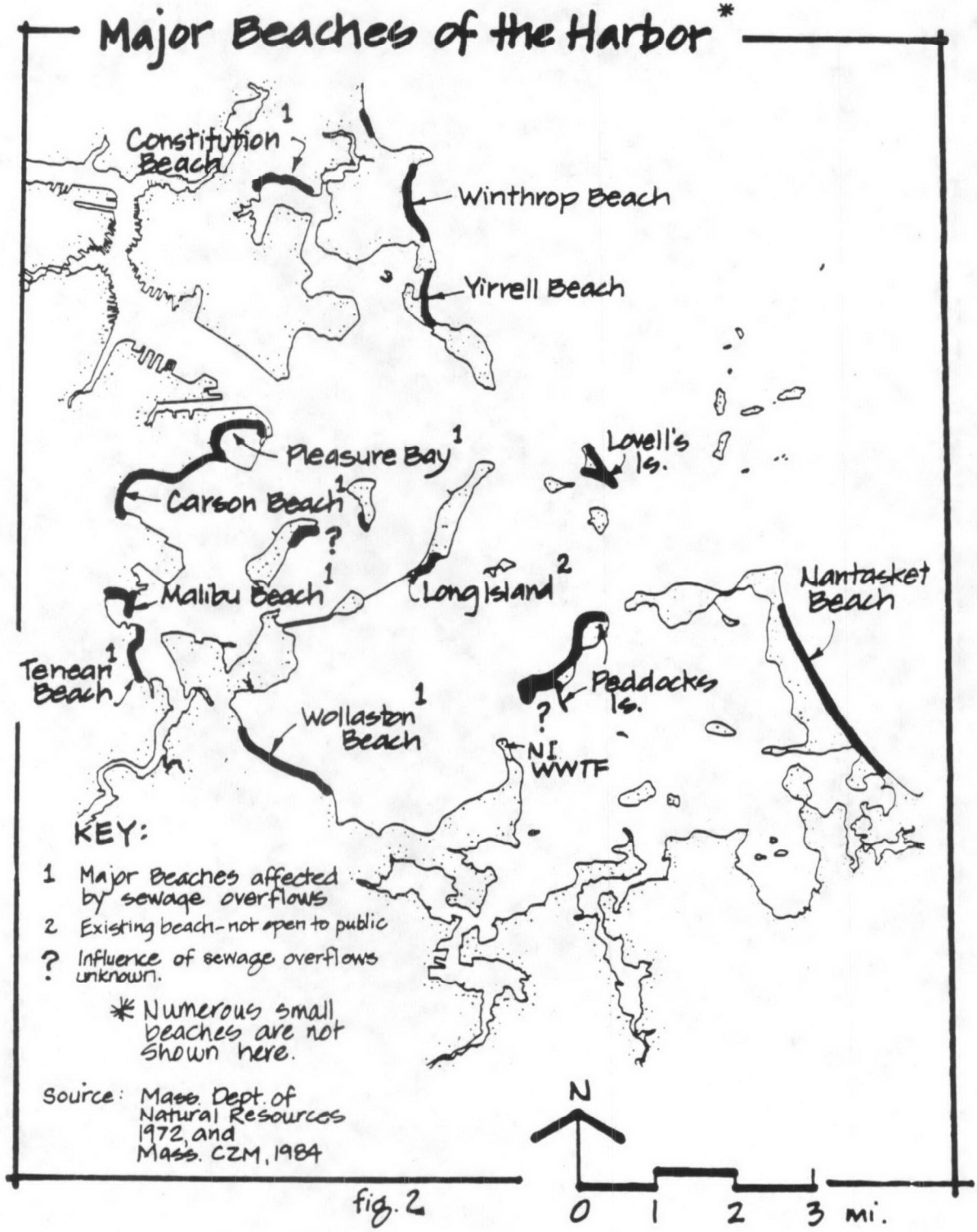
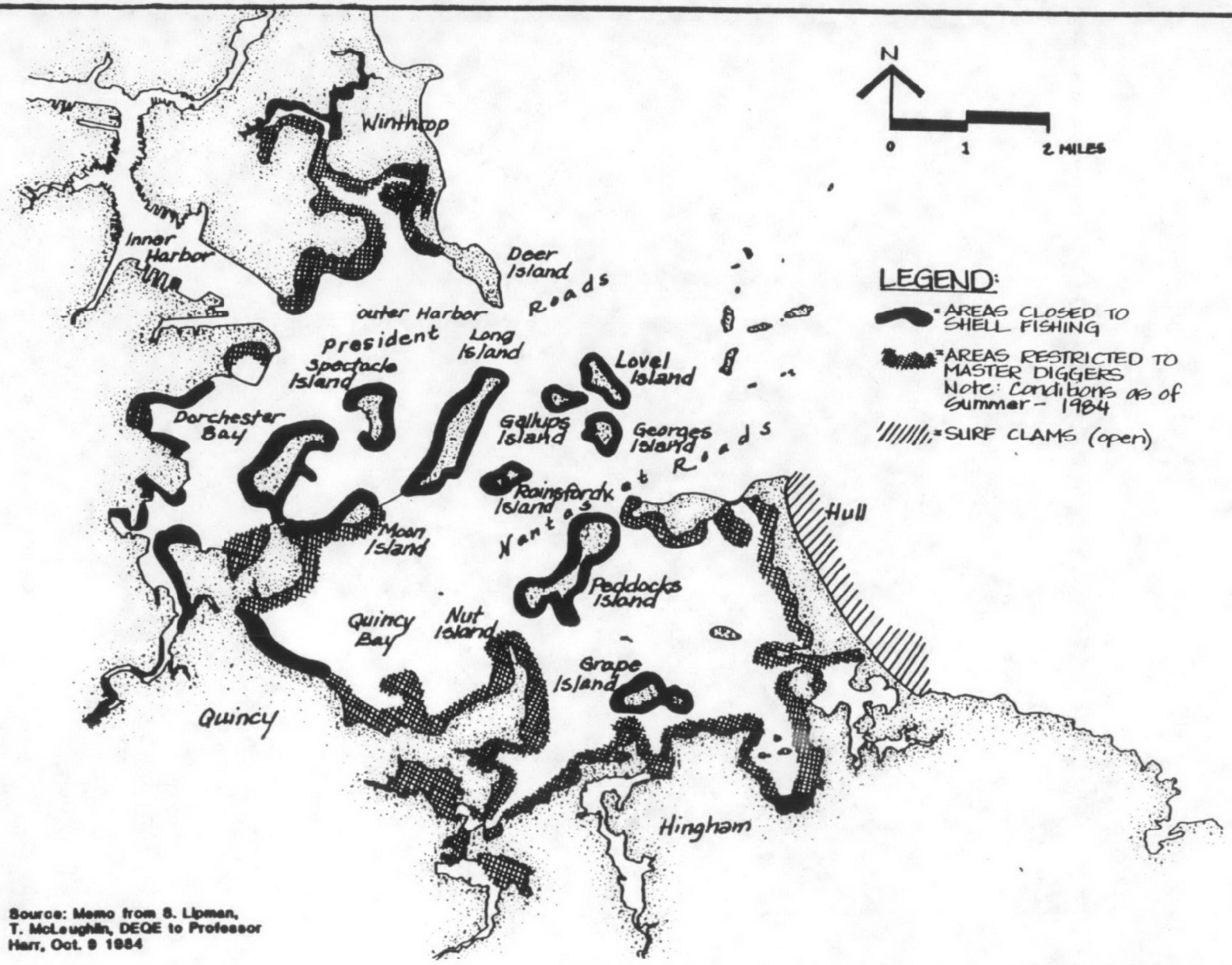

Major Beaches of the Harbor*
Constitution Beach
1
Winthrop Beach
Yirrell Beach
Pleasure Bay
1
Carson Beach
1
?
Malibu Beach
1
Long Island
2
Lovell's Is.
Nantasket Beach
Tenean Beach
1
Wollaston Beach
1
Peddocks Is.
?
NI WWTF
KEY:
1 Major Beaches affected by sewage overflows
2 Existing beach - not open to public
? Influence of sewage overflows unknown.
* Numerous small beaches are not shown here.
Source: Mass. Dept. of Natural Resources 1972, and Mass. CZM, 1984
N
0 1 2 3 mi.

fig. 2



Source: Memo from S. Lipman, T. McLaughlin, DEQE to Professor Herr, Oct. 9 1984

SHELLFISH BEDS IN BOSTON HARBOR fig. 3

C.E. maguire, inc.

Water quality sampling done by DWPC in the summers of 1982, 1983, and 1984 found the worst water quality in the Inner Harbor. These class SC waters have ". . . frequent water quality violations and exhibit stressed environmental conditions" (McKechnie, DWPC, 1983). Bacteria and metals concentrations are generally very high in the Inner Harbor, and dissolved oxygen levels are usually lower there than in the outer harbor. In the Inner Harbor, "dissolved oxygen violations of the 6 mg/l standard occurred about 40% of the time." (Kubit, DWPC, 1984).

In the outer harbor, waters in the vicinity of Belle Isle Inlet (near Orient Heights and Winthrop) ". . . have water quality violations following storm events because of CSO inputs" (McKechnie, DPWC, 1983). In Dorchester Bay, "dissolved oxygen standard violations occurred in 35% of the samples collected." (Kubit, DWPC, 1984).

Sampling near Moon Island's intermittent sewage overflow found "... dissolved oxygen violations ... near the bottom" (McKechnie, DPWC, 1983). "However, coliform bacteria violations were not noted. One suspects that transient, local water quality violations occur after discharges from Moon Island" (McKechnie, DWPC, 1983).

Otherwise, DWPC characterized observed water quality in Boston Harbor as good during their 1982 and 1983 sampling. This does not necessarily reflect shoreline water quality since DWPC sampling was all offshore.

Near shore water samples are collected weekly by the MDC at MDC beaches in Boston Harbor. These samples are analyzed for fecal coliform bacteria. When bacterial concentrations greater than 500 organisms per 100 milliliters are found, MDC posts the beach. After posting, the beach is resampled daily until acceptable concentrations are found.

Boston Harbor water samples collected and analyzed by University of Massachusetts scientists contained copper concentrations in excess of EPA's criteria for the protection of saltwater aquatic life

(Wallace, et al., 1984). The highest concentrations of copper were found in the shallow waters of Quincy and Hingham Bays, and in the Inner Harbor.

E. Marine Life

Boston Harbor supports commercial shellfishing (clams) and lobster fishing. As noted above, about half of the 4,600 acres of shellfish beds are closed because of bacterial contamination of overlying waters. Sport fishing and recreational fishing are very popular in the harbor; the principal bottom fishing catch is flounder.

Winter flounder is the dominant benthic (bottom feeding) finfish in Boston Harbor. The incidence of fin erosion in winter flounder appears to be higher in Boston Harbor than in flounder populations outside the harbor. Biologists have theorized that the disease is caused by some type or combination of environmental stress.

Researchers have also speculated that toxic chemicals found in relatively high concentrations in harbor sediments are responsible for flounder fin erosion. However, no correlation has been found between the concentration of metals, PCBs, or DDT in sediments with the incidence of fin erosion in Boston Harbor flounder (Metcalf & Eddy, 1979 301(h) Waiver Application, Vol. 2, p. BXI-31). Researchers elsewhere have found a probable association between fin erosion and toxicants, particularly chlorinated hydrocarbons (Metcalf & Eddy, 1984 301(h) Waiver Application, Volume 2, p. III-D4.29 through III-D4.45).

Bioaccumulation of toxic chemicals, such as heavy metals, PCBs and pesticides, in Boston Harbor's winter flounder, lobster, and shellfish has been documented. The reported concentrations of toxic chemicals in edible portions of these organisms have not exceeded U.S. Food and Drug Administration limits on toxicants in fish (Metcalf & Eddy, 1979 301(h) Waiver Application, Vol. 2, p. BXII-11).

A 1984 study conducted by the National Marine Fisheries Service found cancerous lesions in 8 percent of 200 winter flounder examined; "however, it is likely that the actual percentage of these lesions considerably exceeds 8 percent ..." (Murchelano and Wolke, 1984). "Only flounder collected from the southern shore of Deer Island had grossly visible hepatic lesions" (Murchelano and Wolke, 1984). Compared to liver disease in flounder from other northeast coastal waters, Boston Harbor flounder livers show more abundant and severe lesions. The National Marine Fisheries Service and the Massachusetts Division of Marine Fisheries are conducting follow up studies on Boston Harbor fish disease, including analysis of flounder tissues for polynuclear (or polycyclic) aromatic hydrocarbons (PAHs) and PCBs (both are toxic compounds).

With the exception of fin erosion and cancer in winter flounder, no adverse health effects are reported for marine life in Boston Harbor. However, the composition of benthic communities in the harbor shows fewer species, fewer numbers of organisms, and lower overall biomass towards the Inner Harbor, Deer Island/Governors Island Flats, and Dorchester Bay, when compared with the less polluted areas of Quincy and Hingham Bays, Nantasket Roads, and Massachusetts Bay. The dominant invertebrate species in the inner harbor and Deer Island/Governors Island Flats is Capitella sp., a pollutant tolerant worm often used as an indicator of a biologically stressed environment.

2. BOSTON HARBOR WATER QUALITY

A. Summary of Physical Characteristics

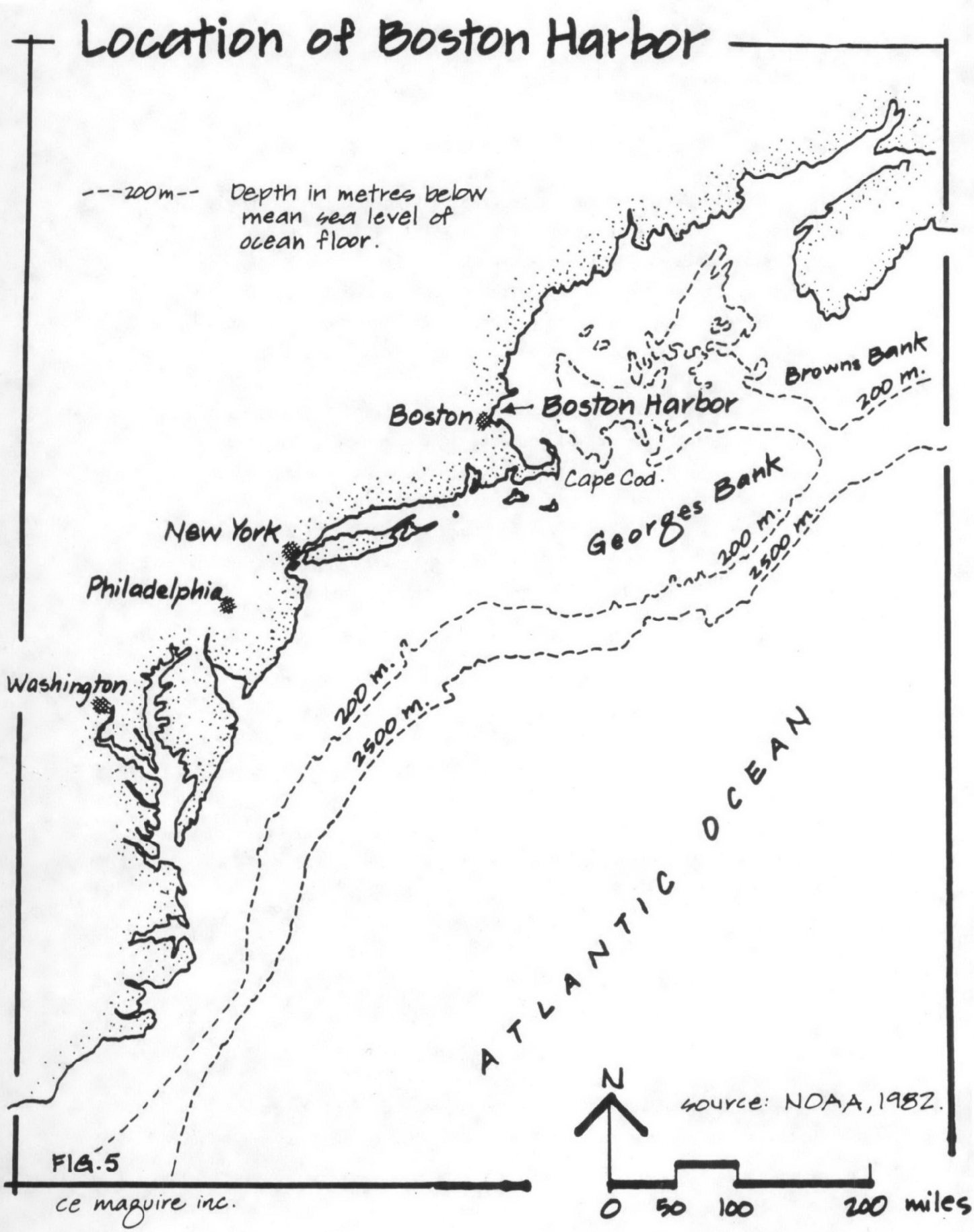
Boston Harbor is located on the Eastern seaboard north of Cape Cod (Figure 5). While its navigation channels have been dredged out to a depth of nearly 40 feet, water depths in the rest of the harbor generally range from 10 to 15 feet at mean low water (MLW). Depths of nearly 90 feet occur in the channel at President Roads (Figure 6). The mean tidal rise and fall in Boston Harbor is 9.5 feet.

Currents within the harbor for spring flood tides are shown in Figure 7. Note that flood currents follow generally the same path as ebb currents, but in opposite directions. Under average spring tide conditions, current velocity at maximum ebb and flood is under 0.7 knots over most of the harbor although velocities of up to 1.7 knots occur in the channels. Maximum currents reported for Boston Harbor are 2.6 knots (ebb) in Hull Gut and 2.0 knots (ebb and flood) in Presidents Roads (White, 1983).

The total volume of the Harbor is approximately 180 billion gallons at high tide and about half that at low tide. Assuming complete tidal mixing, estimated flushing time for the harbor by the tidal prism method would be two tidal cycles. Since harbor tides cycle twice per day, this would equate to daily flushing. In actuality, harbor mixing is not complete and flushing time is greater. Iwanowicz, et al (1974), estimated tidal flushing for several Boston Harbor Bays as follows:

Estuary	% Tidal Exchange
Hingham Bay	49.8
Dorchester Bay	46.9
Quincy Bay	37.9

Flushing of the harbor is enhanced by flow of freshwater through the harbor from groundwater and the coastal rivers and streams. The volume


Location of Boston Harbor
---200m-- Depth in metres below mean sea level of ocean floor.
Browns Bank
200 m.
Boston
Boston Harbor
Cape Cod
Georges Bank
200 m.
2500 m.
New York
Philadelphia
Washington
200 m.
2500 m.
ATLANTIC OCEAN
N
source: NOAA, 1982.
0 50 100 200 miles
FIG. 5
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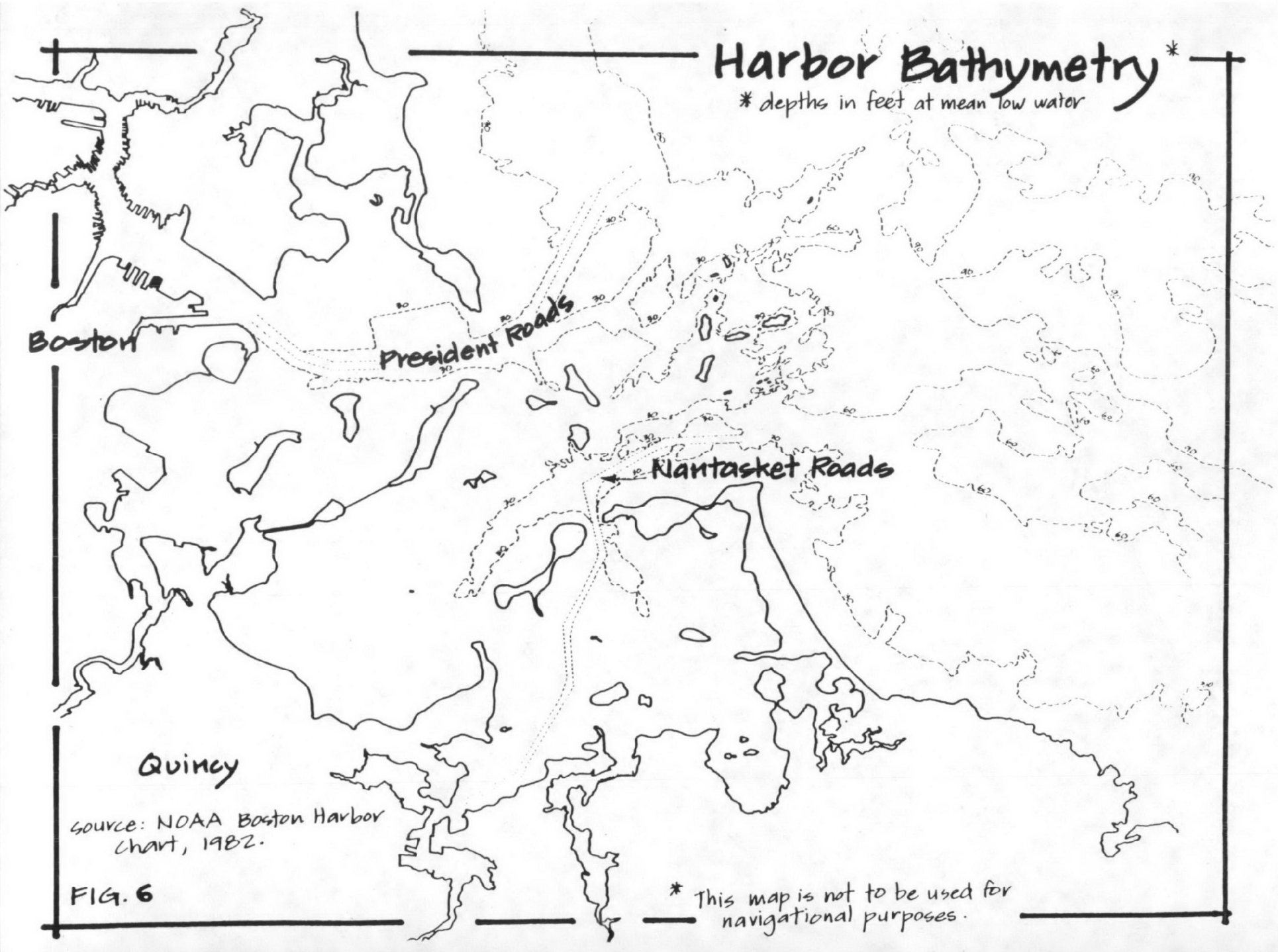
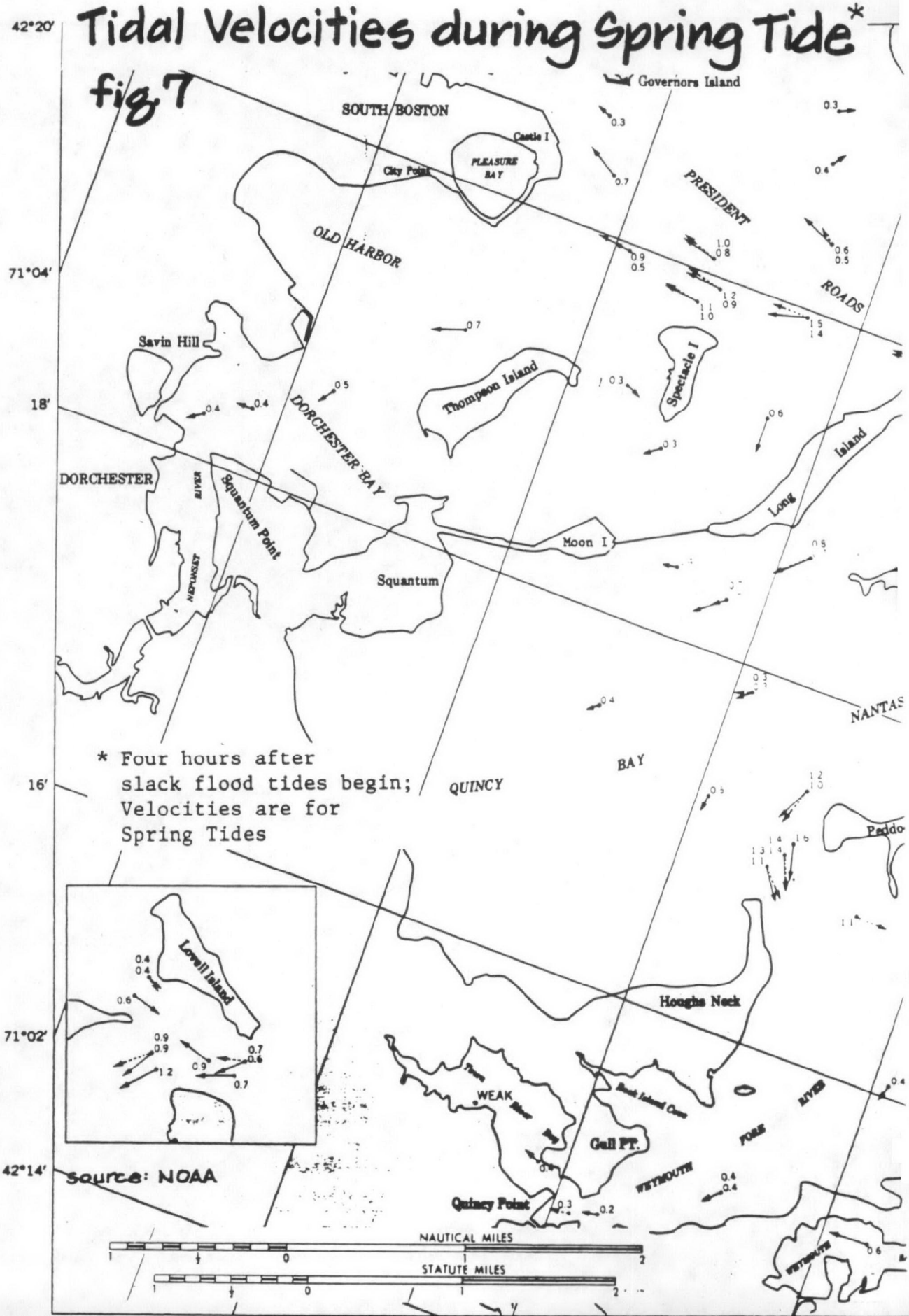
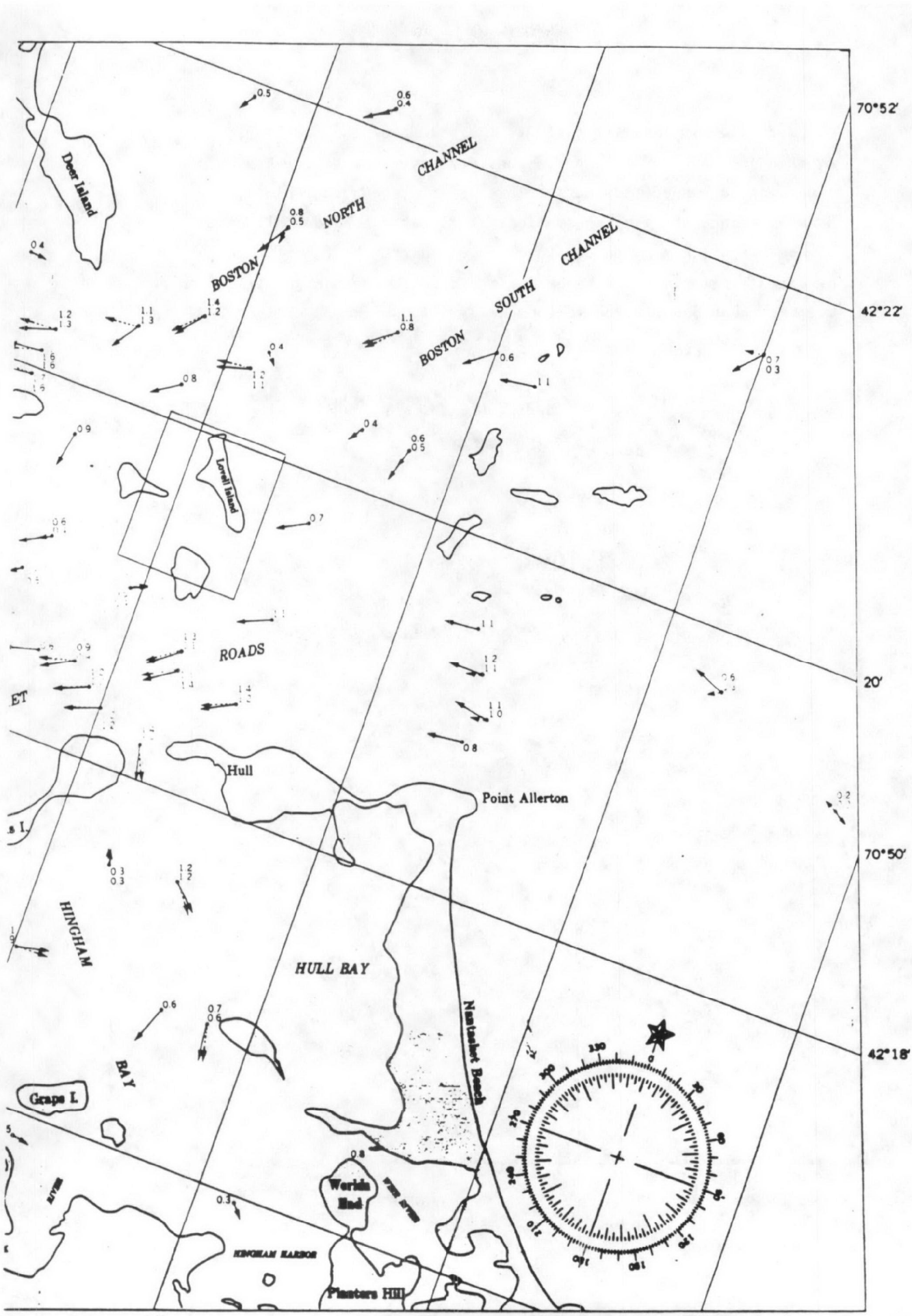

Harbor Bathymetry*
* depths in feet at mean low water
Boston
President Roads
Nantasket Roads
Quincy
source: NOAA Boston Harbor Chart, 1982.
FIG. 6
* This map is not to be used for navigational purposes.

Tidal Velocities during Spring Tide*

fig 7



* Four hours after slack flood tides begin; Velocities are for Spring Tides


70°52'
42°22'
20'
70°50'
42°18'
CHANNEL
NORTH
BOSTON
SOUTH
CHANNEL
BOSTON
Deer Island
Lovell Island
ROADS
Hull
Point Allerton
HINGHAM
HULL BAY
BAY
Grape I.
Nantasket Beach
Worlds End
HINGHAM HARBOR
Planters Hill

of river flow is small compared to the volume of the tidal prism, an average of about 256 million gallons per day flows to the harbor according to gauged flow data. This data is shown in Table 1. However, since the gauging stations are located considerably upstream of the harbor in most cases, this table understates the flow to the harbor. Total river discharges to the Harbor have been estimated to average about 500 million gallons daily (Lipman, DEQE, c. 1983).

FIGURE 8

TABLE 3. GAUGED RIVER DISCHARGES TO BOSTON HARBOR[1]

Watershed/Station	Years of Record	Drainage Area in Square Miles	Discharge in cfs Minimum	Maximum	Mean
Mystic River					
Aberjona	42	24.2	0.25	1,330	27.3
Charles River					
Waltham	50	227	0.2	4,150	294
Neponset River					
Norwood	42	35.2	1.4	1,490	52.9
Canton	29	27.2	0.60	1,790	50.9
Weymouth Fore River					
Town Brook, Quincy	9	4.25	0.62	381	8.11
Weymouth Back River					
Old Swamp River, near South Weymouth	15	4.29	0.11	566	8.92
		322 mi^2	3.18 cfs	9,707 cfs	442 cfs
			2.05 mgd	6,271 mgd	286 mgd

1. Based on: Water Resources Data, Massachusetts and Rhode Island, Water Year 1981, U.S. Geological Survey.

2. Total river discharges to Boston Harbor have been estimated to average about 500 mgd (Steven Lipman, DEQE, c. 1983).

B. Surface Water Quality and Standards

Massachusetts Surface Water Quality Standards ". . . designate the uses for which Massachusetts surface waters shall be enhanced, maintained, and protected, and prescribe the water quality criteria required to sustain the designated uses." (Regulation Filing and Publication form filed by DWPC 9/27/83). These standards consist of five sections:

1. General Provisions (314 CMR 4.01), which include statutory authority, purpose, and definitions.

2. Application of Standards (314 CMR 4.02), which includes guidance to DWPC in the establishment of effluent limitations, the evaluation of criteria in the mixing zone of a point source discharge, the evaluation of "worst case" hydrologic (flow/dilution) conditions, and the approved procedures for water sampling and analysis.

3. Water Quality Criteria (314 CMR 4.03), which defines use classes, and associated minimum criteria (qualitative and quantitative).

4. Antidegradation Provisions (314 CMR 4.04), which call for the protection of high quality waters, low flow waters, and waters which constitute an outstanding national resource. This section allows more stringent criteria to be applied to these waters than is provided under 314 CMR 4.03. This section also provides guidance on limiting nutrient enrichment of water bodies and variance procedures.

5. Basin Classifications and Maps (314 CMR 4.05), which sets out the procedures DWPC must use in classifying waters, and the classification maps and descriptions themselves.

These standards are periodically reviewed and revised by DWPC. The discussion of Massachusetts Surface Water Quality Standards is based on the current standards as revised October 15, 1983.

The Massachusetts classes for coastal waters, associated uses, and minimum water quality criteria are summarized in Tables 4, 5, and 6. Note that the only criteria which differ between these coastal water classes are bacterial. The designated water classes for Boston Harbor are shown in Figure 9.

In the interpretation of minimum criteria included in the Massachusetts Standards, the DWPC is directed to consider EPA water quality guidelines issued under Section 304(a) of the Federal Clean Water Act[1] These guidelines have been issued for conventional pollutants in EPA's "Red Book" (Quality Criteria for Water, 1976) and for 126 toxic pollutants in EPA's "White Book" (guidelines published in the Federal Register 11/20/80, 8/13/81 and 2/15/84 and reports referenced therein). Proposed changes to these guidelines (Federal Register 2/7/84) are now undergoing public review. The application of these guidelines is at the discretion of Massachusetts DWPC. Where applicable, reference is made to these guidelines in this baseline.

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[1]The Massachusetts Standards, 314 CMR 4.03(1) as amended 10/15/83, refer to the Clean Water Act Section 304(b), however, the intent is to refer to water quality guidelines (304(a)) rather than effluent limitation guidelines (304(b)) (Warren Kimbal, DWPC, pers. comm.)

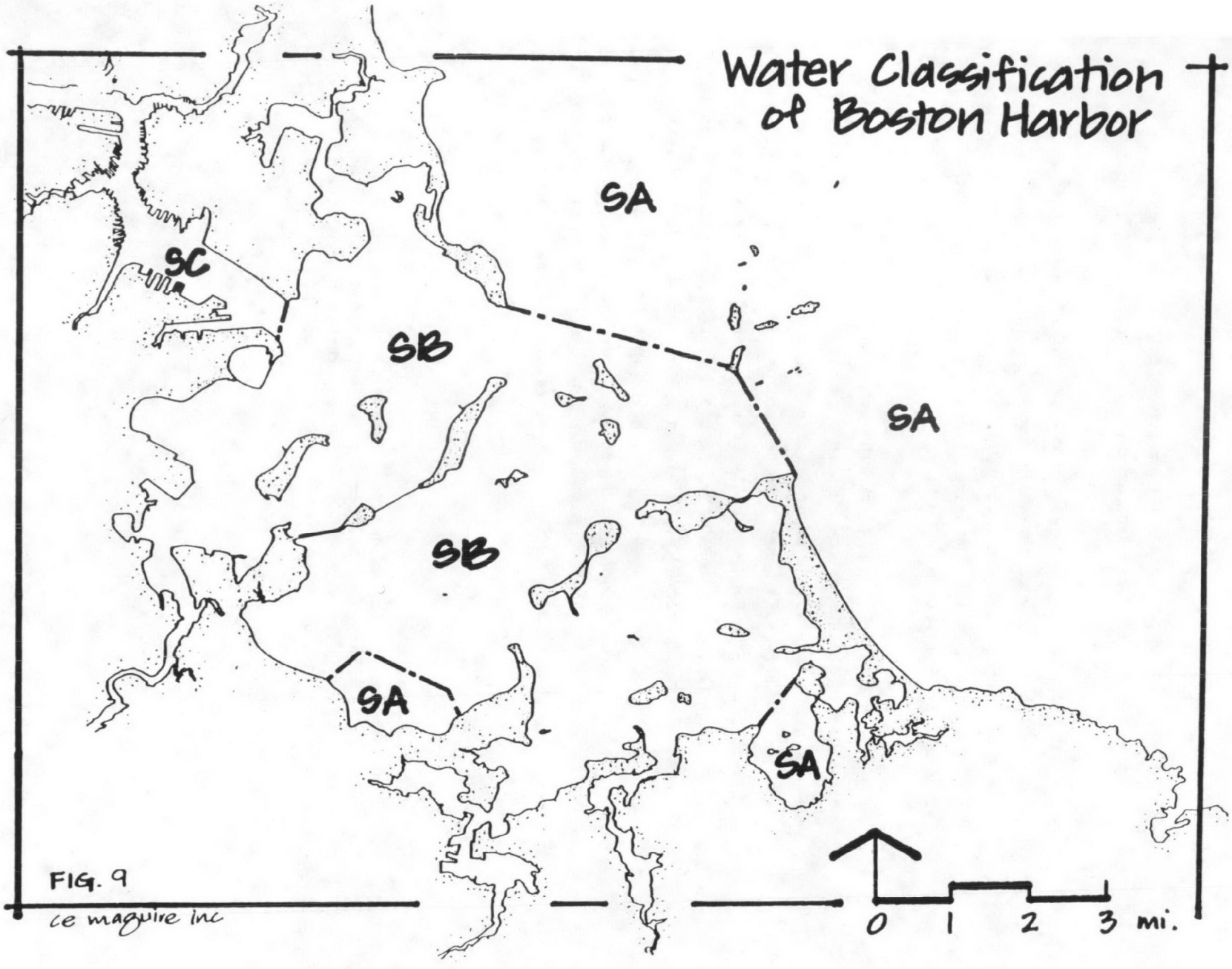

FIG. 9

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TABLE 4.

DESIGNATED MASSACHUSETTS COASTAL WATER CLASSES, USES, AND CRITERIA WHICH DIFFER BETWEEN CLASSES

Class/Use	Differentiating Criteria (Bacterial)
Class SA - Waters assigned to this class are designated for the uses of protection and propagation of fish, other aquatic life and wildlife; for primary and secondary contact recreation, and for shellfish harvesting without depuration in approved areas.	Total coliform bacteria shall not exceed a median value of 70 MPN per 100 ml and not more than 10% of the samples shall exceed 1,000 MPN per 100 ml in any monthly sampling period.
Class SB - Waters assigned to this class are designated for the uses of protection and propagation of fish, other aquatic life and wildlife; for primary and secondary contact recreation, and for shellfish harvesting with depuration (Restricted Shellfish Areas).	Total coliform bacteria shall not exceed a median value of 700 MPN per 100 ml and not more than 20% of the samples shall exceed 1,000 MPN per 100 ml during any monthly sampling period, except as provided in Regulation 2.1.*
Class SC - Waters assigned to this class are designated for the protection and propagation of fish, other aquatic life and wildlife, and for secondary contact recreation.	Fecal coliform bacteria shall not exceed a log mean for a set of samples of 1,000 MPN per 100 ml, nor shall more than 10% of the total samples exceed 2,500 MPN per 100 ml during any monthly sampling period, except as provided in Regulation 2.1.*

*Establishment of effluent limitations.

TABLE 5

MINIMUM WATER QUALITY CRITERIA
WHICH APPLY TO ALL MASSACHUSETTS COASTAL WATER CLASSES
(SA, SB, SC)

	Parameter	Criteria
1.	Dissolved Oxygen	Shall be a minimum of 85 percent of saturation at water temperatures above 77°F (25°C) and shall be a minimum of 6.0 mg/l at water temperatures of 77°F (25°C) and below*.
2.	Temperature	None except where the increase will not exceed the recommended limits on the most sensitive water use.
3.	pH	Shall be in the range of 6.5-8.5 and not more than 0.2 units outside of the naturally occurring range.

*It is DWPC's policy to use the average DO concentration found in the water column (at different depths during a single sampling event) in their interpretation of the 6.0 mg/l criterion (letter from T.C. McMahon, Director DWPC, to K. McSweeney, USEPA 12/15/83).

TABLE 6

MINIMUM CRITERIA WHICH APPLY TO ALL MASSACHUSETTS WATERS
(Unless criteria specified for individual classes are more stringent.)

	Parameter	Criteria
1.	Aesthetics	All waters shall be free from pollutants in concentrations or combinations that: a) Settle to form objectionable deposits; b) Float as debris, scum or other matter to form nuisances; c) Produce objectionable odor, color, taste, or turbidity; or d) Result in the dominance of nuisance species.
2.	Radioactive Substances	Shall not exceed the recommended limits of the United States Environmental Protection Agency's National Drinking Water Regulations.
3.	Tainting Substances	Shall not be in concentrations or combinations that produce undesirable flavors in the edible portions of aquatic organisms.
4.	Color, Turbidity, Total Suspended Solids	Shall not be in concentrations or combinations that would exceed the recommended limits on the most sensitive receiving water use.
5.	Oil and Grease	The water surface shall be free from floating oils, grease and petrochemicals and any concentrations or combinations in the water column or sediments that are aesthetically objectionable or deleterious to the biota are prohibited. For oil and grease of petroleum origin, the maximum allowable discharge concentration is 15 mg/l.
6.	Nutrients	Shall not exceed the site-specific limits necessary to control accelerated or cultural eutrophication.
7.	Other Constituents	Waters shall be free from pollutants in concentrations or combinations that: a) Exceed the recommended limits on the most sensitive receiving water use; b) Injure, are toxic to, or produce adverse physiological or behavioral responses in humans or aquatic life, or c) Exceed site-specific safe exposure levels determined by bioassay using sensitive resident species.

Problems Meeting Standards

Most of Boston's outer harbor waters meet Massachusetts minimum criteria for their designated classes. However, copper in waters across Boston Harbor have been found in concentrations which exceed EPA's White Book criteria for the protection of saltwater aquatic life (Wallace, et al., 1984; see Metals below). Based on sampling results from DWPC's 1982, 1983, and 1984 surveys, the waters in the following areas occasionally fail to meet the minimum criteria for their designated class:

- Inner Harbor (and the Chelsea River)
- Belle Isle Inlet
- Dorchester Bay near Moon Island discharge

Water sampling by several MDC consultants for recent (1980-1981) CSO facilities plans also documented near shore violations in the areas listed above, and in addition, the following areas:

- Neponset River
- Dorchester Bay

Sections of Quincy Bay and Hingham Harbor have also reportedly exceeded Massachusetts minimum water quality criteria (Havens & Emmerson/Parsons Brinkerhoff, 1984 Deer Island Facilities Plan, p. E1.16).

The Inner Harbor has, by far, the worst water quality in Boston Harbor. Low dissolved oxygen (D.O.) and high bacterial concentrations are responsible for water quality violations (McKechnie, DWPC, 1983). 1984 sampling found 40% of the samples failed to meet the 6 mg/l criterion, but only one sample exceeded the 1000 fecal coliform/100 ml criterion. Heavy metals concentrations in the water column also exceeded EPA White Book criteria for the protection of saltwater aquatic life (see Metals, below). Despite these violations, Class SC uses such as boating and fishing still take place in the Inner Harbor and its tributaries.

In the Belle Isle Inlet, violations of water quality criteria were documented by DWPC's August 2, 1983, sampling for D.O. and coliform bacteria following a storm event. DWPC reports that nearby Constitution Beach is closed after such storm events because of a major CSO located in the immediate vicinity of the beach.

Near the Moon Island discharge, DWPC sampling found D.O. below the minimum criteria in the bottom waters after a storm event. Coliform levels were within acceptable limits for Class SB waters. Impairment of designated water uses for this area has not been reported per se, however, activation of the Moon Island discharge is known to lead to shellfish bed closings (through a reporting procedure).

Near shore, water quality violations have been reported in MDC's CSO reports. These reports attribute violations primarily to excessive coliform levels, and to a lesser extent, low D.O. (MDC, 1982 CSO Project Summary Report, p. 5). Oil and grease criteria are also exceeded in the CSO study areas (Inner Harbor and its tributaries, Dorchester Bay, the Neponset River estuary and in the vicinity of Constitution Beach in East Boston). In Dorchester Bay and at Constitution Beach these nearshore violations lead to beach posting on an intermittent basis (particularly after wet weather) and shellfish bed closure on a regular basis.

Ambient Water Quality

The following description of ambient water quality is presented by water quality parameter, beginning with parameters directly referenced in Massachusetts' minimum water quality criteria. These are followed by other water quality parameters which are commonly considered in the ecologic evaluation of marine and estuarine ecosystems.

The results of 1982, 1983, and 1984 DWPC sampling are used herein to characterize ambient conditions for several reasons:

1. Sample collection and analysis for 1982, 1983, and 1984 were performed in a consistent manner.

2. Samples were collected at stations covering most of Boston Harbor.

3. Resampling of permanent stations provides information on time variability of a parameter in a given location.

4. The sampling reflects recent conditions.

The chief drawback of using this data is that only summer conditions are presented. The summer season is, however, of primary concern from the viewpoint of harbor uses affected by water quality.

As the DWPC 1984 data only became available recently the figures which accompany the following discussion show the results of 1982 and 1983 data only. 1984 data is included in the following discussion and is reproduced in Appendix C.

Dissolved Oxygen

Dissolved oxygen must be present in water for higher order marine life such as fish to survive. The maximum amount of oxygen which may be dissolved in water is dependent on temperature, and to a lesser

extent, chloride concentration. At higher water temperatures, less oxygen can be dissolved in the water; similarly, at higher chloride concentrations, less oxygen can be dissolved. DWPC recently amended the D.O. criterion to reflect temperature effects. At temperatures greater than 77°F (25°C) the minimum criterion for D.O. is 85% of saturation. Below this temperature the criterion for D.O. is 6.0 mg/l. Also, it is DWPC's policy to use the average DO concentration found in the water column (at different depths during a single sampling event) in their interpretation of the 6.0 mg/l criterion (letter T.C. McMahon, Director DWPC to K. McSweeney USEPA, 12/15/84).

"When oxygen values become less than 3 mg/l (ppm), most finfish species will not survive. Most shellfish species are more tolerant, but during prolonged periods (weeks) of anoxia, they will also succumb." (MERL, 1980, p.9) Generally, benthic or bottom dwelling species, such as founder, are more adapted to the naturally lower oxygen levels found near the bottom, compared to species which reside higher in the water column.

Figures 10 through 13 depict D.O. concentrations during the 1982 and 1983 sampling. The following observations can be made with regard to DWPC's D.O. data:

1. D.O. concentrations are variable at all stations. The range of D.O. concentrations harbor-wide was 2.4-9.7 mg/l in 1982, 3.5-20.8 mg/l in 1983, and 2.2-17.8 mg/l in 1984. Note that very few values are greater than 10 mg/l and, at the temperatures reported, these high values may represent supersaturated conditions.

2. D.O. concentrations are generally lowest in the Inner Harbor, particularly in the deep water samples.

3. D.O. concentrations are usually within a range adequate to support higher marine organisms, except occasionally near the bottom and in the Inner Harbor. Occasional low D.O. levels

Dissolved Oxygen at Surface (1982)

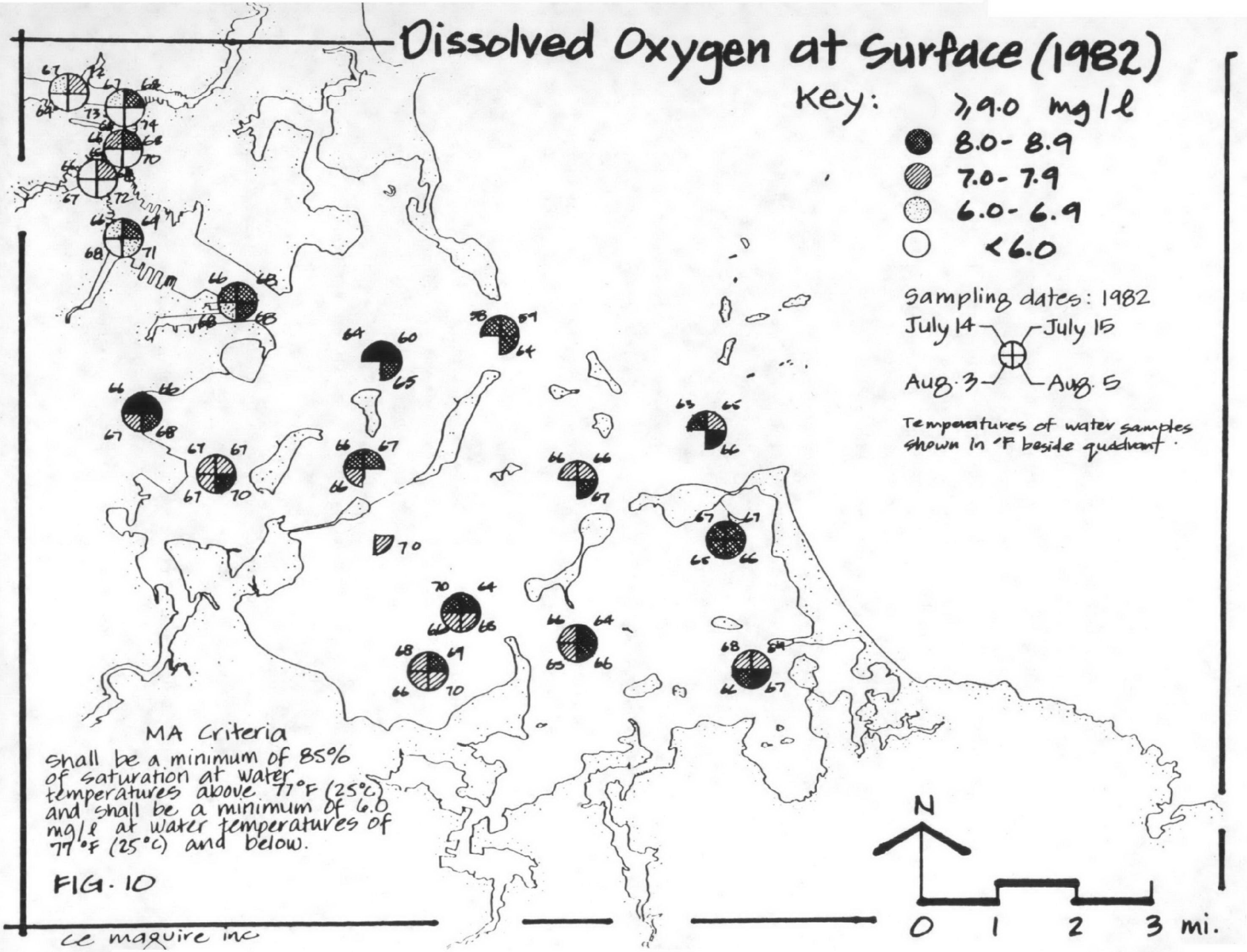


FIG. 10

cc maguire inc

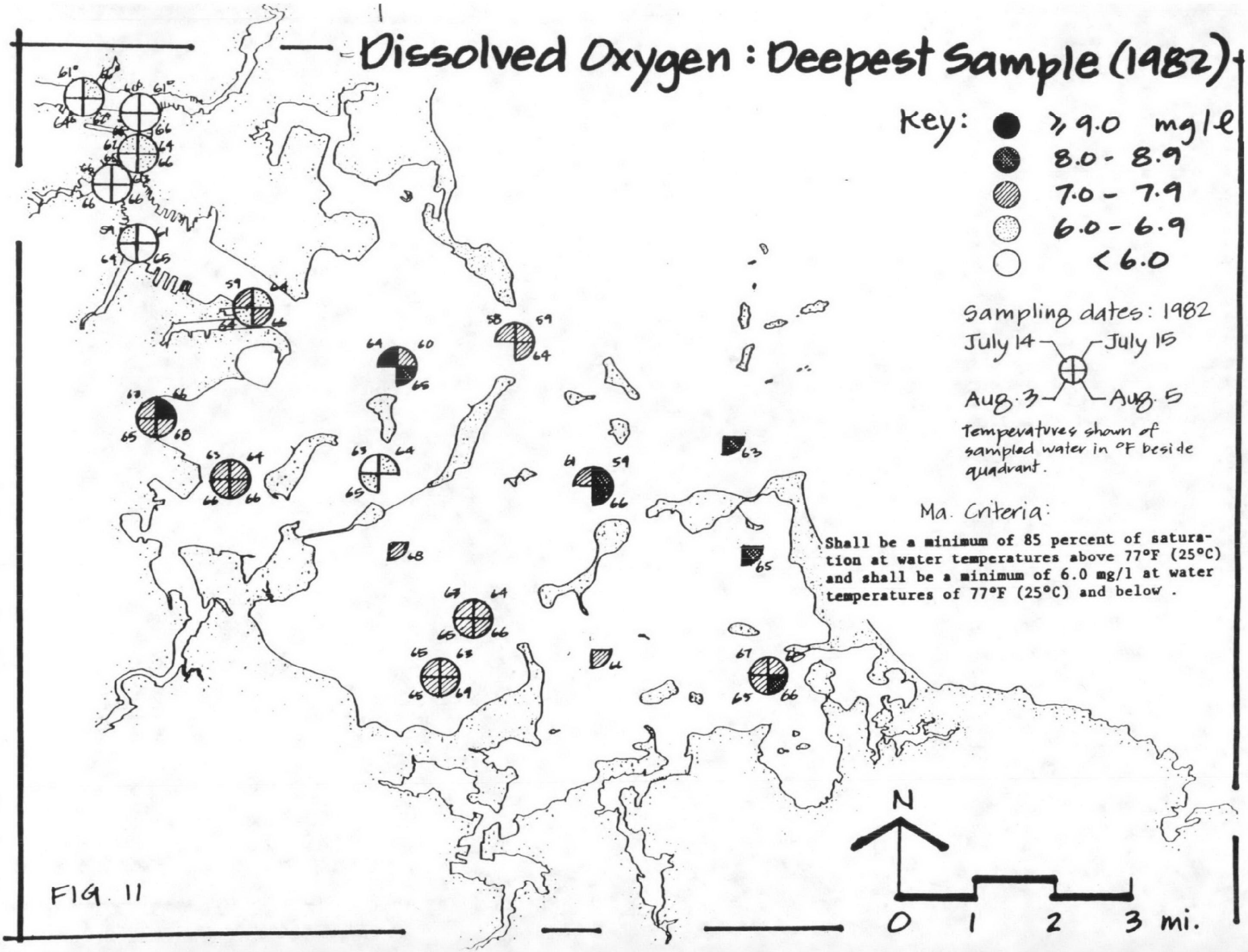

Dissolved Oxygen : Deepest Sample (1982)
Key:
≥ 9.0 mg/l
8.0 - 8.9
7.0 - 7.9
6.0 - 6.9
< 6.0
Sampling dates: 1982
July 14
July 15
Aug. 3
Aug. 5
Temperatures shown of sampled water in °F beside quadrant.
Ma. Criteria:
Shall be a minimum of 85 percent of saturation at water temperatures above 77°F (25°C) and shall be a minimum of 6.0 mg/l at water temperatures of 77°F (25°C) and below .
N
0 1 2 3 mi.

FIG. 11

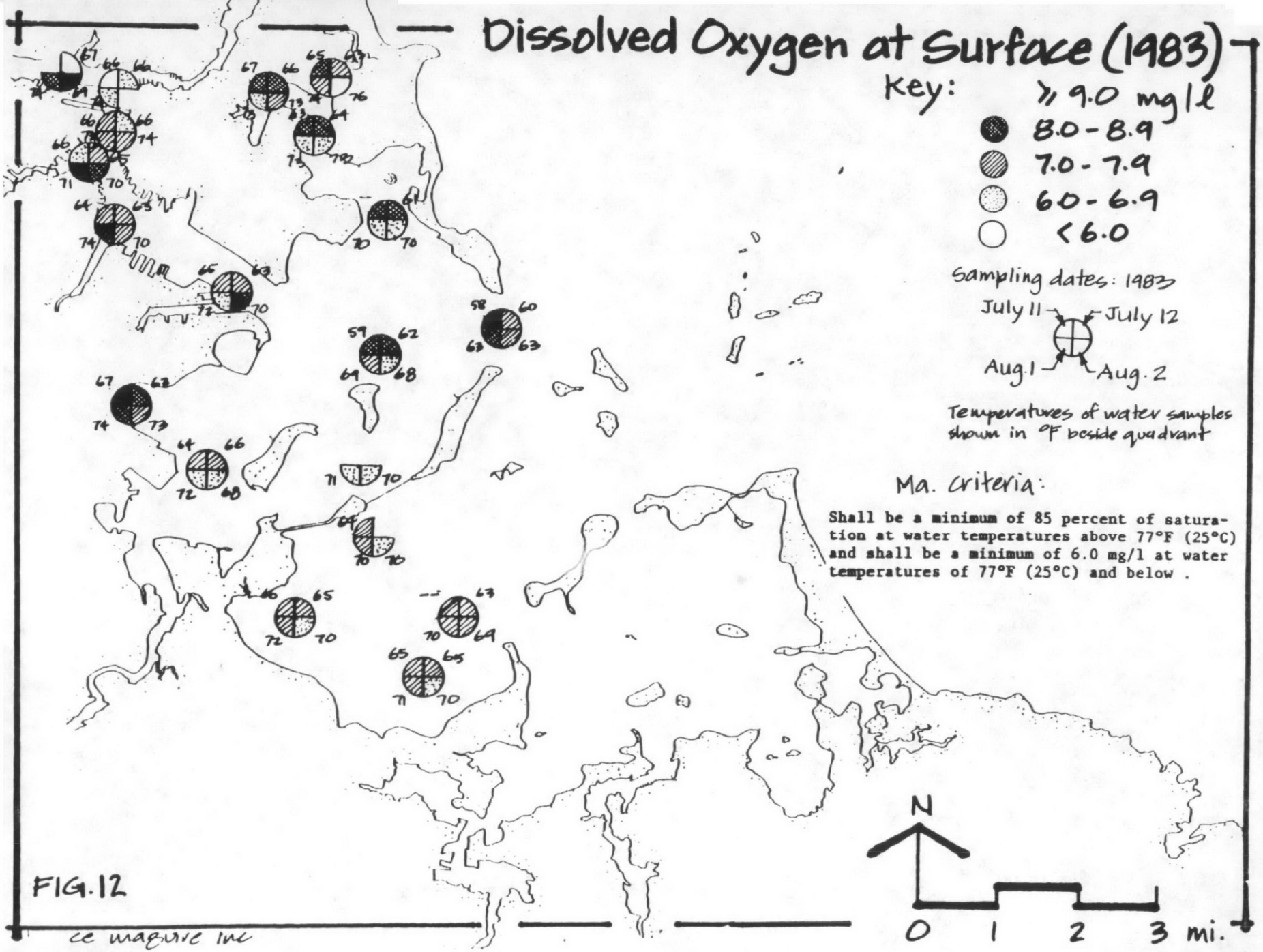


FIG. 12

cc maguire inc

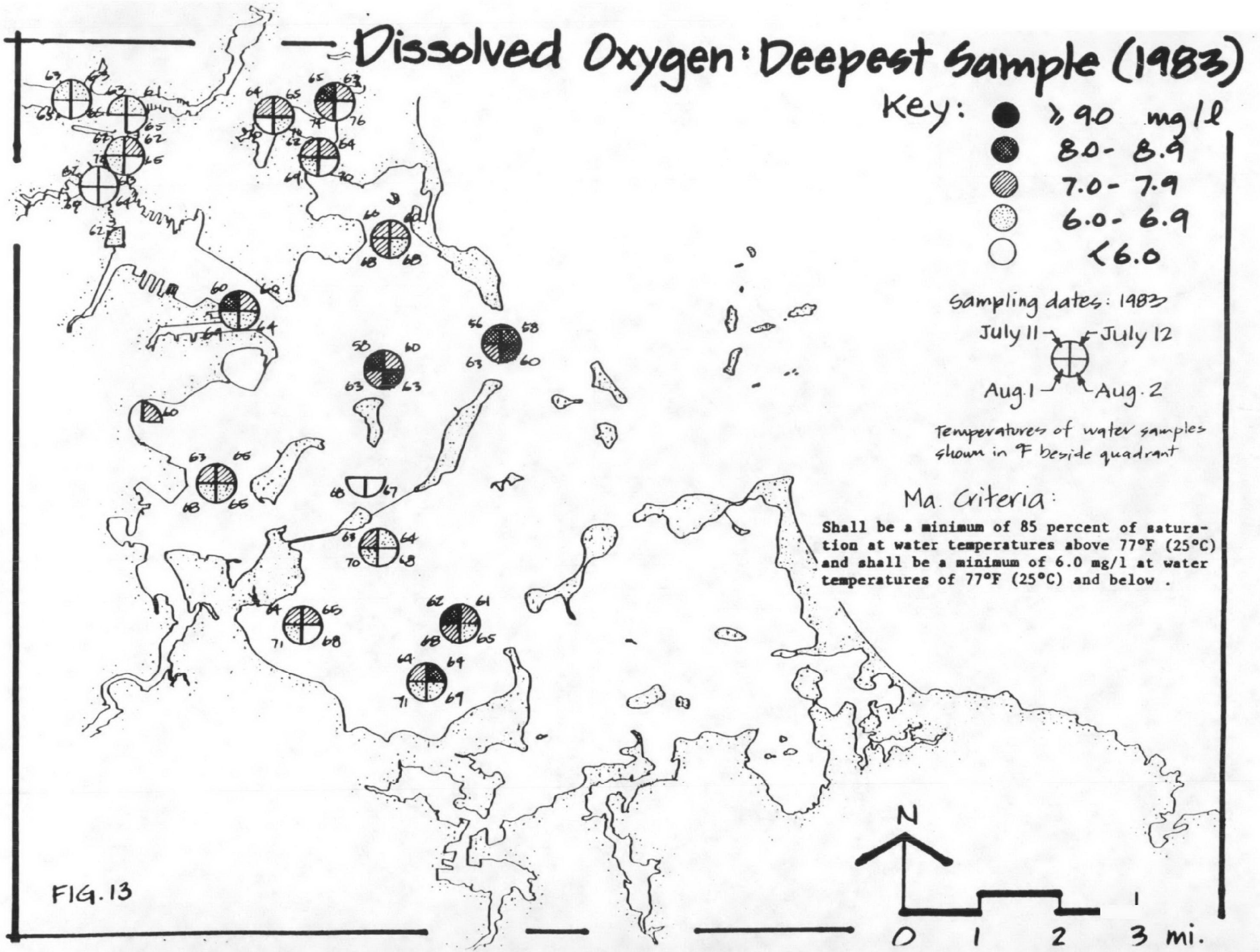

Dissolved Oxygen: Deepest Sample (1983)
Key:
≥ 9.0 mg/l
8.0 - 8.9
7.0 - 7.9
6.0 - 6.9
< 6.0
Sampling dates: 1983
July 11
July 12
Aug. 1
Aug. 2
Temperatures of water samples shown in °F beside quadrant
Ma. Criteria:
Shall be a minimum of 85 percent of saturation at water temperatures above 77°F (25°C) and shall be a minimum of 6.0 mg/l at water temperatures of 77°F (25°C) and below .
N
0 1 2 3 mi.

FIG. 13

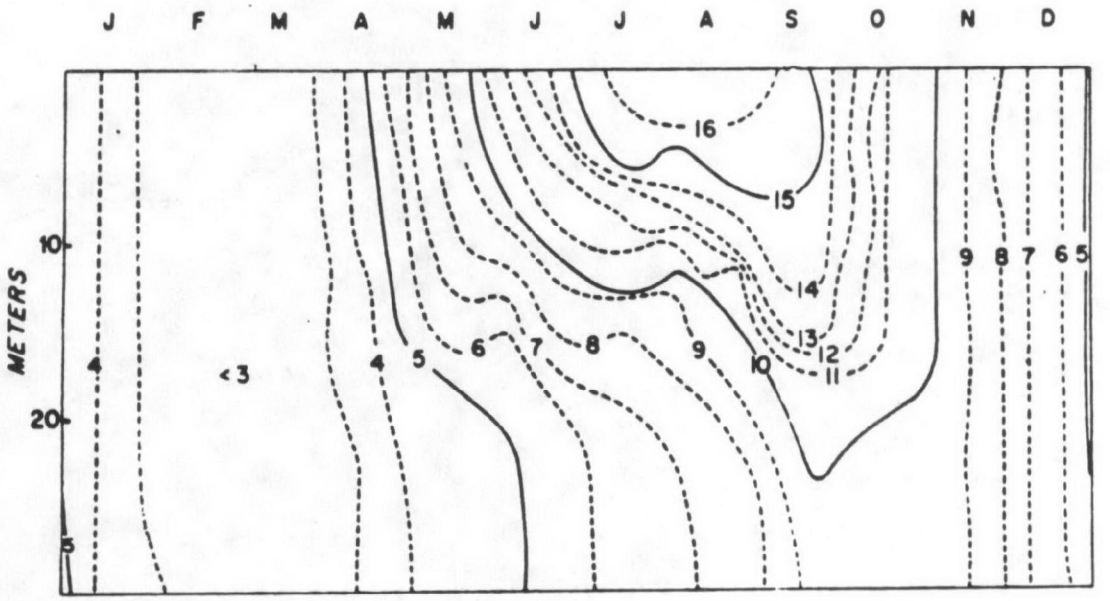


FIGURE TAKEN FROM REVIEW OF THE PHYSICAL OCEANOGRAPHY OF MASSACHUSETTS BAY, WOODS HOLE OCEANOGRAPHIC INSTITUTION FEBUARY, 1974

METCALF & EDDY

Fig. 14

SEASONAL TEMPERATURE VARIATIONS AT BOSTON LIGHTSHIP

Seasonal temperature variations at Boston Lightship showing thermal stratification with depth during summer.

have been reported in the immediate vicinity of the Deer Island discharge.

It is likely that low DO in the Inner Harbor is a contributing factor to the conditions which favor benthic species, such as Capitella sp. (a worm) over species which require higher DO concentrations (see part D, Biologic Conditions). There is no documentation that low DO leads to adverse physiologic effects in the indigenous marine life of Boston Harbor.

Summer thermal stratification is reported in the Harbor in the 301(h) Waiver Application and has been documented as far offshore as the Boston Lightship (see Figure 14). This stratification limits reaeration of bottom waters.

pH

The pH of a solution refers to its hydrogen ion activity. pH is expressed in a range from 0-14 with 0 being very acid, 14 being very basic and 7 corresponding to exact neutrality (at 25°C). 1982 and 1983 pH values reported for the Harbor are shown in Figure 15 and 16.

These values fall in the range of 7.3 to 8.2 units, all within the naturally occurring pH range for seawater. 1984 pH data range from 7.5 to 8.8 units with only one value greater than 8.4 units. There is considerable variability in pH between samplings at each station. pH appears to relate to chloride concentration (see below), and both are influenced by tidal stage.

Total Coliform Bacteria

Total coliform bacteria are a group of bacterial species which include bacteria present in animal feces and other types of decaying organic matter. Generally, member species do not cause disease in humans; the presence of total coliform bacteria is an indicator that the water may be contaminated with sewage, and therefore may contain

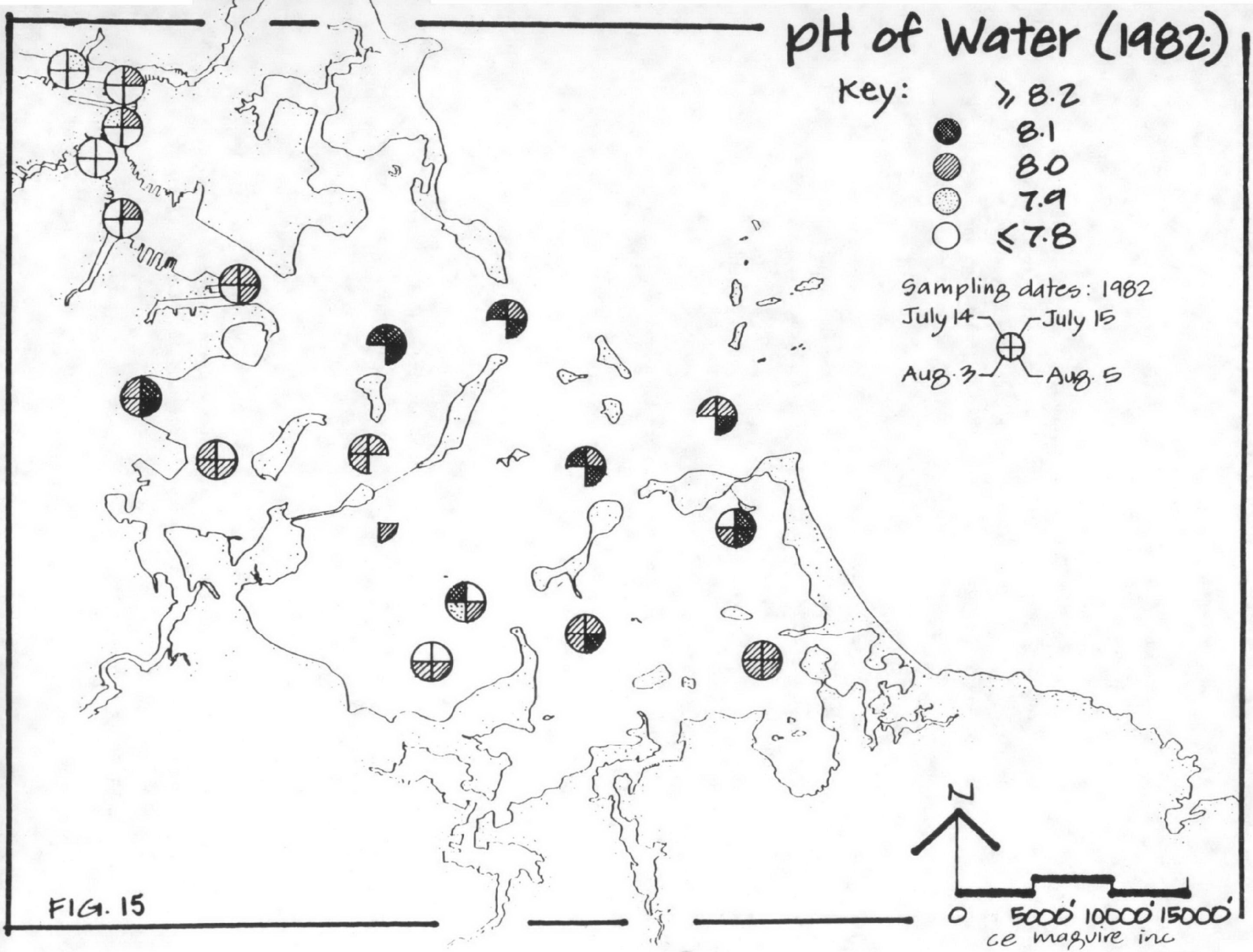

pH of Water (1982)
Key:
≥ 8.2
8.1
8.0
7.9
≤ 7.8
Sampling dates: 1982
July 14
July 15
Aug. 3
Aug. 5
N
0
5000'
10000'
15000'
ce maguire inc

FIG. 15

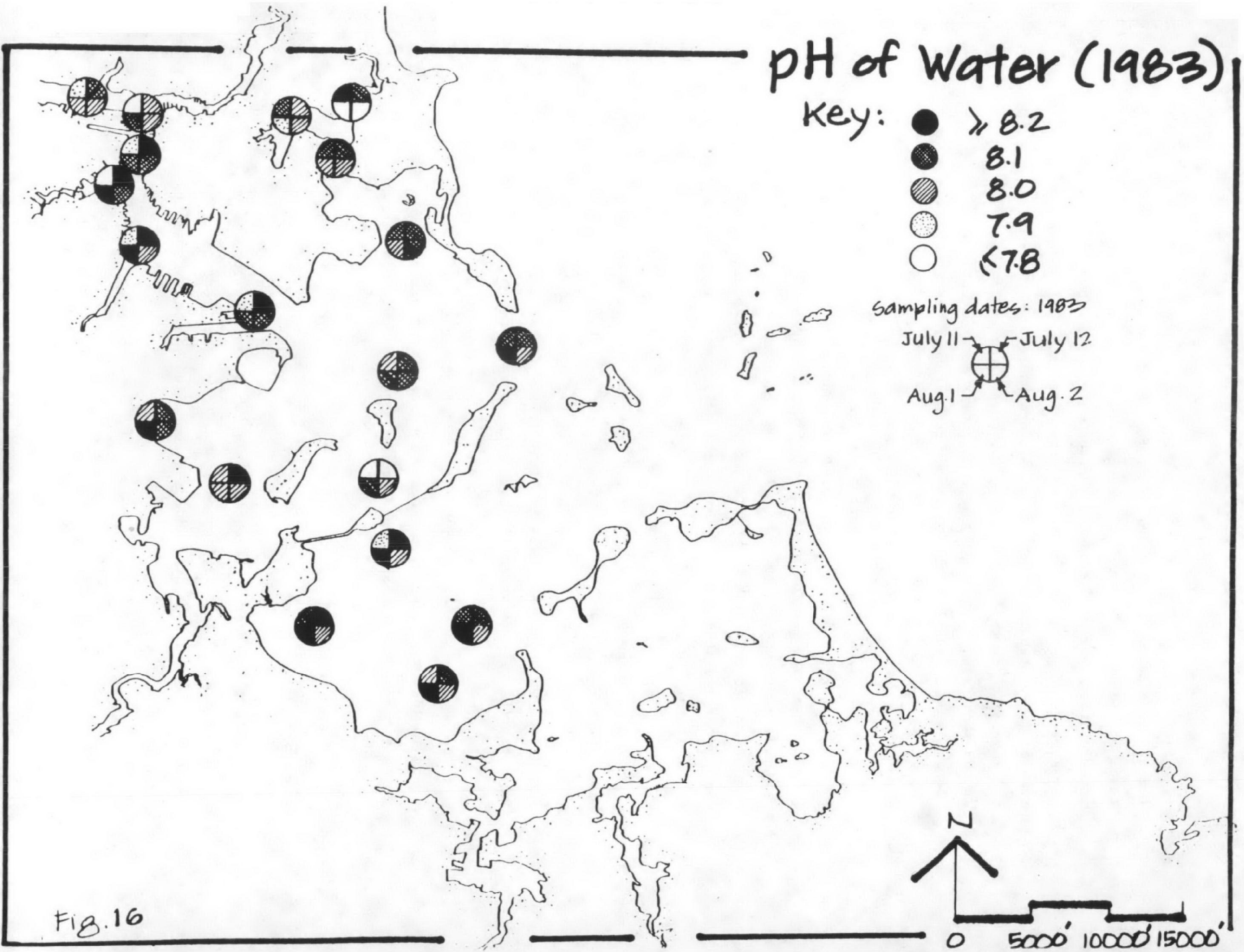

pH of Water (1983)
Key:
≥ 8.2
8.1
8.0
7.9
<7.8
Sampling dates: 1983
July 11
July 12
Aug. 1
Aug. 2
N
0
5000'
10000'
15000'

Fig. 16

human pathogens. Since non-fecal coliform bacteria are common, the total coliform standard may overestimate the threat associated with water contact in some instances. On the other hand, some viral spores may survive longer in marine environments than the coliform bacteria in sewage; the concentration of total coliform bacteria may therefore underestimate the threat associated with water contact in such cases. In the absence of other widely accepted, inexpensive tests for microbial water quality, the total coliform standard remains in popular use.

1982 and 1983 total coliform concentrations in the harbor are shown in Figures 17 and 18. Reported concentrations range from 5 to 110,000 organisms per 100 milliliters of water. 1984 total coliform concentrations ranged from <20 to 200,000 organisms per 100 ml. Highest concentrations are reported in the Inner Harbor and in the northern area of the harbor (where combined sewer overflows occur) than in the southern part.

To the extent that these sampling results are representative of mean concentrations which are the basis of the bathing (class SB) standard's bacterial criteria, these criteria appear to be met in Hingham and Quincy Bays. 1984 sampling showed two samples from Dorchester Bay in excess of 1000 organisms per 100 ml.

The one sample showing high bacterial concentrations at Deer Island in 1983 was taken in the boil from the sludge discharge. High concentrations of ammonia and phosphorus were also found in this sample.

Fecal Coliform Bacteria

The fecal coliform test differentiates between coliforms from animal feces and coliforms from other sources. The presence of fecal coliform is commonly used to indicate contamination with human or animal excrement.

1982 and 1983 fecal coliform concentrations are shown in Figures 19 and 20. They show similar trends to those of total coliform; i.e., higher concentrations in the northern part of the Harbor than in the southern part. Highest reported concentrations occur in the Inner Harbor, Belle Island Inlet, and in the sample taken at the Deer Island sludge discharge. The total range from 1982, 1983, and 1984 sampling is <5-15,000 fecal coliform organisms per 100 ml.

Chloride and Conductance

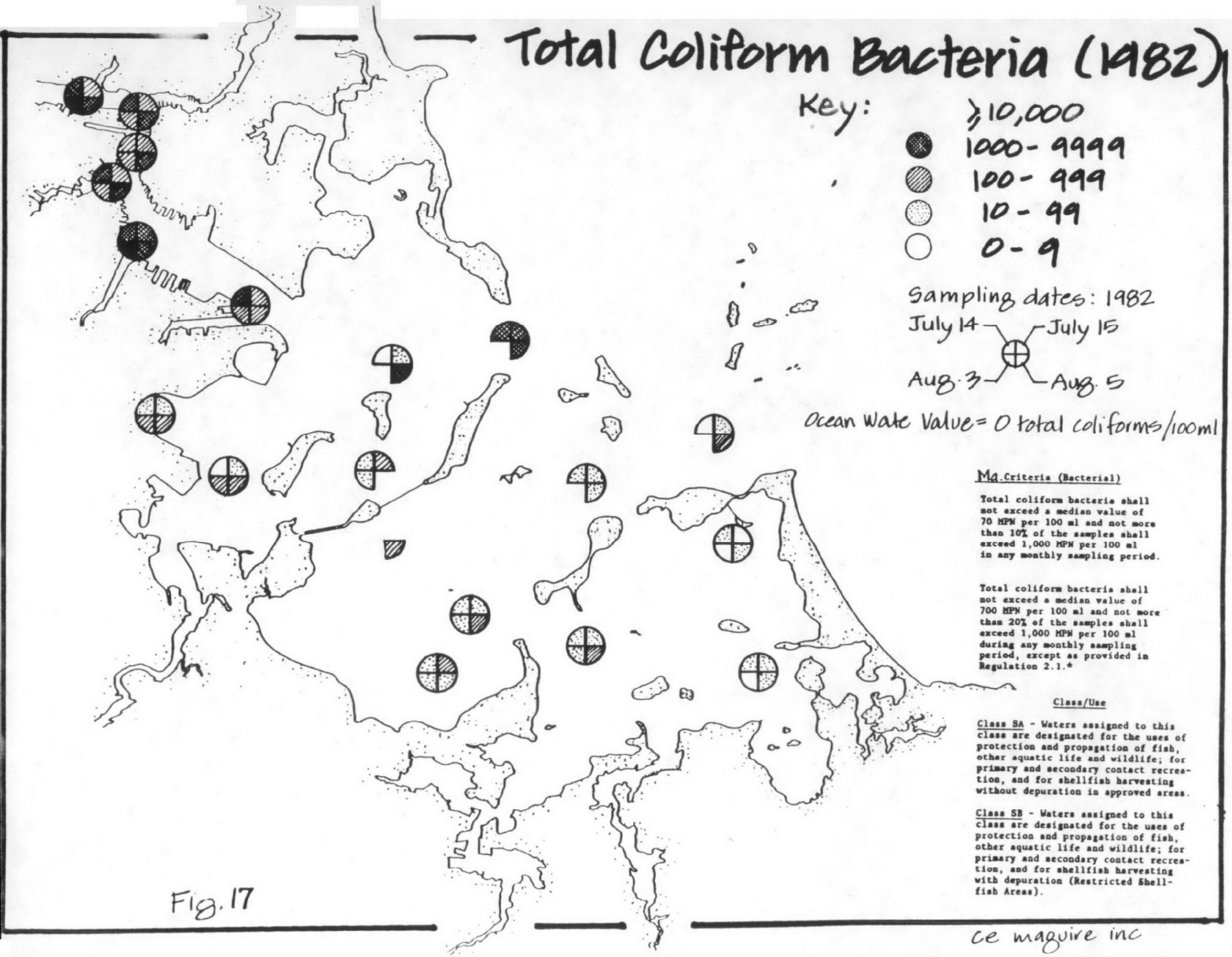
Chloride and conductance data for 1982 and 1983 are shown in Figures 21 through 24. These data show considerable variability between samplings at each station and from station to station. This variability is probably attributable to the effects of tide. Nonetheless, concentrations of both parameters generally appear slightly lower nearer fresh water inputs along the shore than in the outer harbor.

Suspended Solids (non-filterable residue)

Suspended solids (SS) concentrations, shown on Figures 25 and 26, are also highly variable. This variability could be attributable to the effects of currents and winds on settling and resuspension of solids or to the inherent inaccuracy of analysis techniques. Because of the impossibility of controlling all of the variables in solids testing, determinations are not subject to the usual criteria of accuracy (Standard Methods pg. 89). Therefore, only statistical analysis of large numbers of random samples can be used to indicate trends.

If all the data for the Harbor are viewed collectively, reported values are elevated compared to seawater but fairly typical for an urban estuary. Suspended solids concentrations reported for 1984 sampling are generally lower than 1982 and 1983 concentrations.

Total Coliform Bacteria (1982)



Ma. Criteria (Bacterial)

Total coliform bacteria shall not exceed a median value of 70 MPN per 100 ml and not more than 10% of the samples shall exceed 1,000 MPN per 100 ml in any monthly sampling period.

Total coliform bacteria shall not exceed a median value of 700 MPN per 100 ml and not more than 20% of the samples shall exceed 1,000 MPN per 100 ml during any monthly sampling period, except as provided in Regulation 2.1.*

Class/Use

Class SA - Waters assigned to this class are designated for the uses of protection and propagation of fish, other aquatic life and wildlife; for primary and secondary contact recreation, and for shellfish harvesting without depuration in approved areas.

Class SB - Waters assigned to this class are designated for the uses of protection and propagation of fish, other aquatic life and wildlife; for primary and secondary contact recreation, and for shellfish harvesting with depuration (Restricted Shellfish Areas).

Fig. 17

ce maguire inc

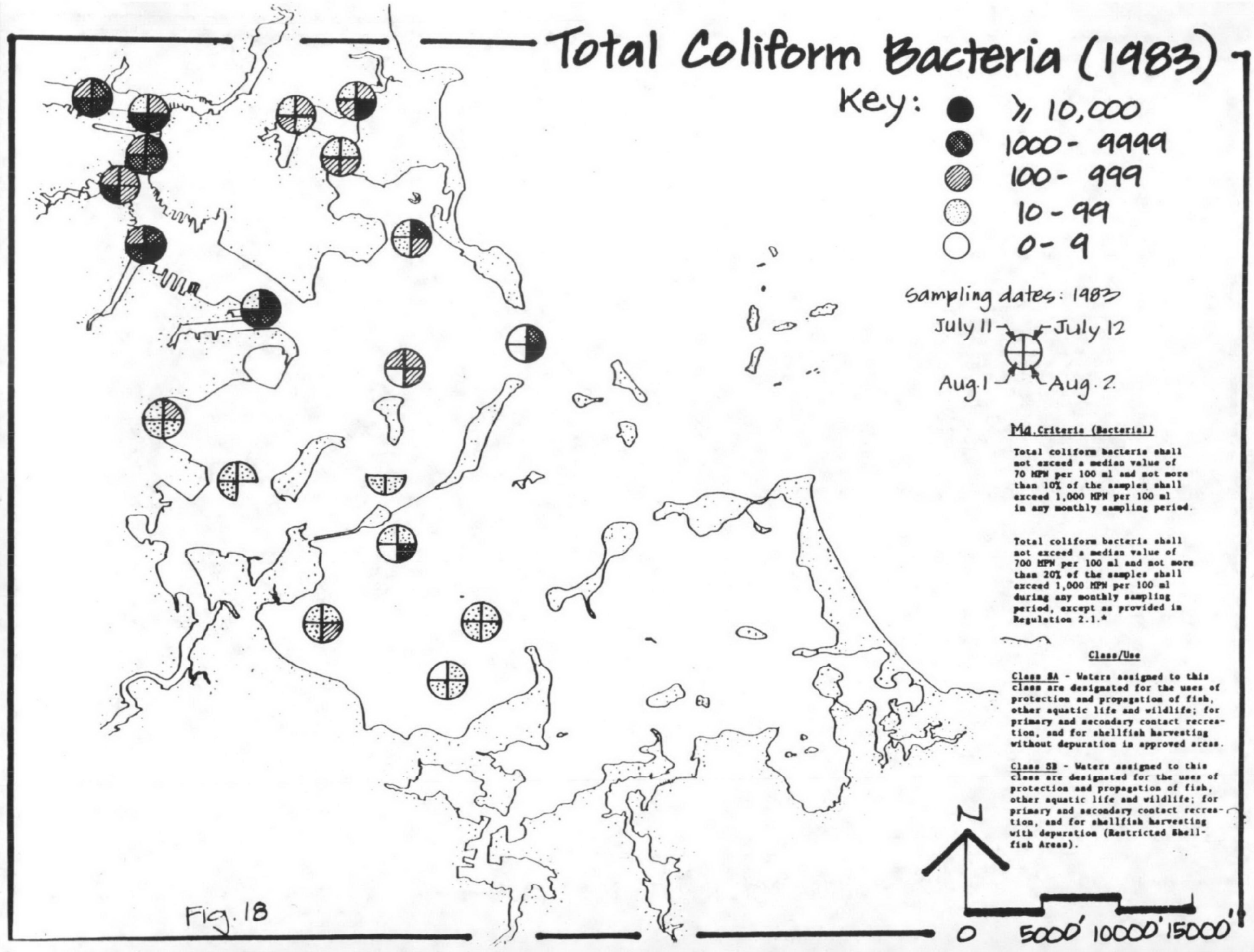

Total Coliform Bacteria (1983)
Key:
≥ 10,000
1000 - 9999
100 - 999
10 - 99
0 - 9
Sampling dates: 1983
July 11
July 12
Aug. 1
Aug. 2
Mq. Criteria (Bacterial)
Total coliform bacteria shall not exceed a median value of 70 MPN per 100 ml and not more than 10% of the samples shall exceed 1,000 MPN per 100 ml in any monthly sampling period.
Total coliform bacteria shall not exceed a median value of 700 MPN per 100 ml and not more than 20% of the samples shall exceed 1,000 MPN per 100 ml during any monthly sampling period, except as provided in Regulation 2.1.*
Class/Use
Class SA - Waters assigned to this class are designated for the uses of protection and propagation of fish, other aquatic life and wildlife; for primary and secondary contact recreation, and for shellfish harvesting without depuration in approved areas.
Class SB - Waters assigned to this class are designated for the uses of protection and propagation of fish, other aquatic life and wildlife; for primary and secondary contact recreation, and for shellfish harvesting with depuration (Restricted Shellfish Areas).
N
0
5000'
10000'
15000'

Fig. 18

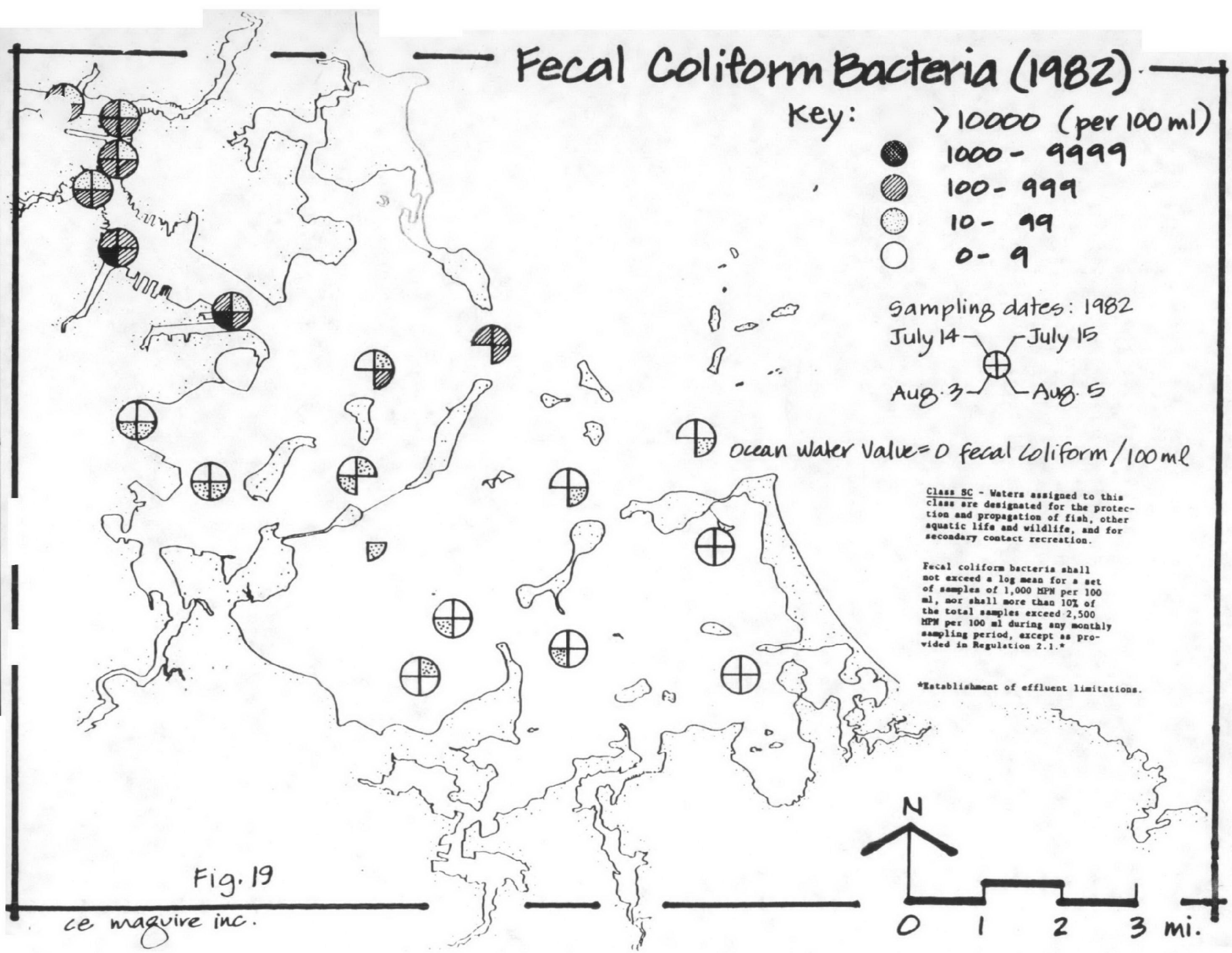


Fig. 19

ce maguire inc.

Fecal Coliform Bacteria (1983)

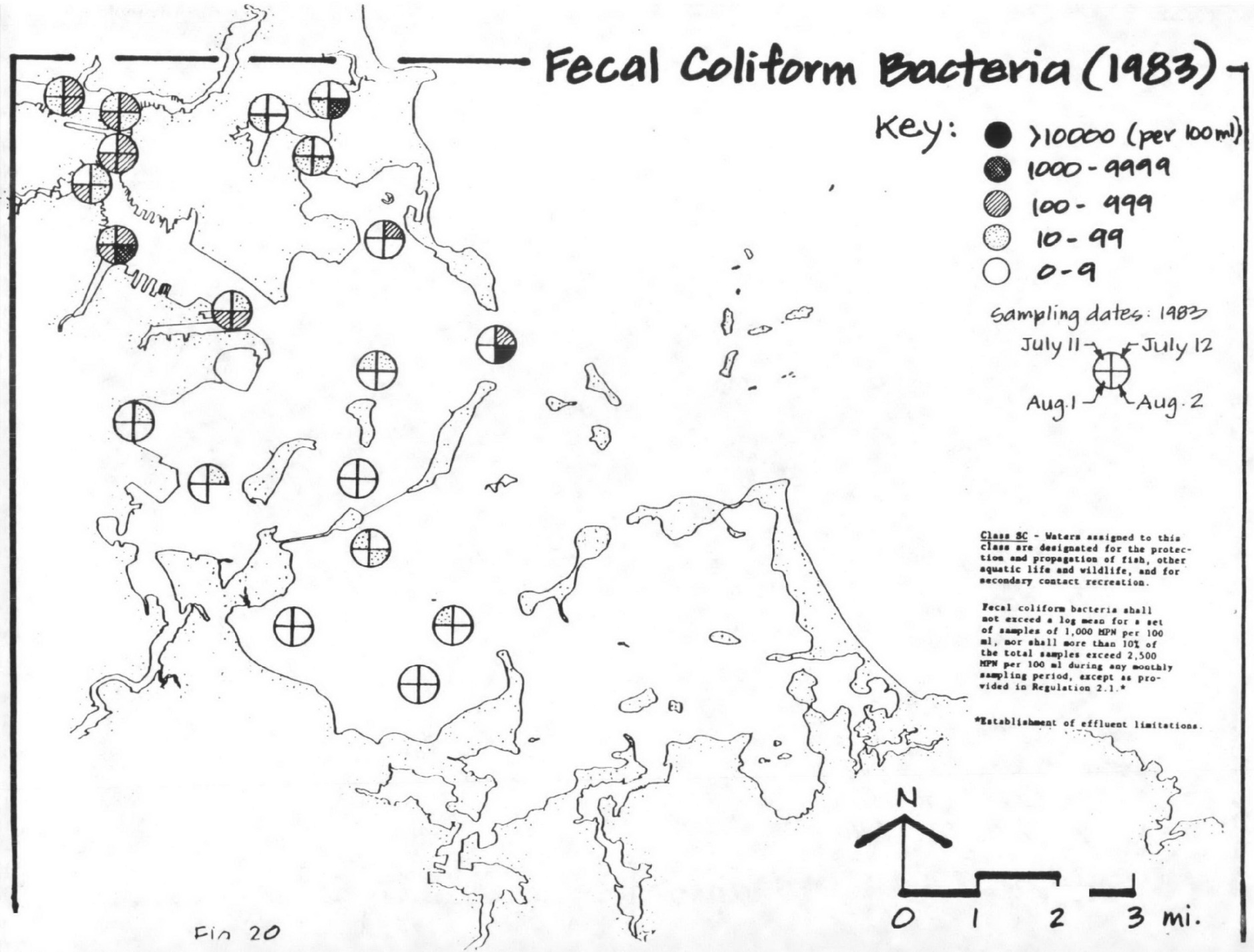


Fig 20

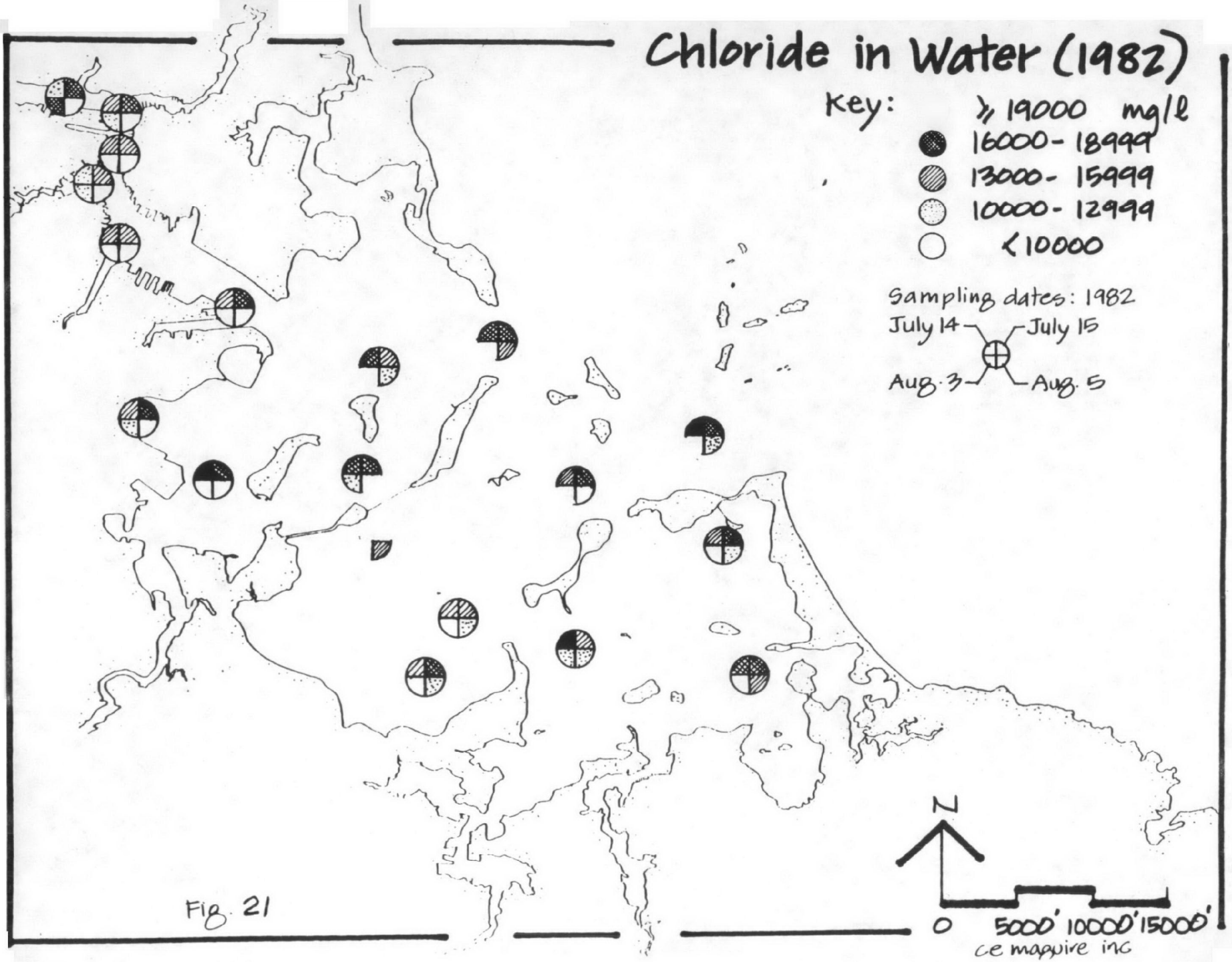

Chloride in Water (1982)
Key:
≥ 19000 mg/l
16000 - 18999
13000 - 15999
10000 - 12999
< 10000
Sampling dates: 1982
July 14
July 15
Aug. 3
Aug. 5
N
0
5000'
10000'
15000'
ce maguire inc

Fig. 21

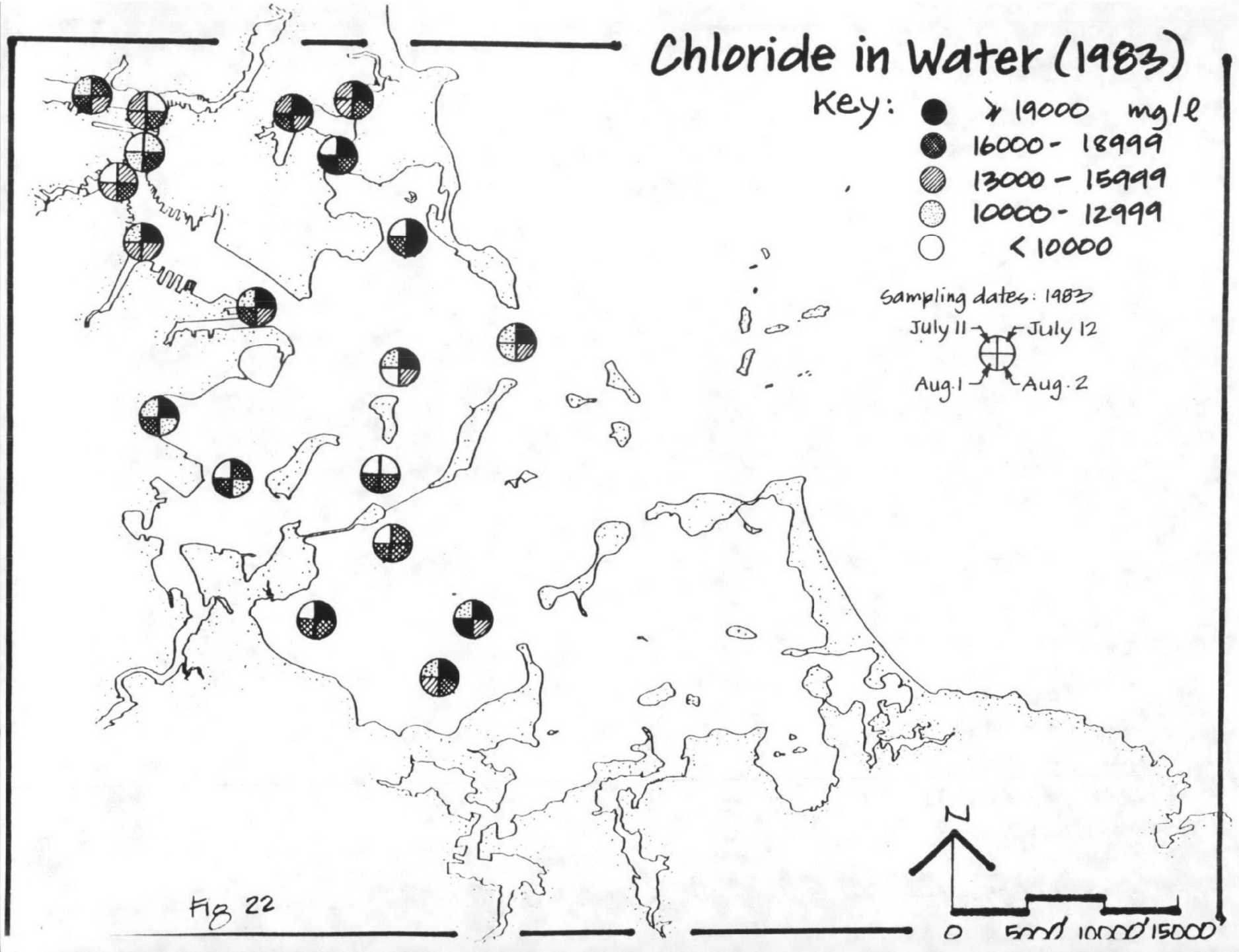

Chloride in Water (1983)
Key:
≥ 19000 mg/l
16000 - 18999
13000 - 15999
10000 - 12999
< 10000
Sampling dates: 1983
July 11
July 12
Aug. 1
Aug. 2
N
0
5000
10000
15000

Fig 22

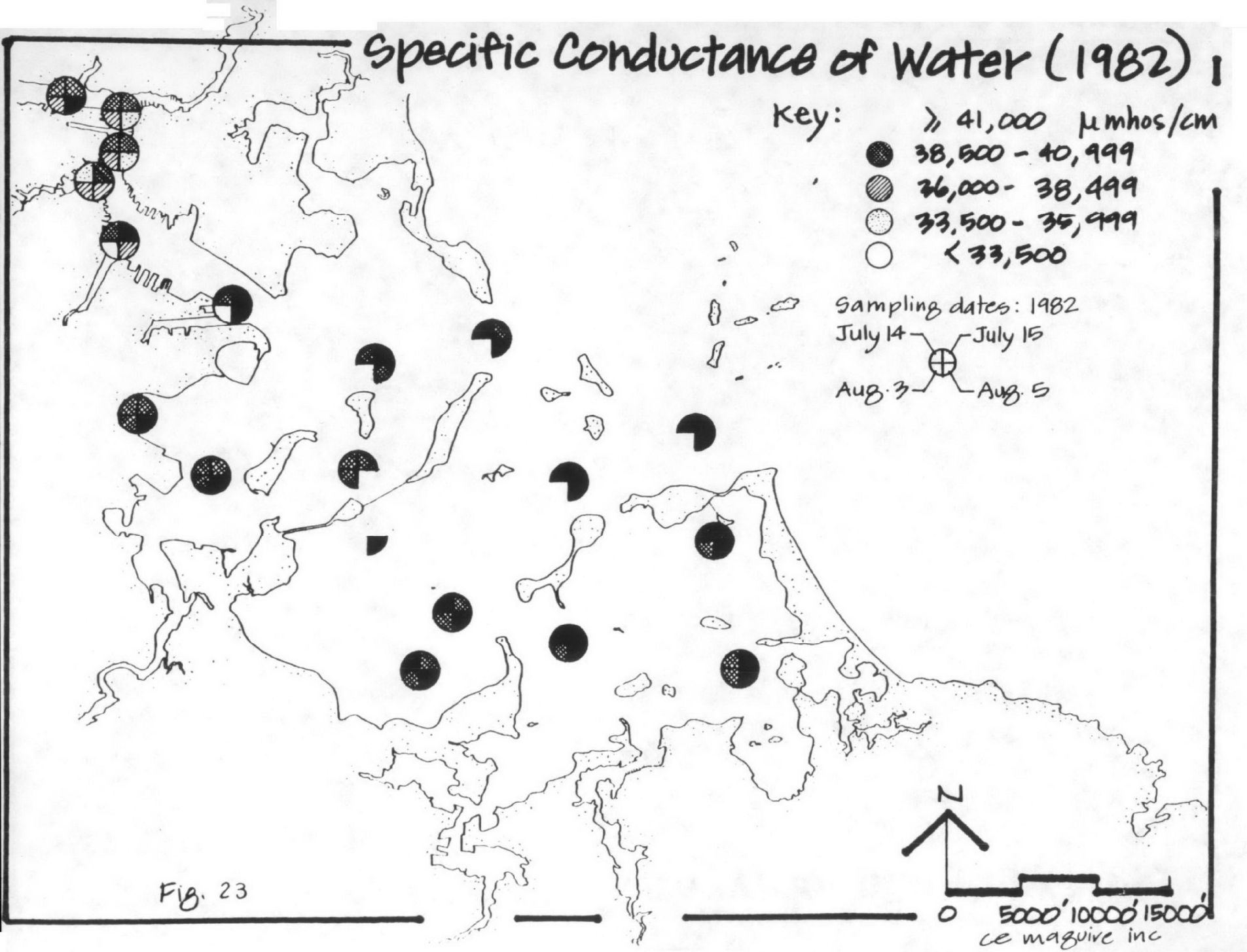

Specific Conductance of Water (1982)
Key:
≥ 41,000 µmhos/cm
38,500 - 40,999
36,000 - 38,499
33,500 - 35,999
< 33,500
Sampling dates: 1982
July 14
July 15
Aug. 3
Aug. 5
N
0
5000'
10000'
15000'
ce maguire inc

Fig. 23

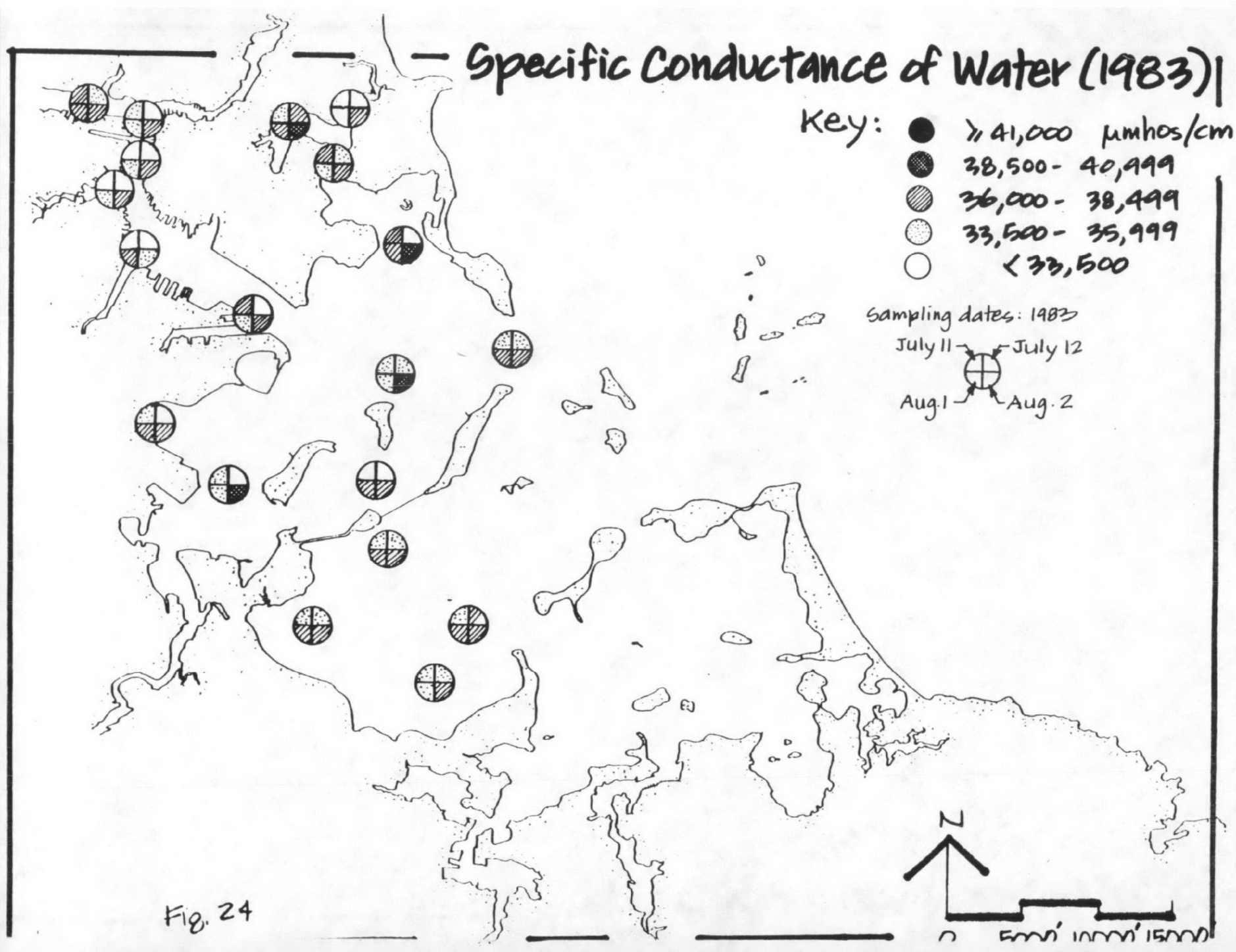

Specific Conductance of Water (1983)
Key:
≥ 41,000 µmhos/cm
38,500 - 40,999
36,000 - 38,499
33,500 - 35,999
< 33,500
Sampling dates: 1983
July 11
July 12
Aug. 1
Aug. 2
N
0
5mi
10mi
15mi

Fig. 24

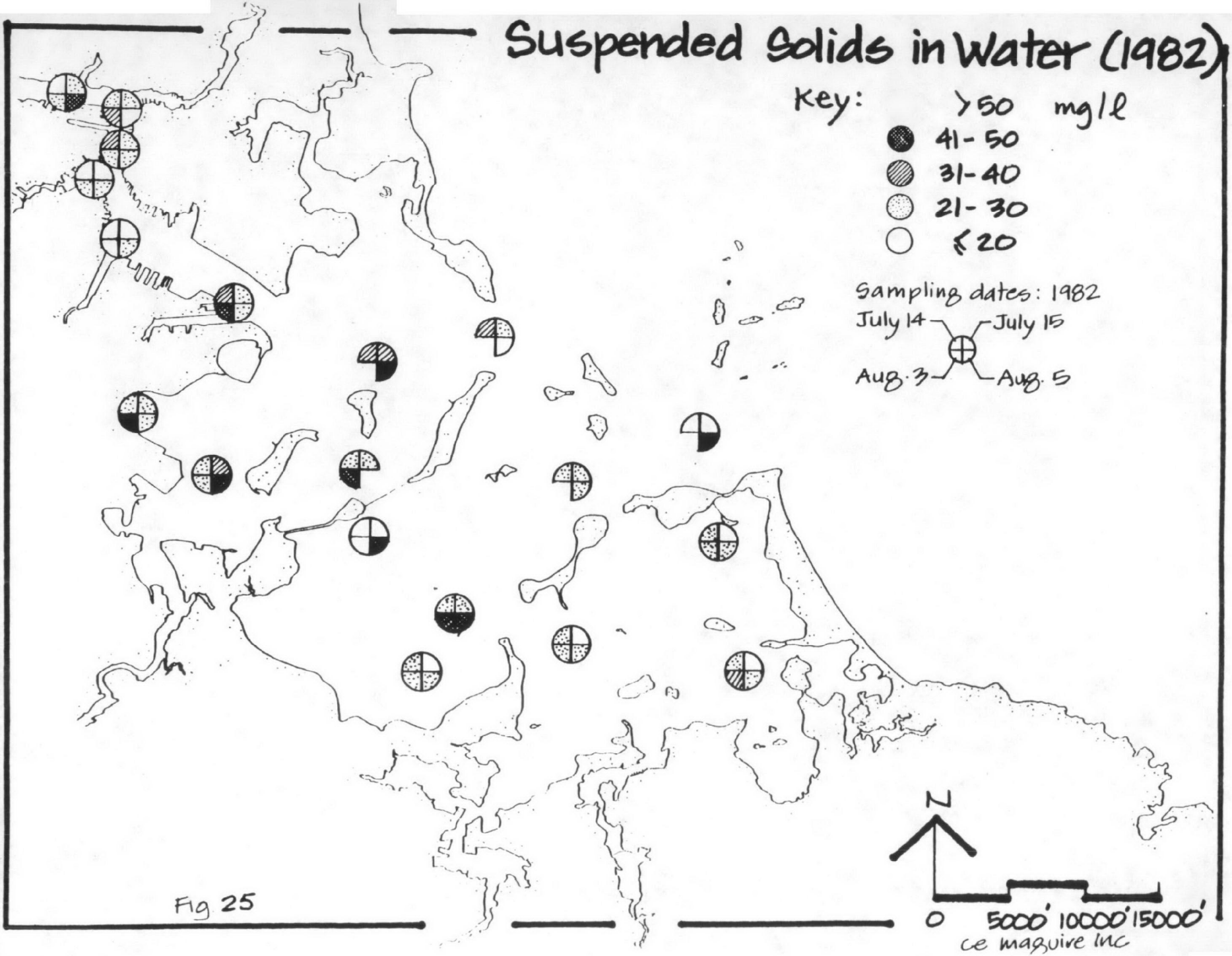

Suspended Solids in Water (1982)
Key:
>50 mg/l
41-50
31-40
21-30
≤20
Sampling dates: 1982
July 14
July 15
Aug. 3
Aug. 5
N
0
5000'
10000'
15000'
ce maguire inc

Fig 25

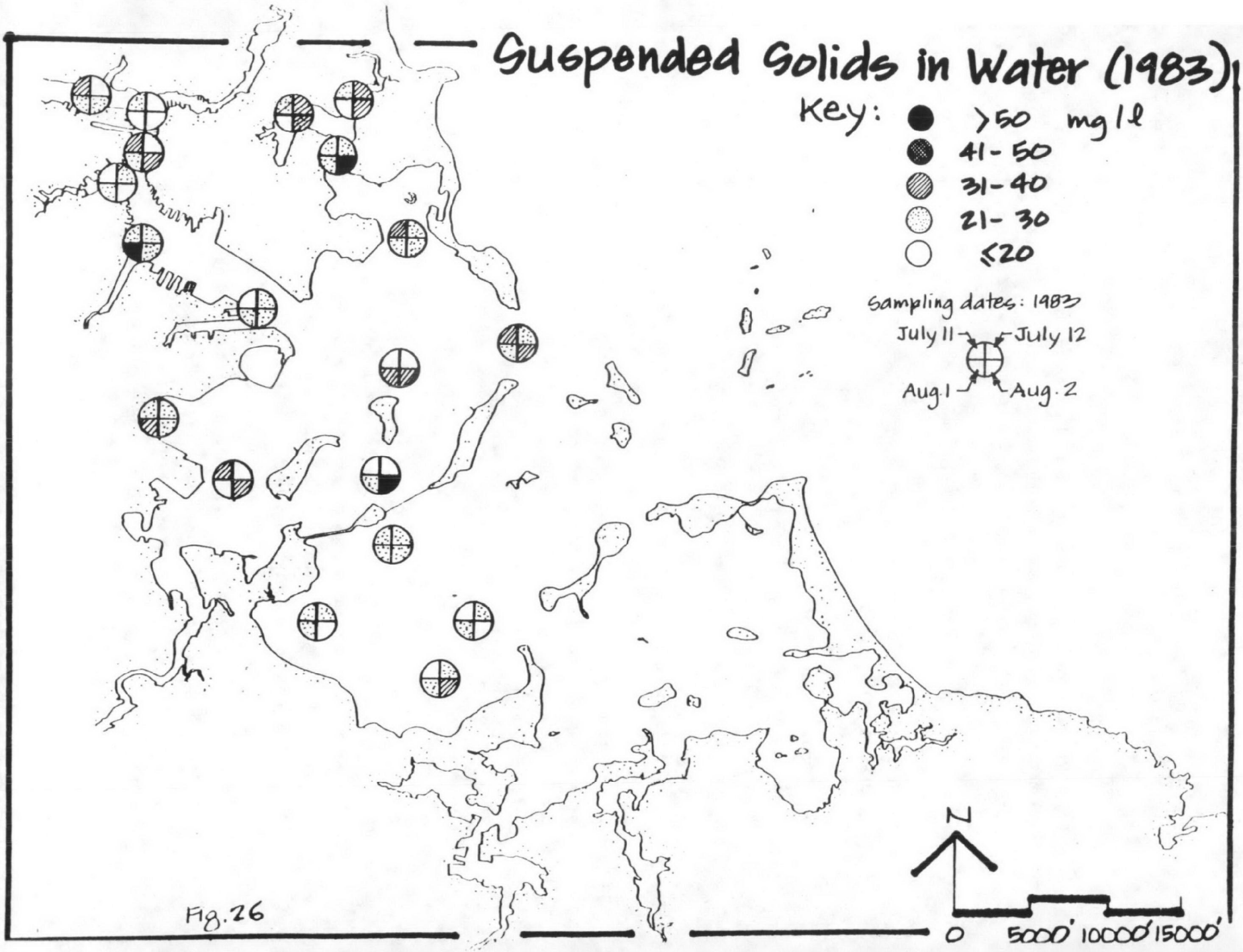

Suspended Solids in Water (1983)
Key:
>50 mg/l
41-50
31-40
21-30
≤20
Sampling dates: 1983
July 11
July 12
Aug. 1
Aug. 2
N
0
5000'
10000'
15000'

Fig. 26

Nutrients

Nitrogen and phosphorus are essential nutrients for many phytoplankton and are often limiting to phytoplankton growth. Their availability can therefore trigger algal "blooms" in water bodies.

As described below under "Biologic Conditions", algae blooms have been reported in Boston Harbor and its tributaries. However, there is no indication that such blooms have recently lead to nuisance conditions affecting harbor uses.

Nutrient enrichment caused by Nut Island wastewater discharges has been held responsible for higher biologic productivity (in numbers of organisms) in the vicinity of the outfalls (Metcalf & Eddy, 1982 301(h) Waiver Application, Addendum 3, p. 5-53).

Levels of nitrogen and phosphorus in the Harbor are generally higher than outside the Harbor, with the highest levels reported in the Inner Harbor. Seawater typically contains concentrations of about .05 mg/l of ammonia nitrogen and phosphorus (McKechnie, 1983). Concentrations reported in the Inner Harbor frequently exceeded .15 mg/l (McKechnie 1983). Each of these nutrients is discussed in greater detail below.

Ammonia

1982 and 1983 concentrations of ammonia nitrogen in the Harbor are shown in Figures 27 and 28. Elevated levels are evident in samples taken at each of the wastewater outfalls in 1982 and at the Deer Island outfall in 1983. Results also show higher concentrations in the northern part of the Harbor, where combined sewer overflows occur, than in the southern part where they do not. The range of ammonia-N in these samples is 0.00-0.91 mg/l. 1984 values ranged from 0.01 to 1.1 mg/l. Note that all stations had high ammonia levels on the 27th and 28th of August 1984.

Ammonia "... is a biologically active compound present in most waters as a normal biological degradation product of nitrogenous organic matter" (EPA 1976). When ammonia dissolves in water, some of it becomes un-ionized ammonia which may be toxic in high concentrations. The highest concentrations of un-ionized ammonia result when high temperatures occur in alkaline waters of low ionic strength. Although EPA criteria are available for fresh waters, "data available for saltwater species are insufficient to derive a criterion for salt water" (EPA, February 7, 1984, Federal Register, Vol. 49, No. 26, p. 4551).

Total Kjeldahl Nitrogen

Total Kjeldahl Nitrogen (TKN) is the sum of ammonia nitrogen and organic nitrogen. Organic nitrogen is not readily available as a plant nutrient. Rather, it is tied up in organic matter, such as dead marsh plants, algae and sewage. Organic nitrogen becomes available to plants when microorganisms break down organic matter and release ammonia nitrogen as a by-product. The organic fraction of TKN is therefore an indicator of the nitrogen "in storage" in harbor waters at a given time. This is important, since nitrogen is often the limiting plant nutrient in seawater.

Concentrations of TKN reported for 1982 and 1983 are shown in Figures 29 and 30. No significant trends are apparent from these data. It is interesting to compare these TKN concentrations with the ammonia concentrations shown in Figures 27 and 28. Note that the typical range for ammonia reported for 1982 and 1983 is less than 0.2 mg/l, only 20% of the lowest reported range of TKN (1.0 mg/l). This indicates that reported TKN is predominantly organic nitrogen and less than 20% ammonia. The range of TKN in 1982, 1983 and 1984 samples is 0.39-6.0 mg/l. This range is not unusual for an estuary.

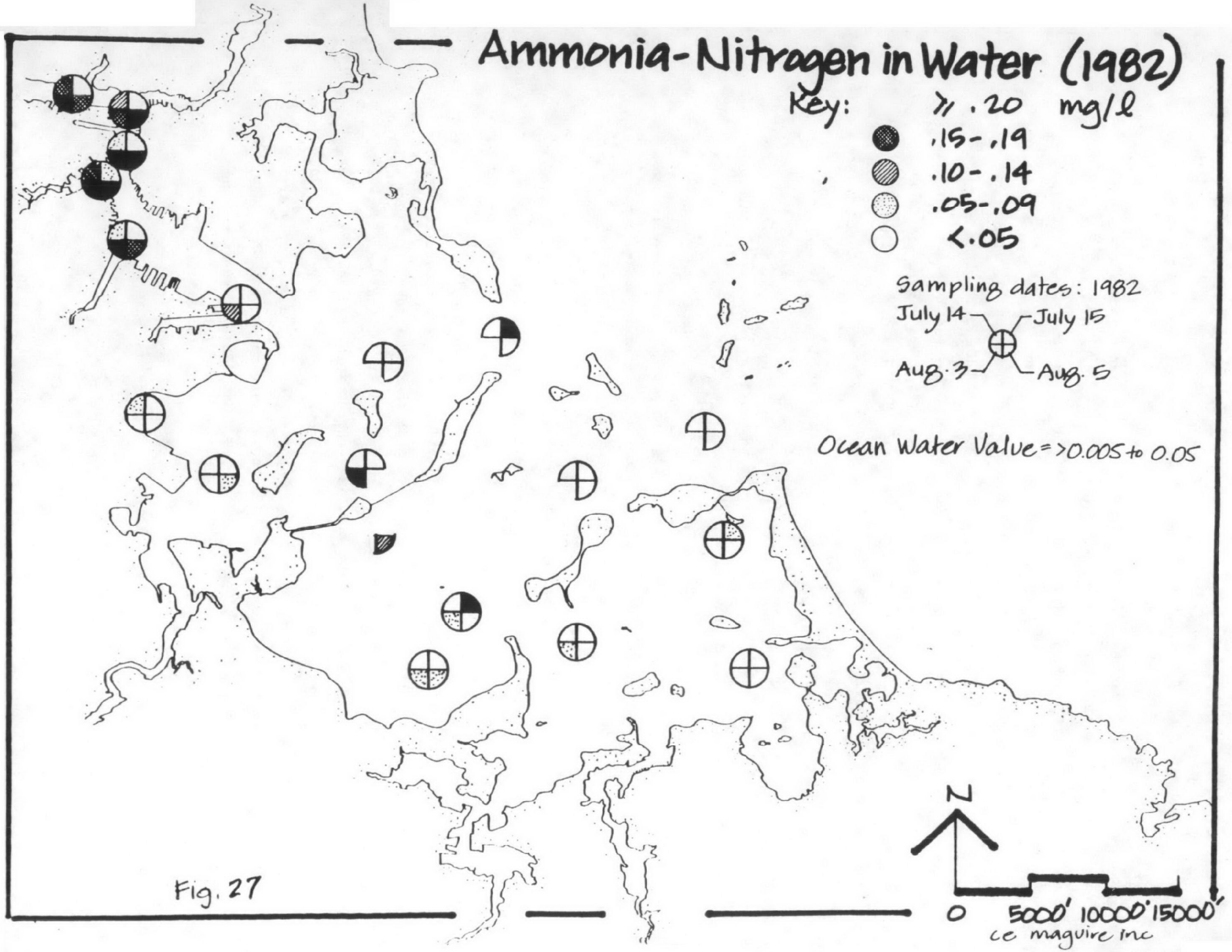

Ammonia-Nitrogen in Water (1982)
Key:
≥ .20 mg/l
.15-.19
.10-.14
.05-.09
<.05
Sampling dates: 1982
July 14
July 15
Aug. 3
Aug. 5
Ocean Water Value = >0.005 to 0.05
N
0 5000' 10000' 15000'
ce maguire inc

Fig. 27

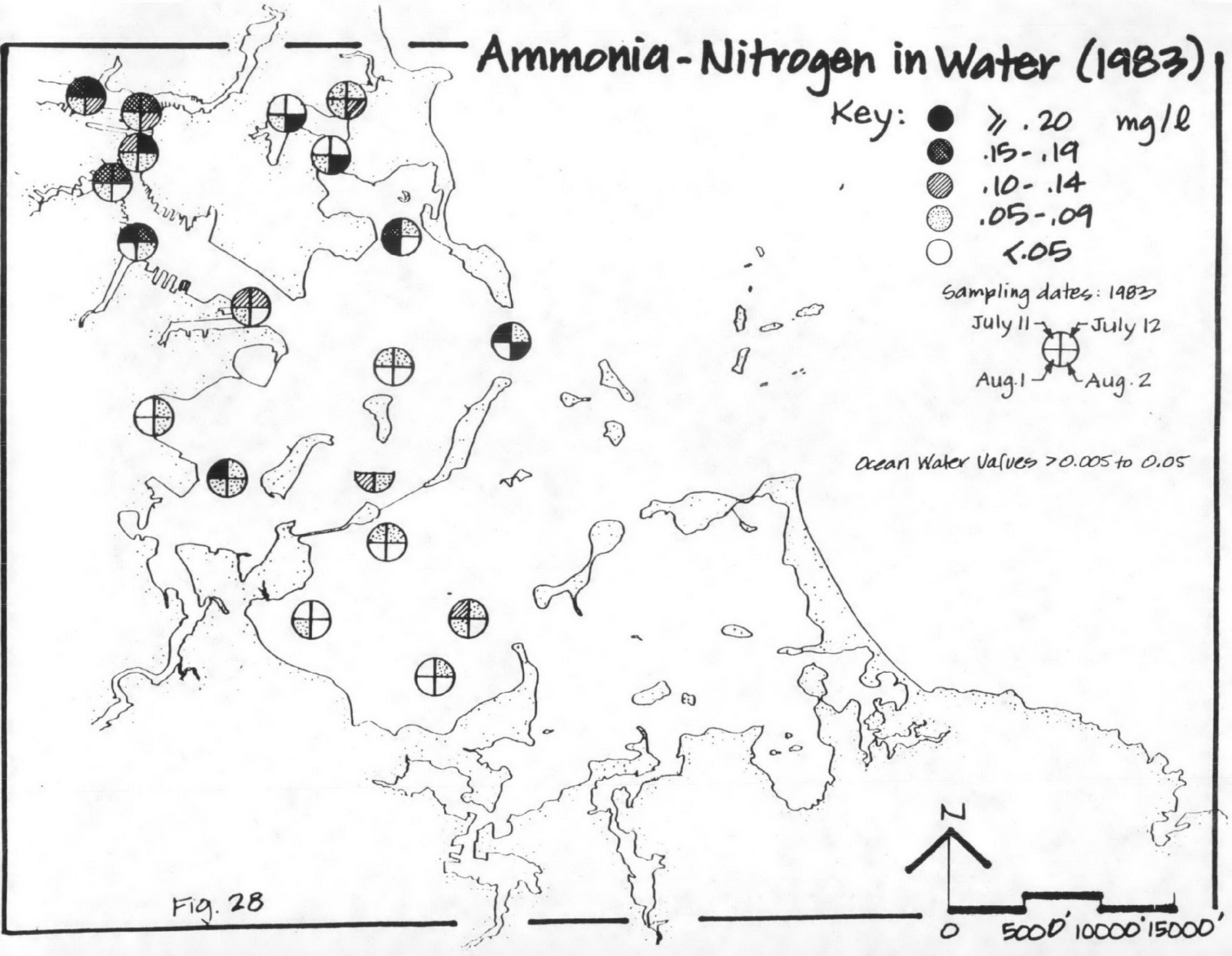

Ammonia - Nitrogen in Water (1983)
Key:
≥ .20 mg/l
.15 - .19
.10 - .14
.05 - .09
< .05
Sampling dates: 1983
July 11
July 12
Aug. 1
Aug. 2
Ocean Water Values > 0.005 to 0.05
N
0
5000'
10000'
15000'

Fig. 28

Total Kjeldahl-Nitrogen in Water (1982)

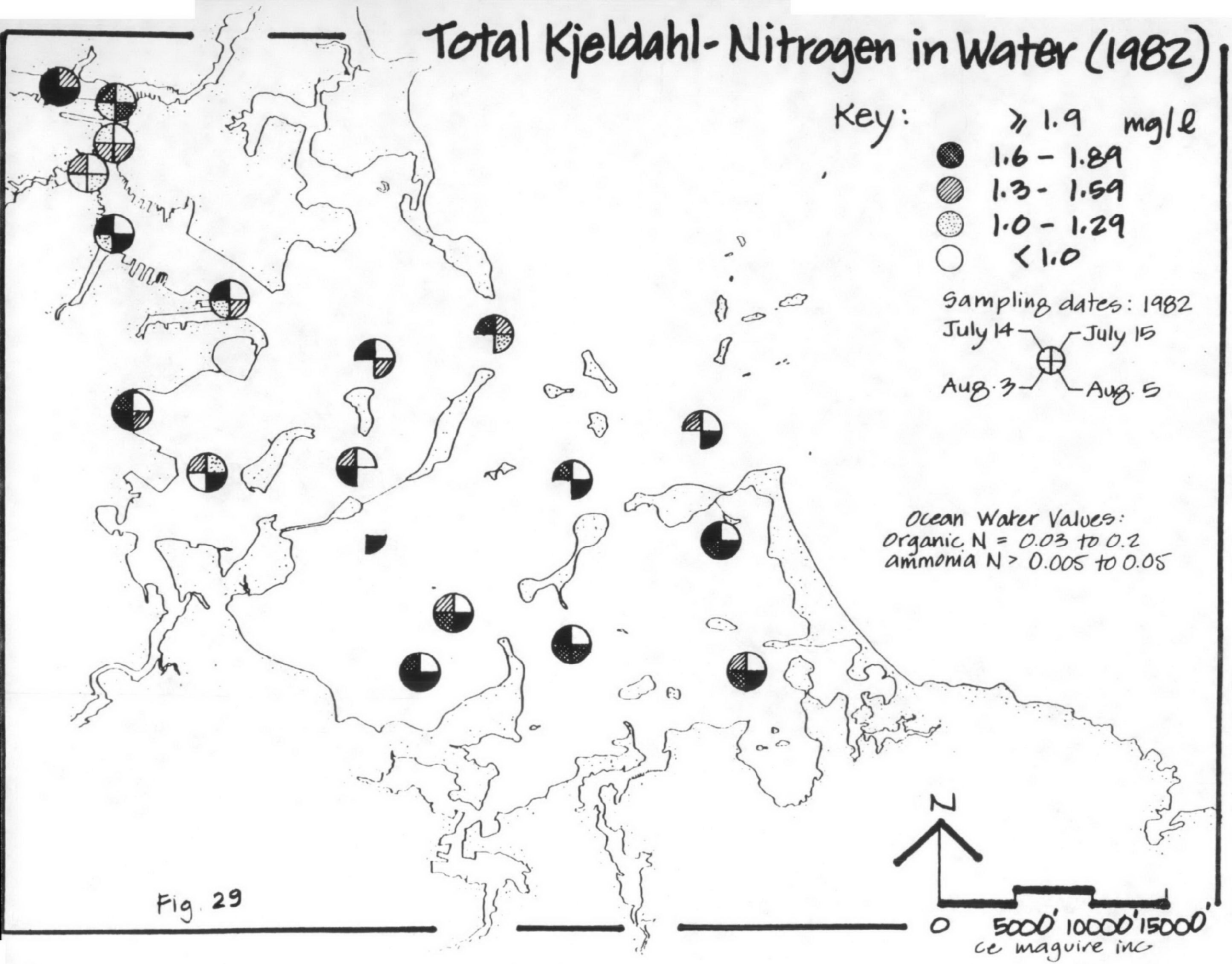


Fig. 29

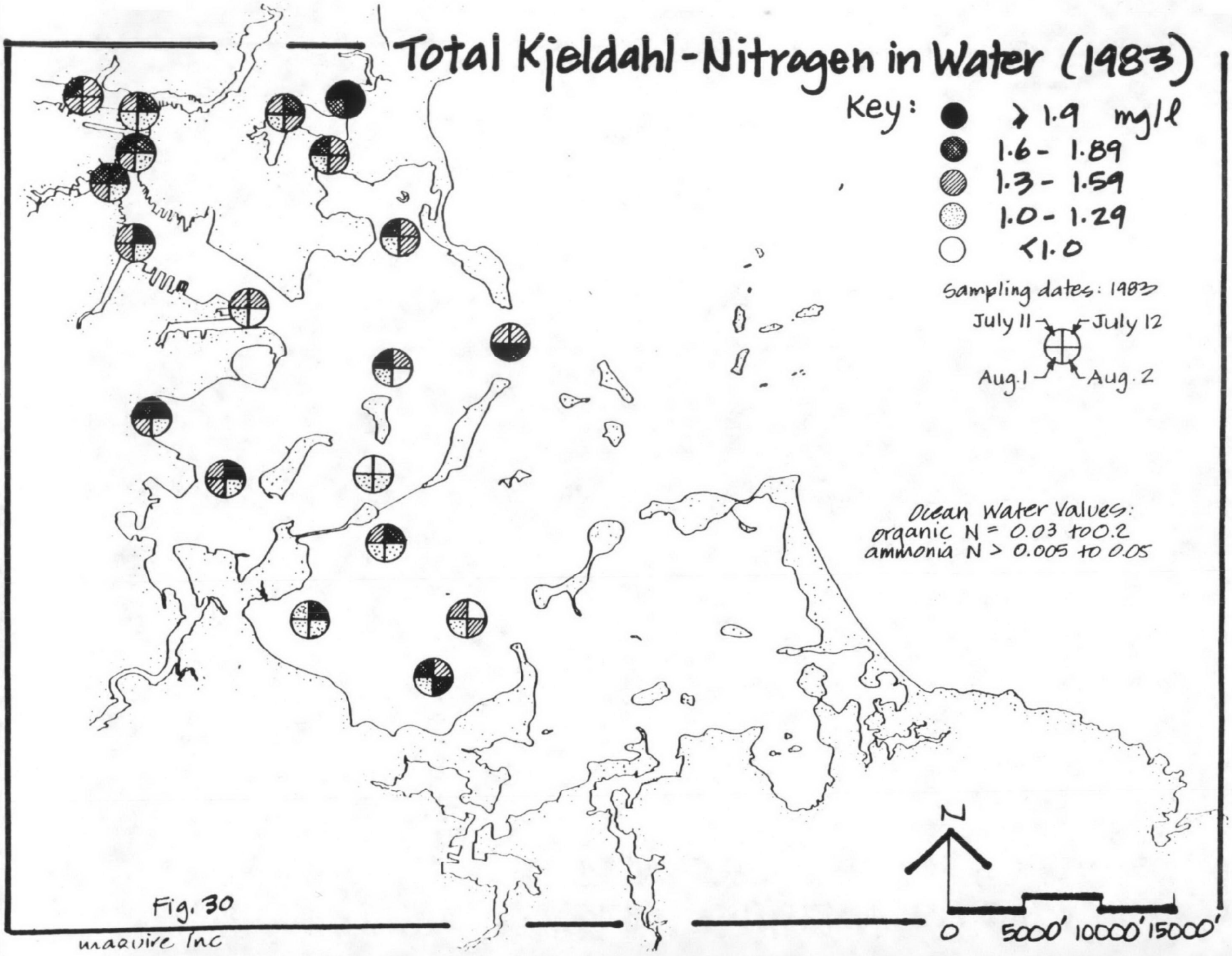


Fig. 30

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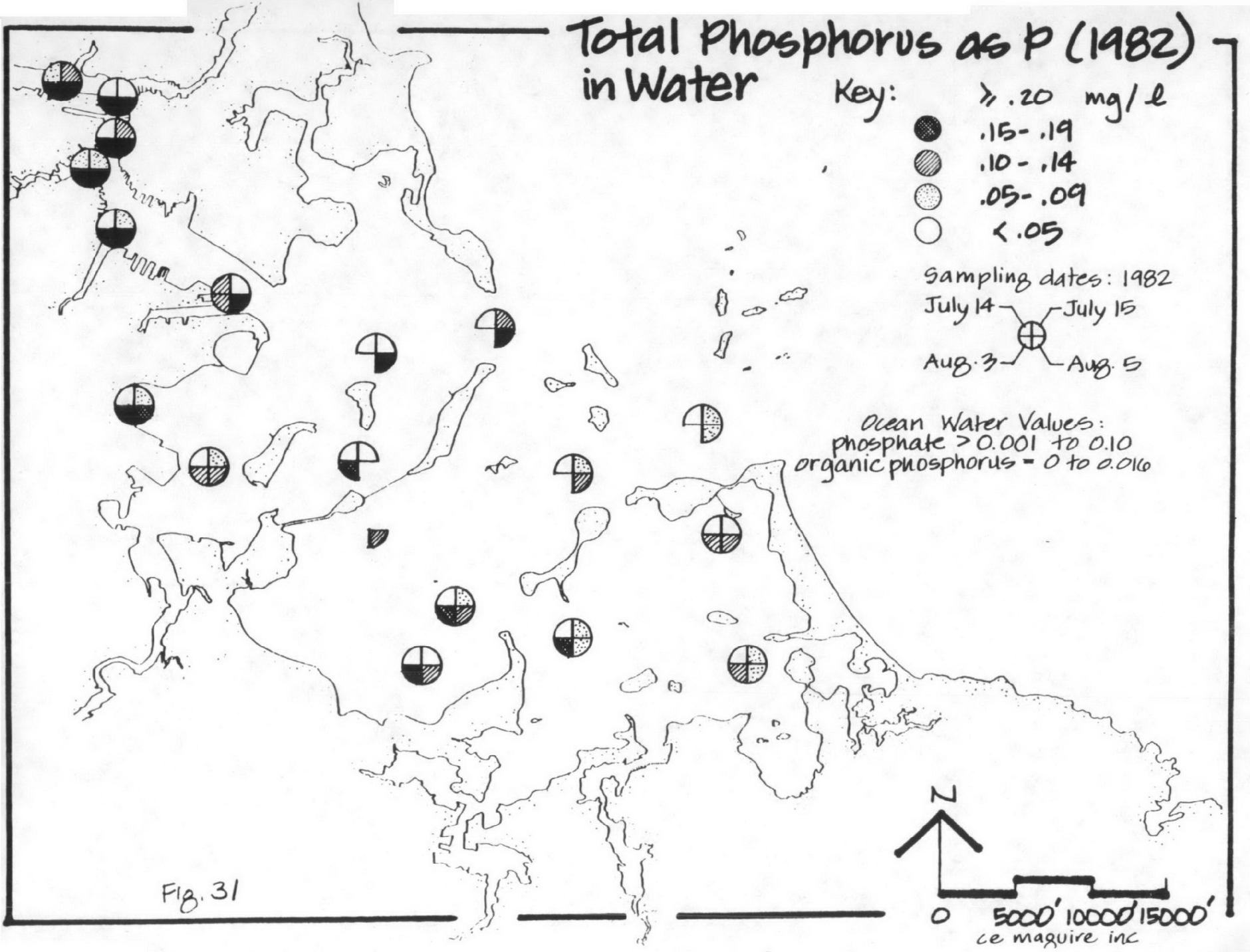

Total Phosphorus as P (1982) in Water
Key:
≥ .20 mg/l
.15 - .19
.10 - .14
.05 - .09
< .05
Sampling dates: 1982
July 14
July 15
Aug. 3
Aug. 5
Ocean Water Values:
phosphate > 0.001 to 0.10
organic phosphorus = 0 to 0.016
N
0 5000' 10000' 15000'
ce maguire inc

Fig. 31

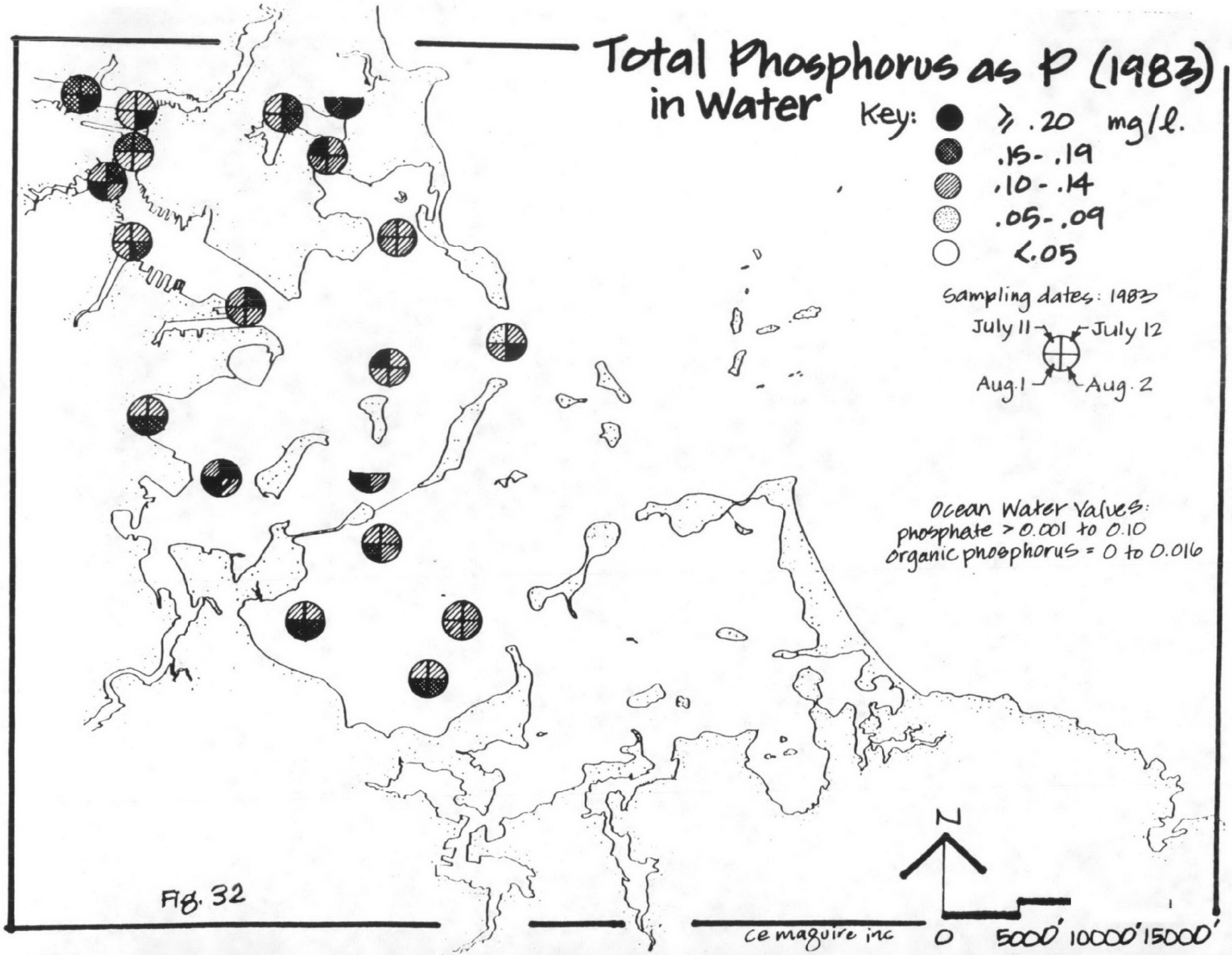

Total Phosphorus as P (1983)
in Water
Key:
≥ .20 mg/l.
.15 - .19
.10 - .14
.05 - .09
< .05
Sampling dates: 1983
July 11
July 12
Aug. 1
Aug. 2
Ocean Water Values:
phosphate > 0.001 to 0.10
organic phosphorus = 0 to 0.016
N
0
5000'
10000'
15000'
ce maguire inc

Fig. 32

Phosphorus

Total phosphorus concentrations are shown in Figures 31 and 32. Most samples exceed expected background concentration (.05 mg/l) and concentrations are highest in the Inner Harbor. The range of total phosphorus-P in 1982, 1983, and 1984 samples is 0.01-0.58 mg/l.

Metals

DWPC's 1982 and 1983 concentrations of trace metals and arsenic in harbor waters are shown in Figures 33 through 42. The references to ocean water values shown on these figures are from: (a) Sverdrup et al., 1942 and (b) Mason 1966. Except for one sample taken in President Roads in 1982, DWPC data is available only for the Inner Harbor.

These metals concentrations are compared with EPA's White Book criteria for the protection of saltwater aquatic life.* When using these criteria, acute toxicity values refer to the concentrations which may be harmful to saltwater aquatic life when the duration of exposure is brief; chronic toxicity concentrations may be harmful if marine life is exposed for relatively longer durations, such as 24 hours or more. Proposed EPA criteria (Feb. 7, 1984, Federal Register), if adopted, would change the terminology to "criterion maximum concentration" (one half of existing acute criteria) and would change the chronic or criterion average concentration to a 30-day average from its present 24-hour average.

Under EPA's proposed criteria for the protection of saltwater aquatic life, Boston Inner Harbor metals fall into two groups:

1. those in concentrations exceeding maximum levels - copper, nickel, silver, cadmium, lead.

---

*In some cases, the criteria refer to specific phases or species of a metal. Sample results represent total concentration of several metal species.

2. those in concentrations between 30-day average and maximum values - arsenic, mercury and zinc.

A 1972 data set for metals concentrations in outer harbor waters is summarized in Table 7. These results show copper and nickel concentrations in excess of EPA's 30-day average criteria (proposed).

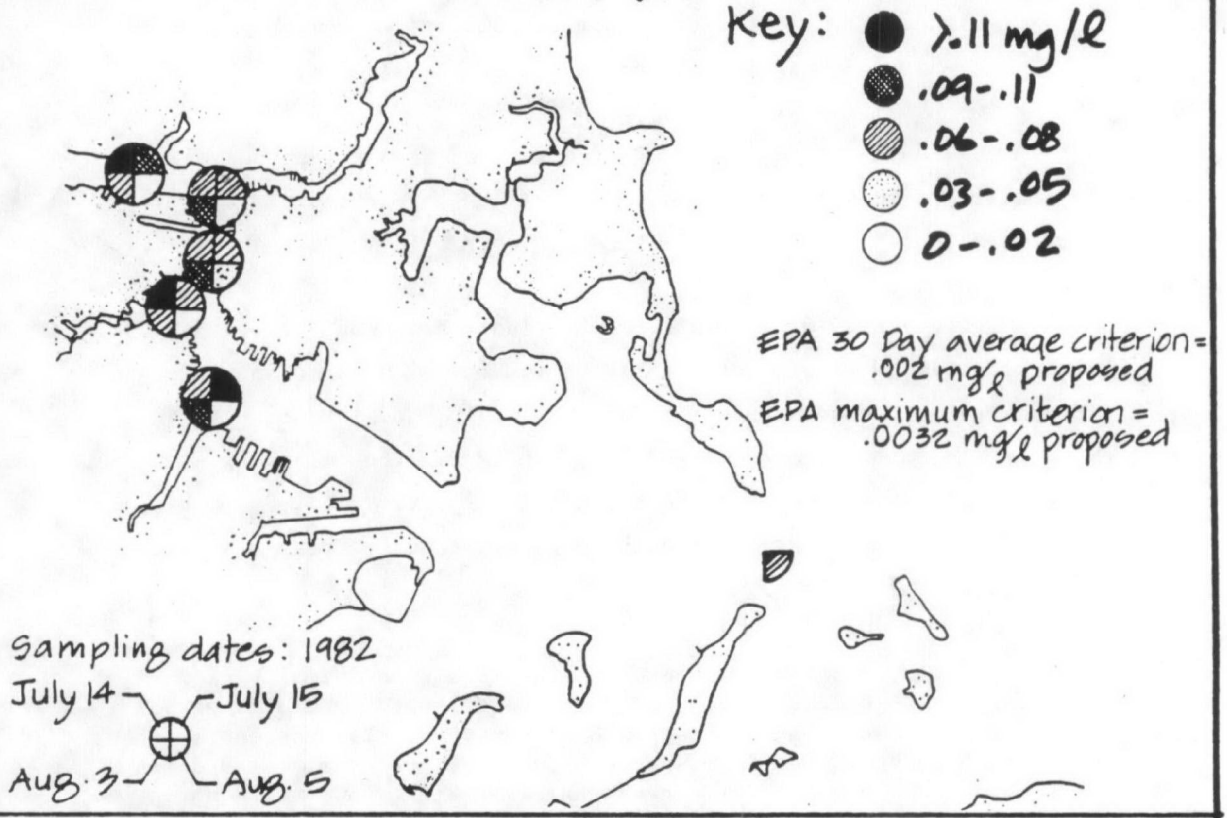
A recent study of metals concentrations throughout Boston Harbor was conducted by researchers at the University of Massachusetts-Boston. Their results are summarized in Tables 8 and 9; complete results and sampling locations are presented in Appendix D. The following conclusions have been excerpted from their report: "Metal Distribution in a Major Urban Estuary (Boston Harbor) Impacted by Ocean Disposal" (Wallace, et al., 1984):

> Metal concentrations in Boston Harbor are substantially higher than those of ambient New England coastal water where comparable data are available. Within the harbor most metal concentrations are highest in the inner harbor and in waters overlying sediments with the highest metal concentrations. High concentrations in the inner harbor are attributed to local sources coupled with poor tidal flushing and not the sewage outfalls at the entrance to the harbor. The Charles River is not a significant source of metals in the inner harbor. Metal concentrations outside of the inner harbor reflect either remobilization from heavily contaminated sediments and/or poor tidal flushing.
>
> Order of magnitude increases in zinc and cadmium were observed in the outfall plume under slack tide conditions. Particulate forms were the dominant forms of Zn, Pb, Cd, Cu, and Fe in the plume. The majority of Pb and Fe at most stations in the harbor was retained by 0.4 um filters. Elevated suspended aluminum concentrations in the deep samples obtained suggest active resuspention and transport of fine grained sediments in Boston Harbor.
>
> Copper concentrations reached potentially toxic concentrations at low tide in the shallow southern most stations in the harbor. This increase has been tentatively ascribed to short term episodic remobilization from recently deposited material at the sediment-water interface.

Note that almost all copper concentrations reported in this study exceed EPA's criteria for the protection of saltwater aquatic life.

Fig. 33

Copper in Water



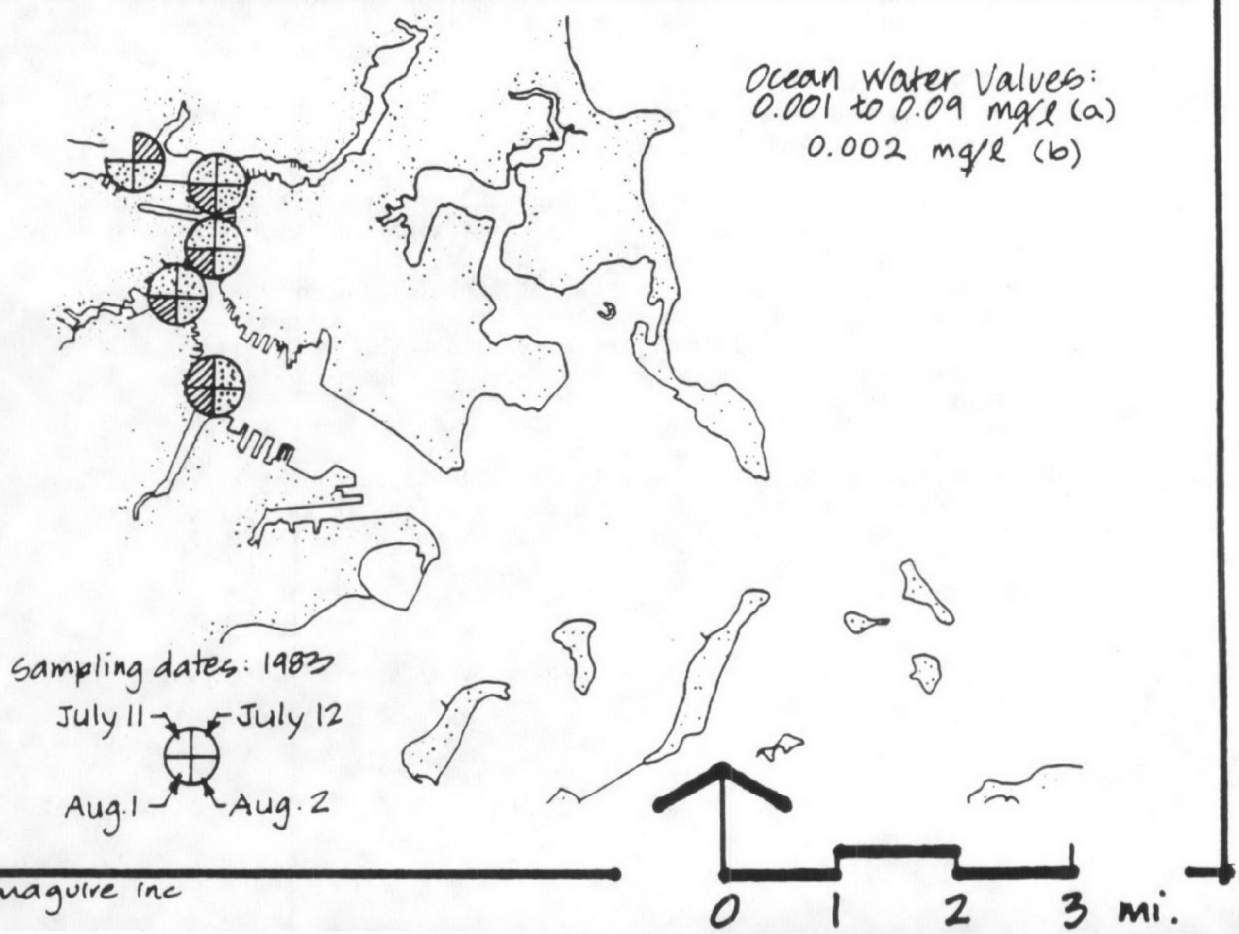


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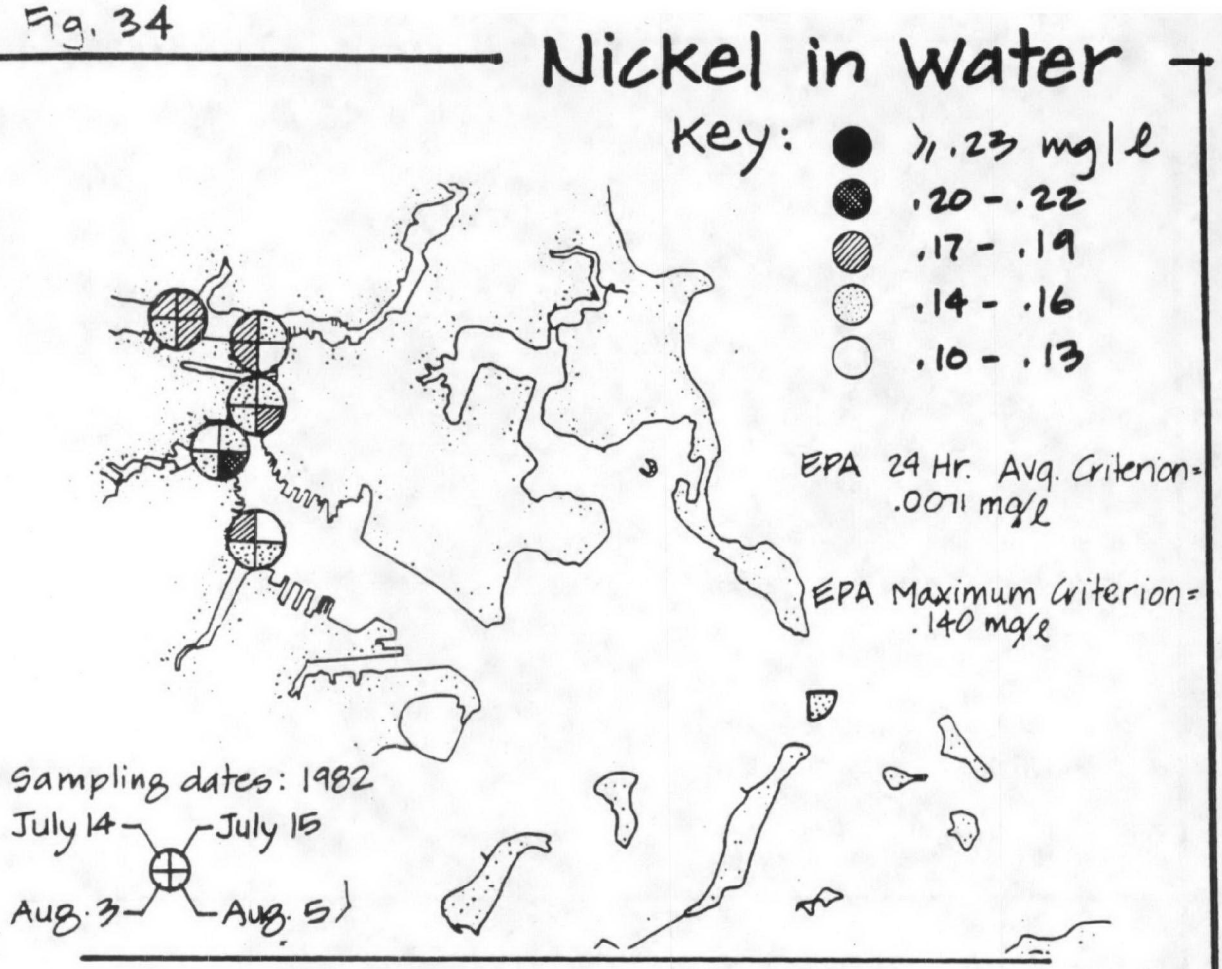
Fig. 34

Nickel in Water



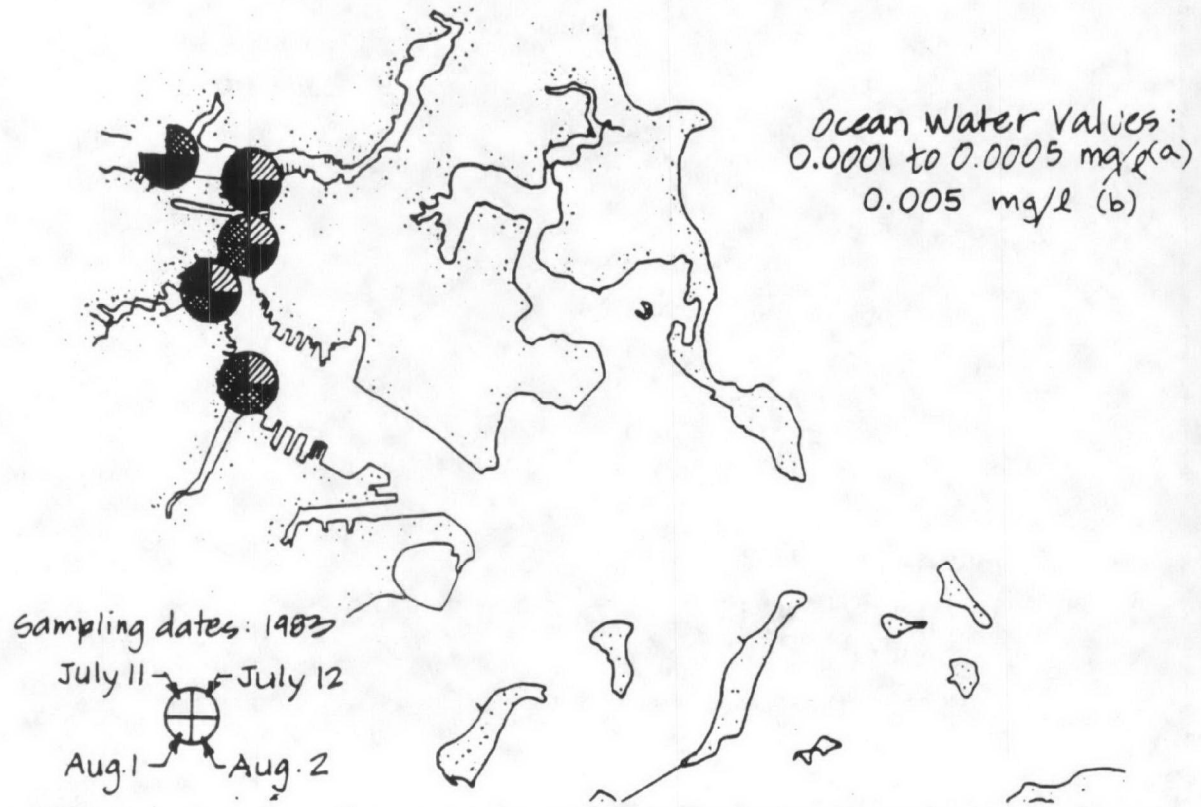


Fig. 35

Silver in Water

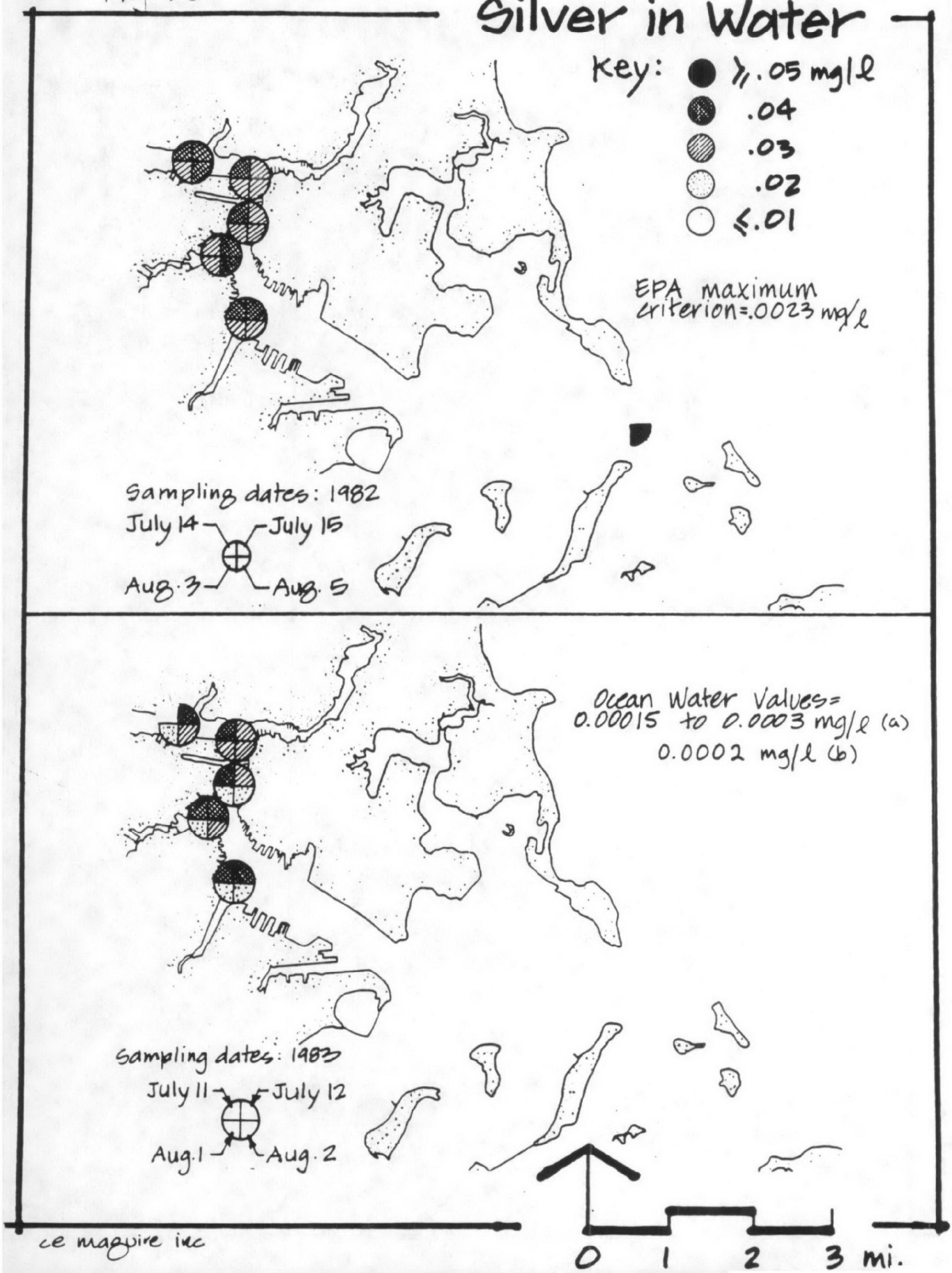


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Fig. 36

Arsenic in Water

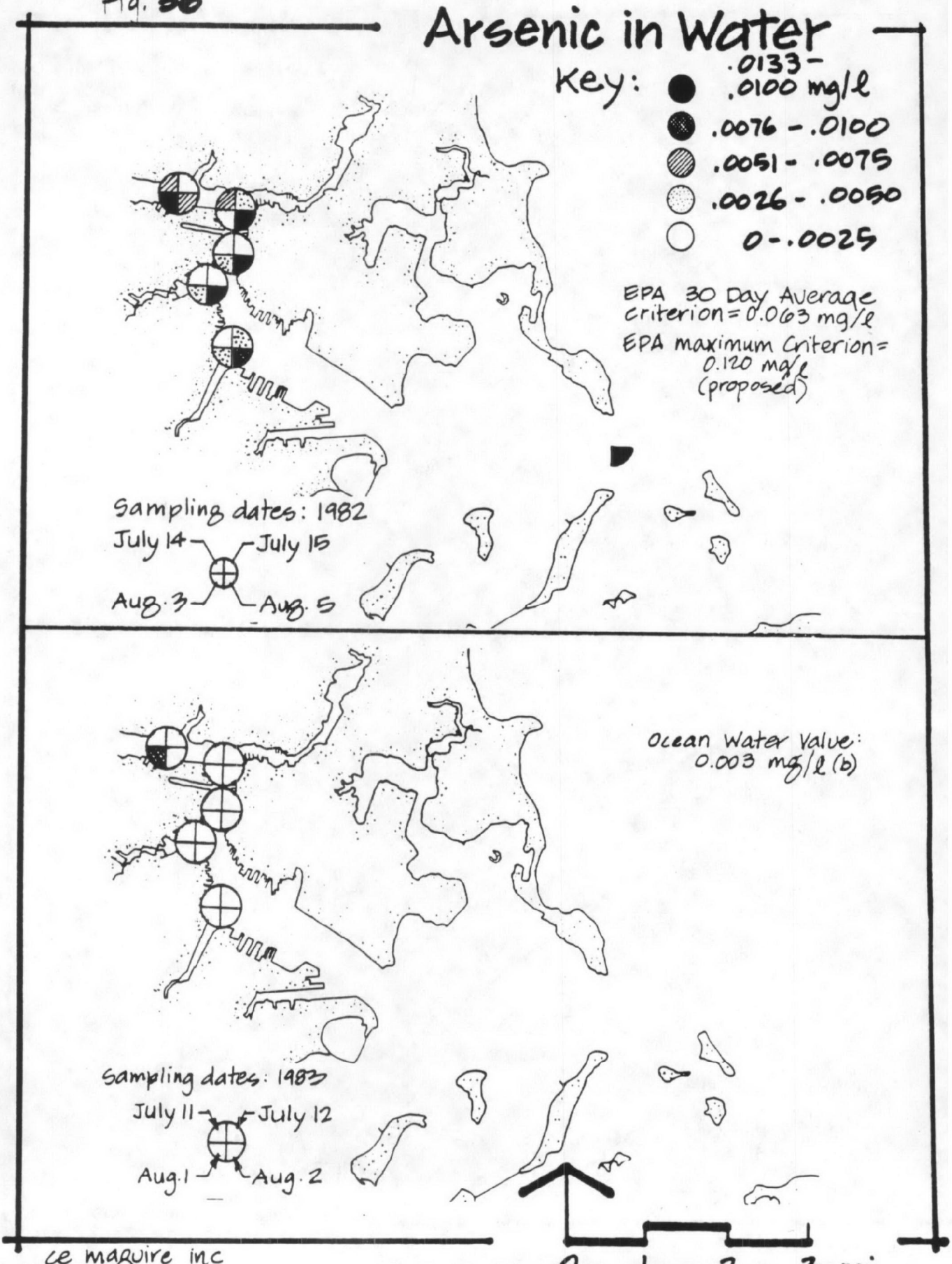

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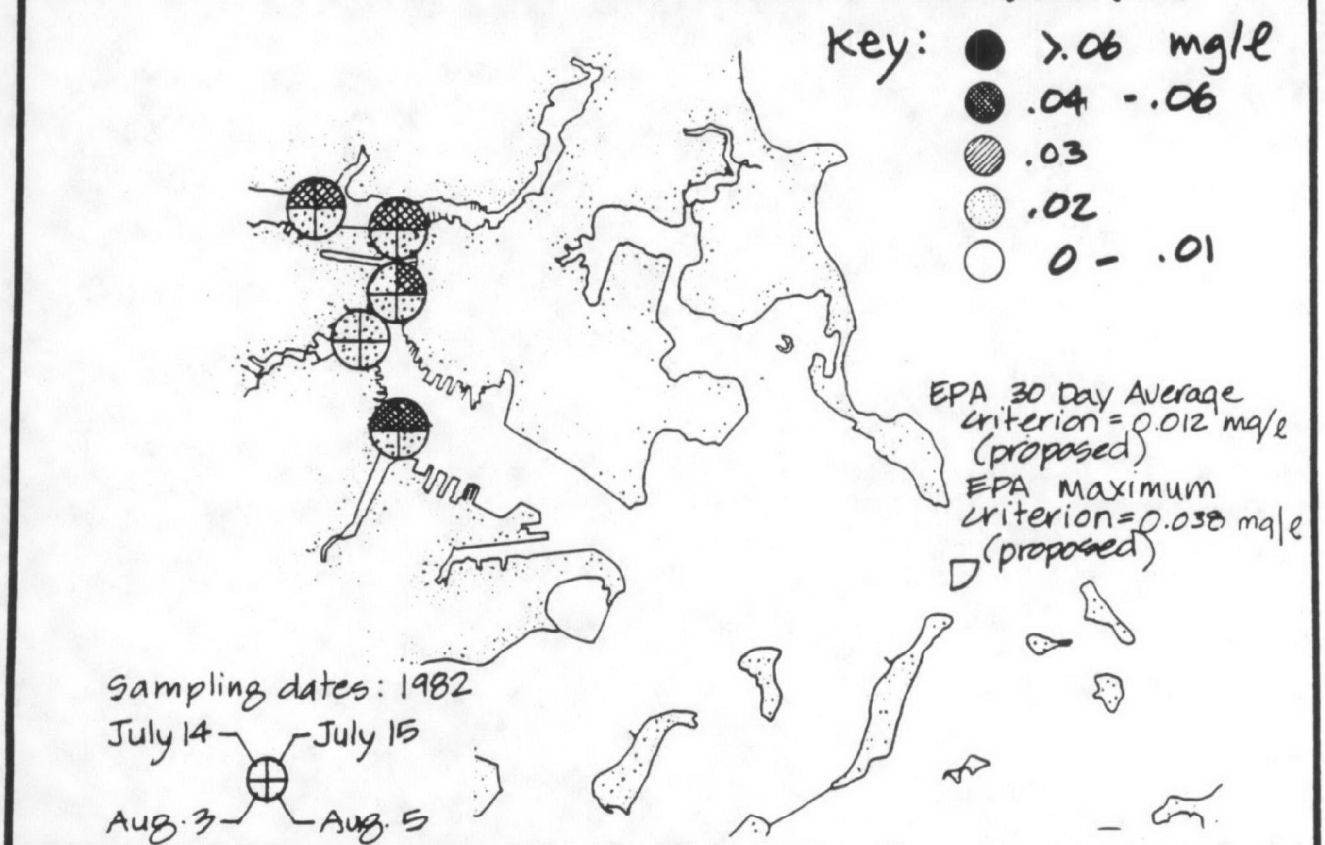
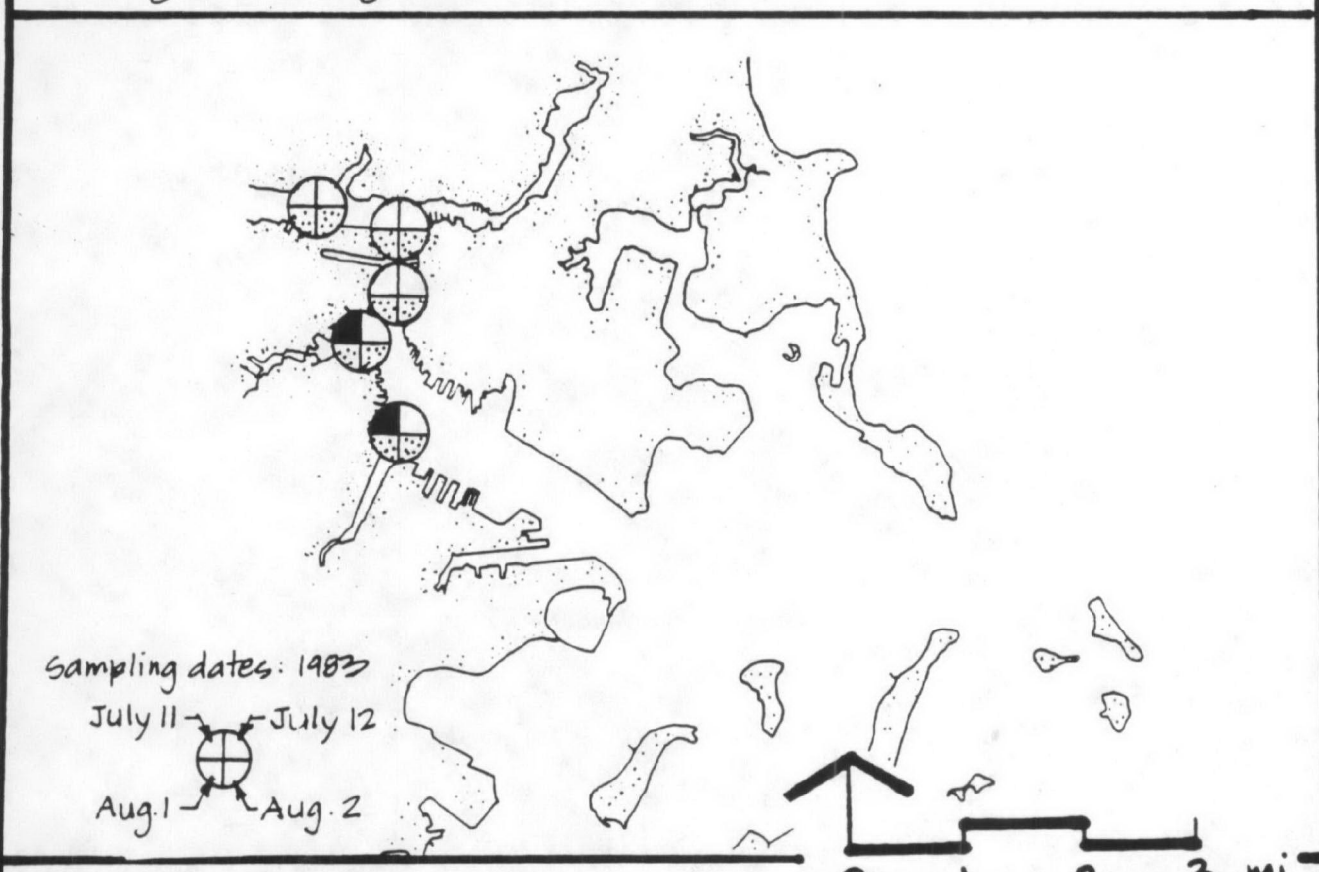
Fig. 37

Cadmium in Water

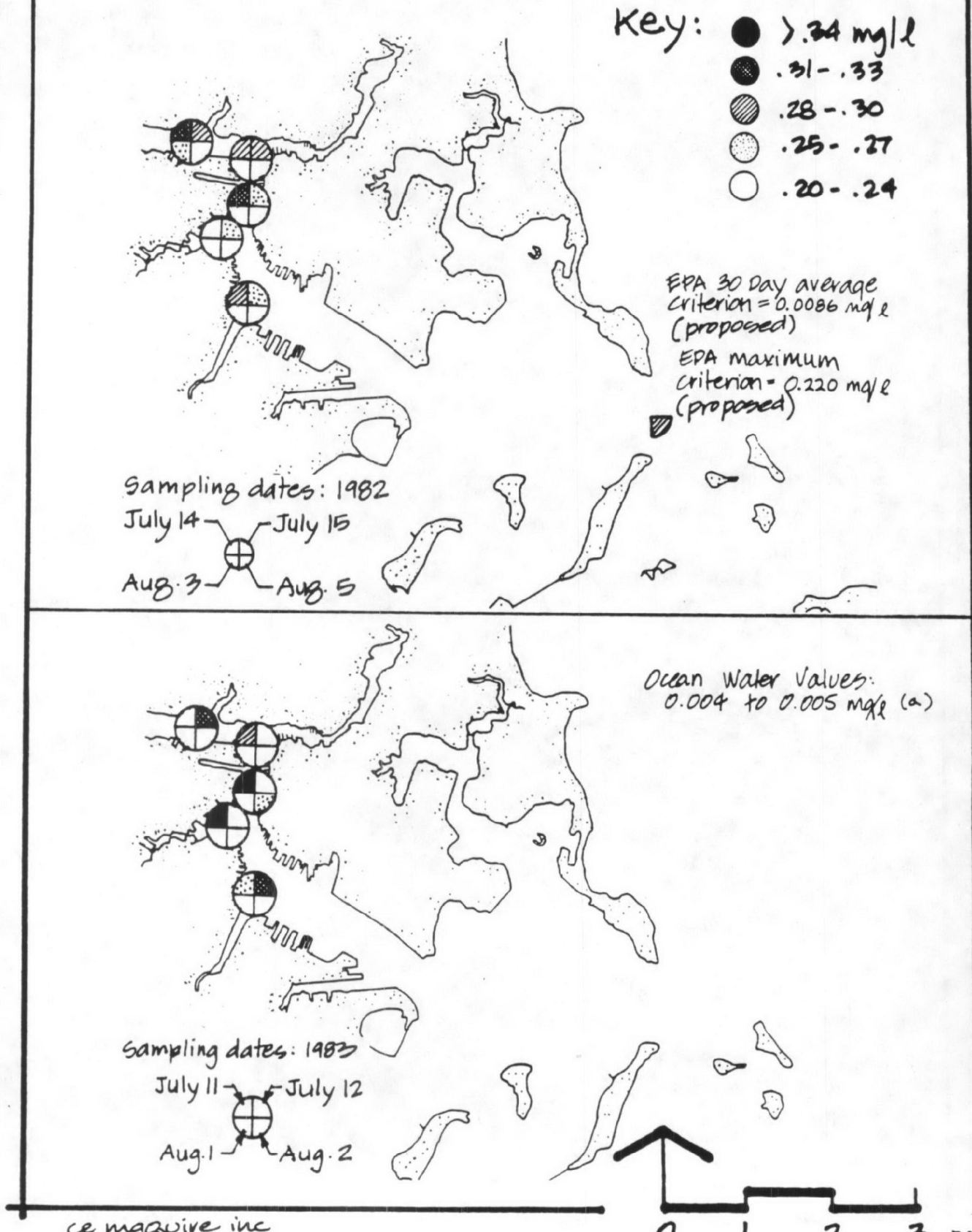




ce maguire inc

Fig. 38

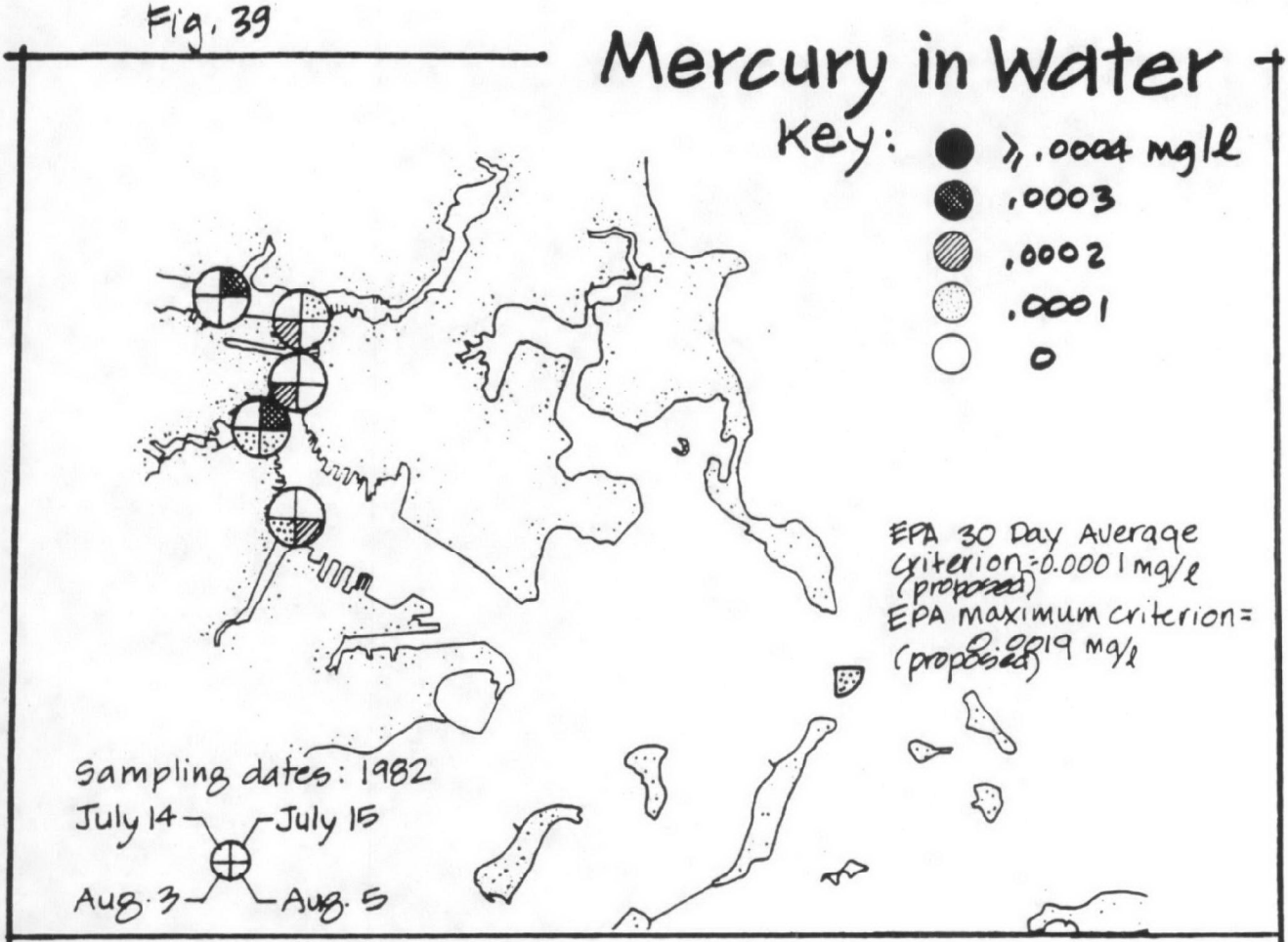
Lead in Water



ce maguire inc

Fig. 39

Mercury in Water



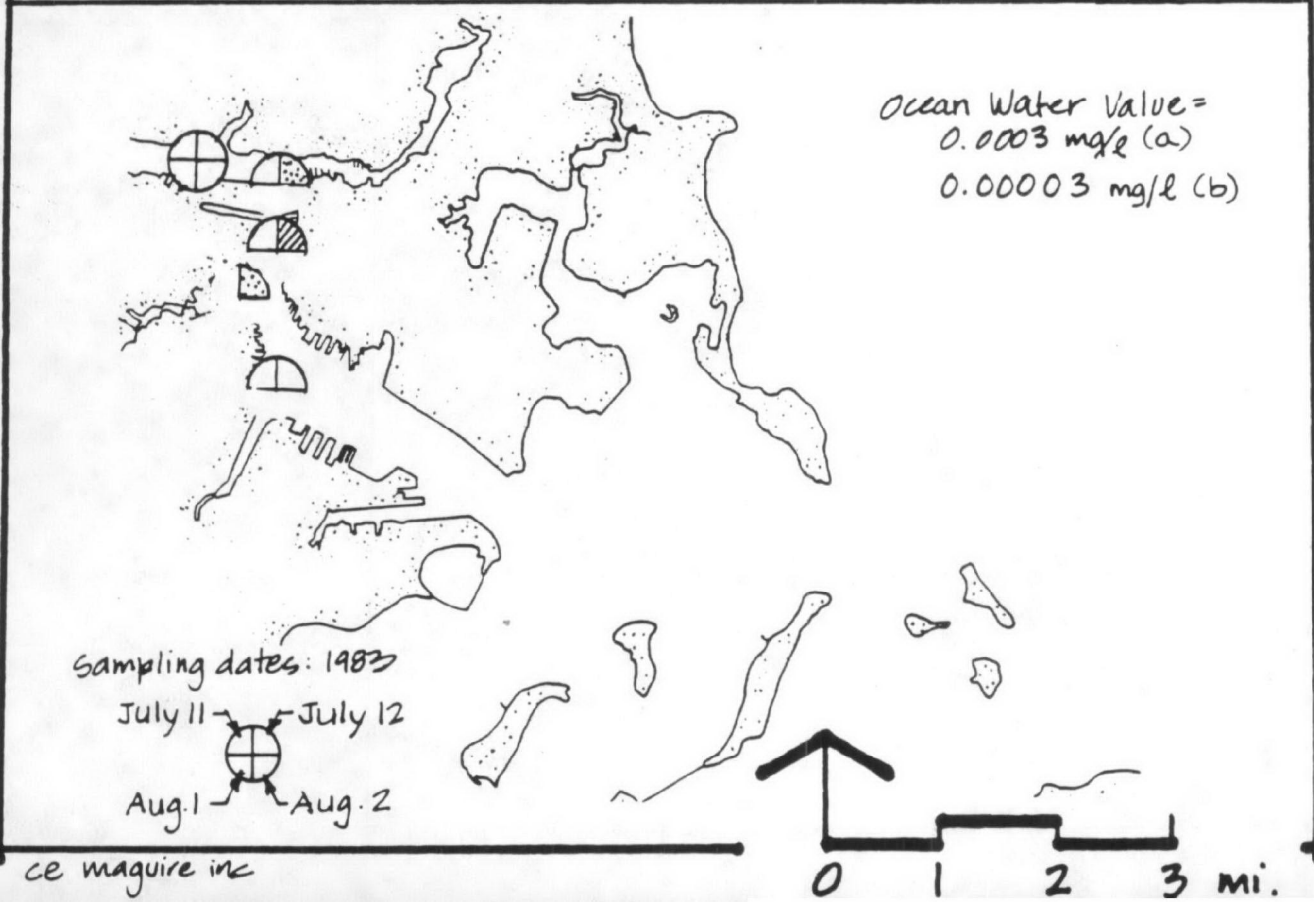


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Fig. 40

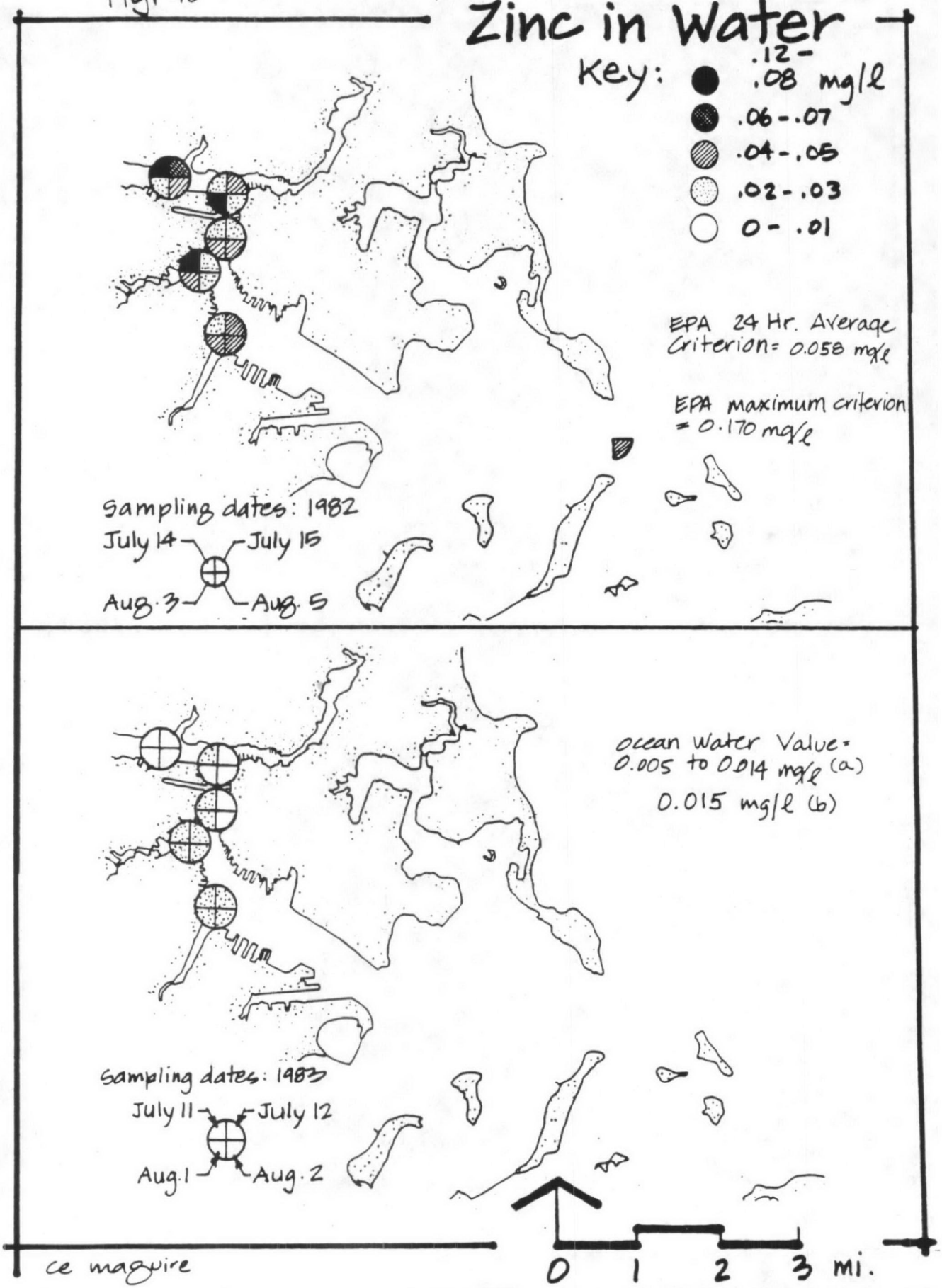
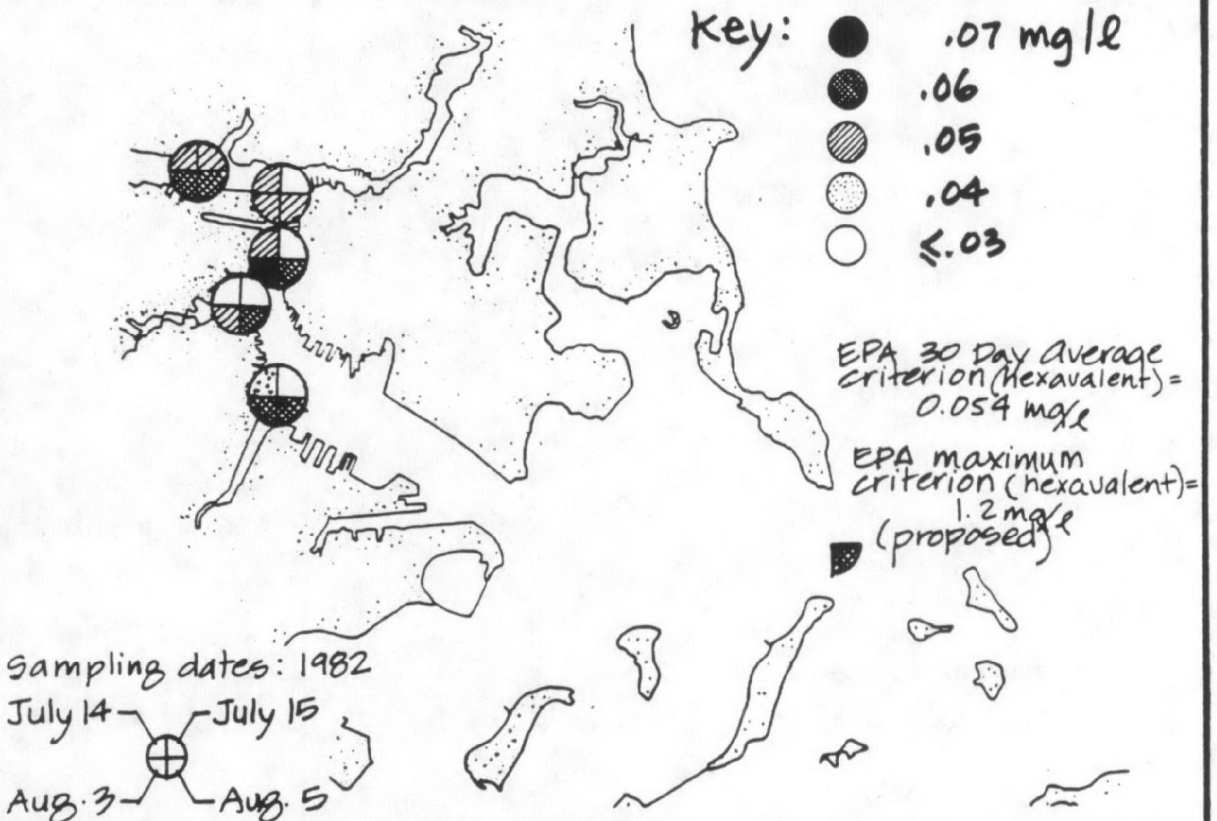

Zinc in Water
Key:
.12 - .08 mg/l
.06 - .07
.04 - .05
.02 - .03
0 - .01
EPA 24 Hr. Average Criterion = 0.058 mg/l
EPA maximum criterion = 0.170 mg/l
Sampling dates: 1982
July 14
July 15
Aug. 3
Aug. 5
ocean water Value = 0.005 to 0.014 mg/l (a)
0.015 mg/l (b)
Sampling dates: 1983
July 11
July 12
Aug. 1
Aug. 2
0 1 2 3 mi.
ce maguire

Fig. 41

Chromium in Water



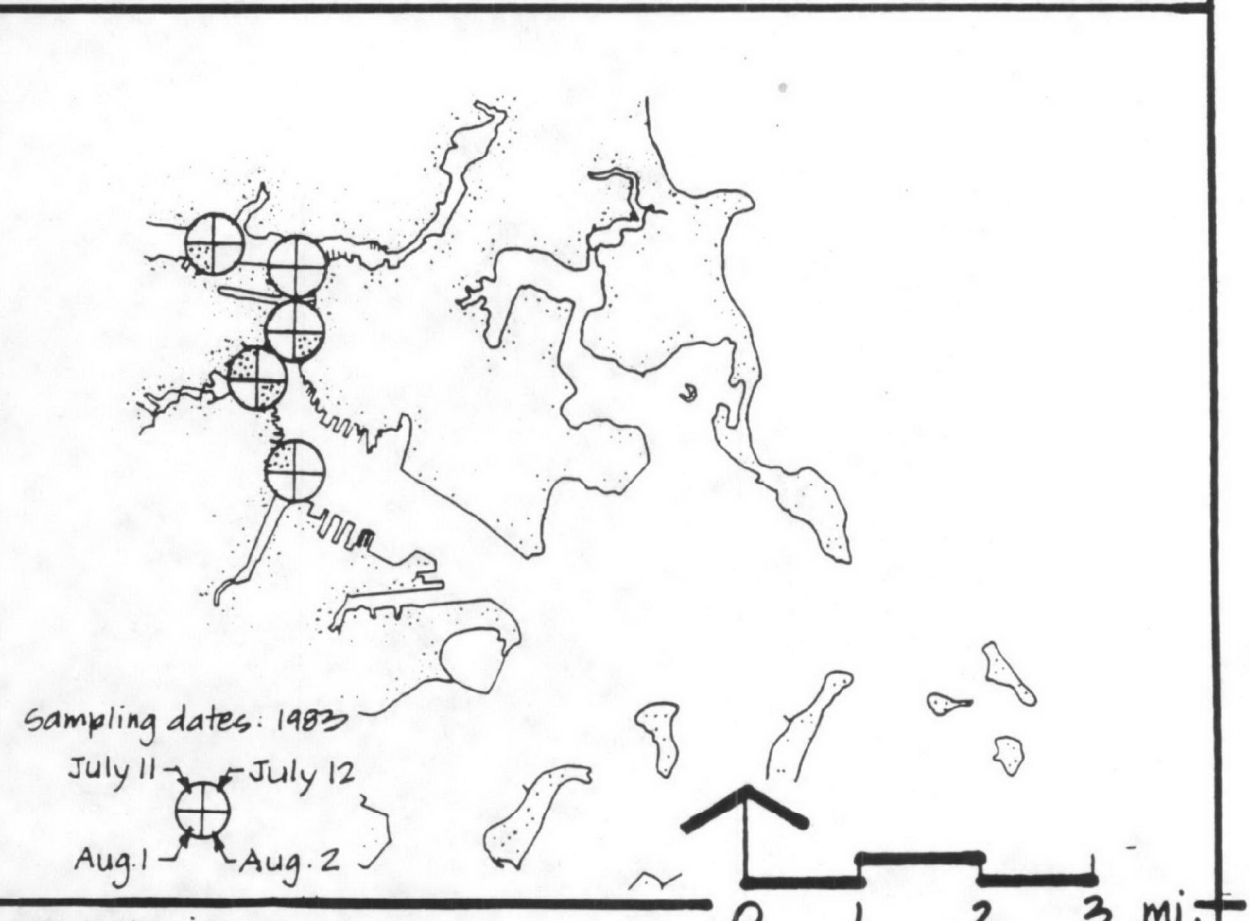


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Fig. 42

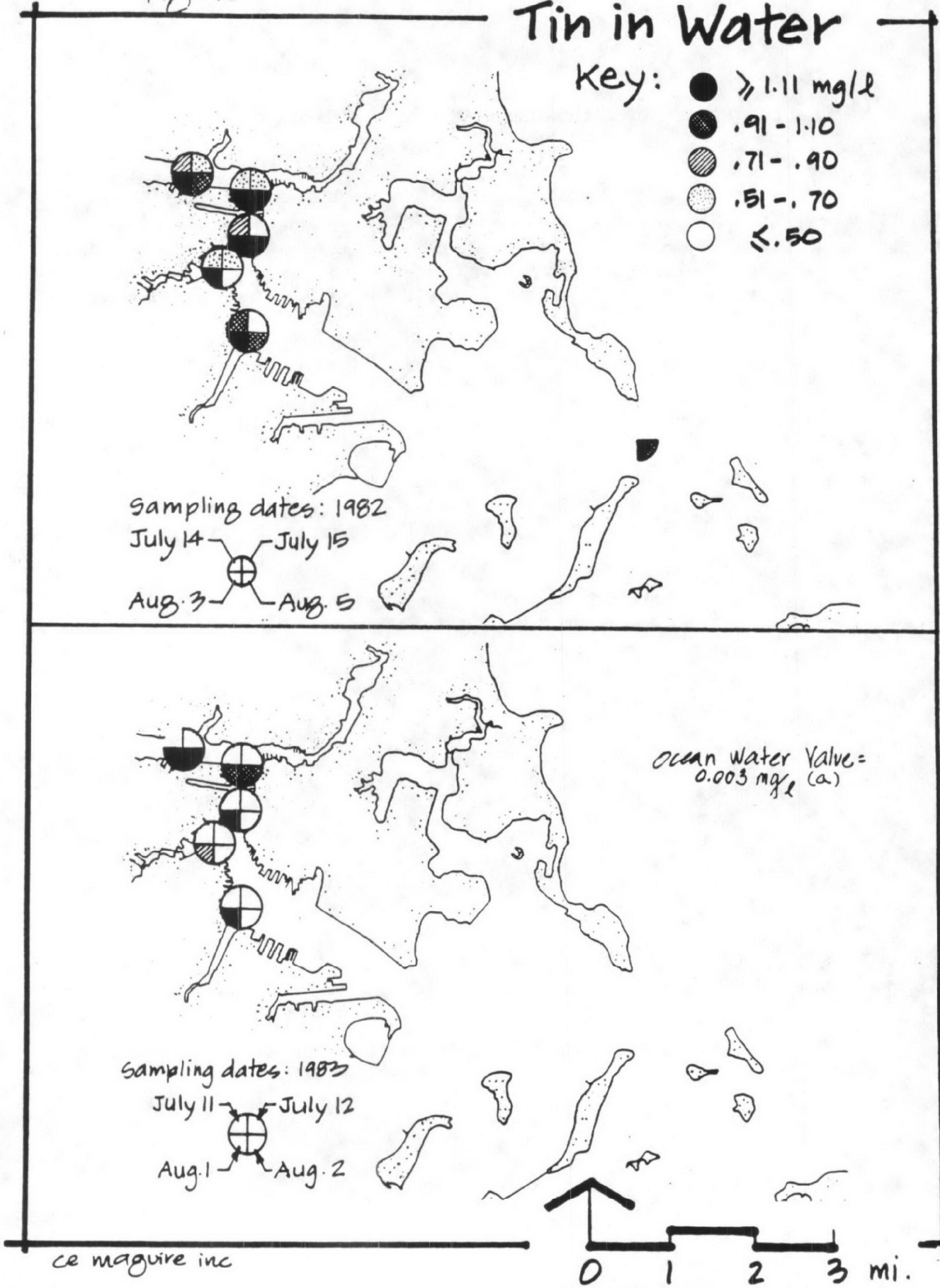

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TABLE 7

METAL CONCENTRATION (ug/l) IN WATERS OF BOSTON HARBOR (GILBERT, 1972)

		General Sampling Areas											
	Recommended	Inner Harbor			President Roads			Dorchester Bay			Thompson-Long Island		
Metal	EPA Criteria	D	P	Total	D	P	Total	D	P	Total	D	P	Total
Cadmium	4.5	0.42	ND	0.42	0.46	ND	0.46	0.24	ND	0.24	0.20	ND	0.20
Chromium	18	1.90	2.12	4.02	0.5	3.2	3.7	0.3	4.5	4.8	0.5	1.3	1.8
Copper	4	5.0	1.8	6.8	5.2	1.6	6.8	2.6	0.8	3.4	2.2	1.5	3.7
Lead	-	5.4	6.4	11.8	2.0	3.5	5.5	2.0	2.4	4.4	1.9	1.7	3.6
Nickel	7.1	7.8	1.6	9.4	8.2	1.9	10.1	4.7	1.8	6.5	6.8	1.3	8.1
Zinc	58	40.2	3.7	43.9	11.6	7.5	19.1	11.2	1.7	12.9	9.0	1.8	10.8

D = dissolved fraction

P = particulate fraction

ND = not detected

Source: EG&G 1984

TABLE 8. DISSOLVED METAL CONCENTRATIONS
LOW TIDE SAMPLING (25 SAMPLES)

	Metal Concentration, ug/l[1]						
	Zn	Pb	Cd	Cu	Ni	Fe	Mn
Range							
Low	1.83	0.18	0.05	1.65	0.59	3.74	2.20
High	15.69	0.56	0.57	18.49	21.61	84.88	39.28
Mean	5.00	0.30	0.09	6.46	2.09	11.81	11.95
Median	4.05	0.29	0.08	4.96	1.21	8.04	11.54
EPA Criteria[2]							
Avg./Chronic	58	8.6*	4.5	2*	7.1	N.C.	N.C.
Max./Acute	170	220*	38*	3.2*	170	N.C.	N.C.

Notes:

1. Original data reported as nM/l except for Cd which was reported as pM/l.
2. Lowest of the applicable White Book criteria shown, see SDEIS Section 11.3 for more detail.

* Proposed criteria.

N.C. No criteria, Fe and Mn are not priority pollutants.

Source: Wallace et al. 1984

TABLE 9. METAL CONCENTRATIONS
HIGH TIDE SAMPLING (36 SAMPLES)

a. Dissolved Metals — Metal Concentration, ug/l[1]

	Zn	Pb	Cd	Cu	Ni	Fe	Mn
Range							
Low	0.78	0.09	0.04	0.38	0.52	1.79	1.76
High	8.11	1.03	0.09	13.09	2.71	31.33	27.58
Mean	3.22	0.27	0.07	4.22	0.97	9.29	8.41
Median	3.07	0.25	0.07	3.18	0.80	7.71	7.58

b. Particulate Metals[2] — Metal Concentration, ug/l[1]

	Zn	Pb	Cd	Cu	Ni	Fe	Mn
Range							
Low	0.28	0.09	0.000	0.10	0.02	13.40	0.64
High	8.56	0.81	0.069	3.20	0.26	157.47	2.26
Mean	0.84	0.35	0.004	0.51	0.07	69.07	1.23
Median	0.58	0.32	0.002	0.39	0.06	58.91	1.16

c. Total Metals — Metal Concentration, ug/l[1]

	Zn	Pb	Cd	Cu	Ni	Fe	Mn
Range							
Low	1.17	0.18	0.04	0.98	0.53	15.30	0.77
High	12.42	1.68	0.12	14.03	2.78	172.60	28.65
Mean	4.05	0.62	0.07	4.73	1.04	78.36	9.64
Median	3.61	0.59	0.07	3.56	0.87	65.70	17.65

EPA Criteria[3]							
Avg./Chronic	58	8.6*	4.5	2*	7.1	N.C.	N.C.
Max./Acute	170	220*	38*	3.2*	170	N.C.	N.C.

Notes:
1. Original data reported as nM/l except for Cd which was reported as pM/l.
2. Particulate fraction retained by 0.40 micron filter.
3. Lowest of the applicable White Book criteria shown, see SDEIS Section 11.3 for more detail.

* Proposed criteria.

N.C. No criteria, Fe and Mn are not priority pollutants.

Source: Wallace et al. 1984

C. Sediment Conditions

Boston Harbor sediments have generally been found to contain high concentrations of heavy metals, particularly in the Inner Harbor and northern area of the outer harbor. Under the Massachusetts criteria for the classification of dredge or fill material (Table 10), most of the Harbor's sediments would be classified under Category Two or Three. These sediments are therefore subject to a more thorough evaluation with respect to biological impacts of dredging or filling than that which is required with Class One material. Categories of dredge and fill material also determine the DWPC approvable methods or options for handling and disposing the sediments. For example, Category II and III sediments may not be disposed using sidecast methods, nor disposed unconfined within the harbor. Physical characteristics also determine which options for handling and disposal are approvable; fine grained, high organic content sediments generally lead to more restrictive options.

Data on Boston Harbor sediment characteristics suggest that high metals concentrations found in the outer harbor are associated with fine grained sediments and organic matter. The few data on the organic toxic compounds DDT and PCB suggest that they are also associated with fine grained sediments and probably organic matter.

The reported concentrations of toxic metals and synthetic organics in harbor sediments are of concern due to the potential for bioaccumulation in organisms dependent on benthic organisms as a food source (mechanisms include chelation of heavy metals to organic ligands and fat solubility of the synthetic organics). Flounder and lobster

Table 10

MASSACHUSETTS DWPC CLASSIFICATION OF DREDGE AND FILL MATERIAL

Chemical Contsituent		Category One	Category Two	Category Three
Arsenic (As)	<	10	10 - 20	> 20
Cadmium (Cd)	<	5	5 - 10	> 10
Chromium (Cr)	<	100	100 - 300	> 300
Copper (Cu)	<	200	200 - 400	> 400
Lead (Pb)	<	100	100 - 200	> 200
Mercury (Hg)	<	0.5	0.5 - 1.5	> 1.5
Nickel (Ni)	<	50	50 - 100	> 100
PCB	<	0.5	0.5 - 1.5	> 1.5
Vanadium (V)	<	75	75 - 125	> 125
Zinc (Zn)	<	200	200 - 400	> 400

Note: All values in parts per million.

Source: Massachusetts Division of Water Pollution Control, 1978, Regulations for Water Quality Certification for Dredging, Dredged Material Disposal and Filling in Waters of the Commonwealth.

tissues throughout the harbor have been found to contain these toxic chemicals in varying concentrations (see discussion under "Biologic Conditions").

The data presented in the following maps are from the 1979 sampling done for MDC's 301(h) Waiver Application. Recent sampling done for the 1982 amendments to MDC's 301(h) Waiver Application found lower concentrations of mercury, lead, chromium, and silver; higher concentrations were found for copper and DDT (Metcalf & Eddy, 1982 Amendment to 301(h) Waiver Application, Addendum 3, p. 6-2 to 6-15).

For comparison purposes, Table 11 shows reported concentrations of heavy metals in sediments from around the world.

Grain Size Distribution

Figure 43 shows the grain size distribution found in Harbor sediments. Notice the sediments in the Harbor, particularly the northern part, are finer overall than those outside the Harbor. Samples from Presidents Roads and Dorchester Bay show almost complete dominance of the <0.5 mm grain size classes.

Organic Fraction

Figure 44 shows the percent of organic matter in the Harbor sediment samples. Again, the organic fraction of sediments in Boston Harbor is greater than in sediments outside the Harbor.

Metals Content: Cd, Cr, Cu, Pb, Hg, Ag, Zn

Figures 45 through 51 show the concentrations of heavy metals found in 1979 sediment sampling. For all these metals, the highest concentrations are found in the northern area of Boston Harbor.

The following metals are found in concentrations which would classify sediments under Category Three of DWPC's criteria for classifying dredge or fill material:

Cadmium	Station 1
Chromium	Stations 2, 21
Lead	Stations 1, 2, 12, 14, 21
Mercury	Stations - all except 25
Zinc	Stations 1, 2

Comparing these metals concentrations with those reported for other parts of the world (Table 11), it appears Boston Harbor sediments are within the general range of those found near urban areas.

Toxic Organic Compounds: PCB and DDT

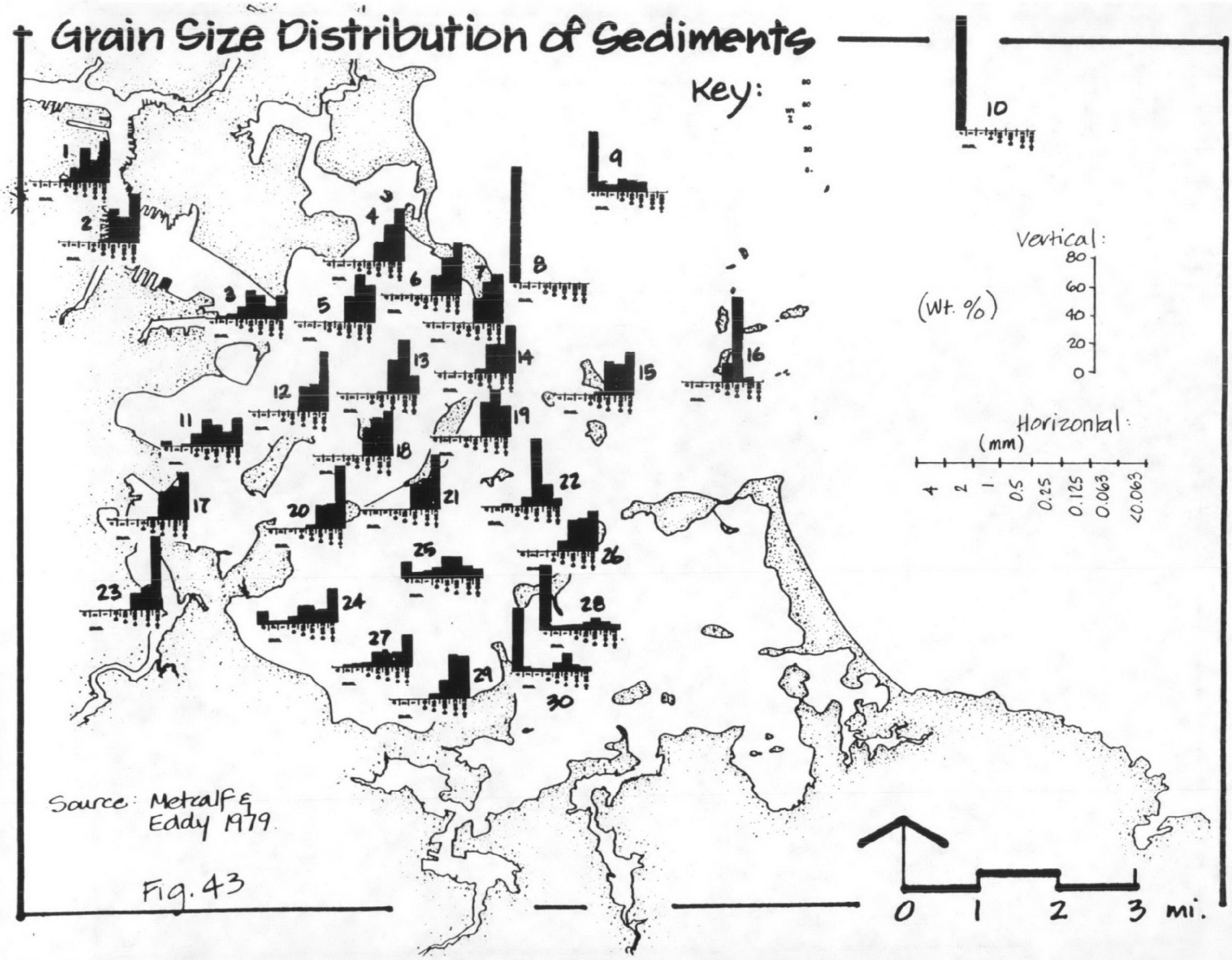
Figures 52 and 53 show the concentrations of PCB and DDT reported for Harbor sediments. None of the analyses for PCB found concentrations which would cause the sediments to be classified under Category Three of DWPC's criteria for dredge and fill material. The concentration found at Station 1 (0.889 ug/g) would result in a Category Two classification (if other constituents did not result in a higher classification).

TABLE II : CONCENTRATIONS OF HEAVY METALS IN SEDIMENTS AS REPORTED IN THE LITERATURE (values in ppm)

SEDIMENT SOURCE	CHROMIUM	ZINC	COPPER	LEAD	MERCURY	CADMIUM
deep sea clays[1]	90	165	250	80	0.001-0.4	0.43
Fossil lake, river[2]	47-59	105-115	25-45	16-30	0.2-0.5	0.2-0.3
Lake George (ave)[3]	0.5	15.3	1.4	—	--	0.3
Adirondock Lakes (range)[4]	0.1-72.5	1.7-78.7	0.0-2.1	—	—	0.1-0.4
Lake Washington[5]	—	—	—	3.4-38.9	0.06-0.74	—
Background Levels:[6]						
Lake Michigan	77	120	44	40	0.04	—
Wisconsin Lake	7	15	22	14	0.24	2.5
Lake Washington	--	60	16	20	0.1	—
Lake Erie	13	7	18	—	0.004	0.14
Lake Constance	50	124	30	19	0.2	0.21
Maximum Levels:[7]						
Lake Michigan	85	317	75	145	0.2	—
Wisconsin Lakes	49	92	268	124	1.12	4.6
Lake Washington	--	230	50	400	1.0	—
Lake Erie	42	42	59	—	4.48	2.4
Lake Constance	153	380	34	52	0.8	0.68
Lake Constance[8]	78	79	29	40	—	--
unmined area[9]	—	320	89	89	--	2
mined area[10]	—	2750	3245	291	—	3
Rhine River[11]	388	1240	268	482	—	—
Rhine River[12]	121-493	1240-3900	86-286	155-369	3-9	4-13
Rhine River (Biesbosh)[13]	760	520	470	850	18	—
San Francisco Bay[14]	—	177.0	72.8	50.7	0.63	0.91
San Francisco Bay	—	222.0	118.3	80.7	1.01	1.56
San Francisco Bay	—	204.3	92.6	35.1	0.36	0.62
New Bedford Harbour[15]	3200	2300	7500	560	3.8	76
Sorfjord (fjord)[16]	—	118000	12000	30500	—	850
Derwent estuary[17]	258	10000	—	1000	1130	862
Los Angeles River[18]	—	--	—	9000	—	860
Lake Erie[19]	--	--	—	—	--	130

* for footnotes - see Appendix A

Grain Size Distribution of Sediments



Source: Metcalf & Eddy 1979

Fig. 43

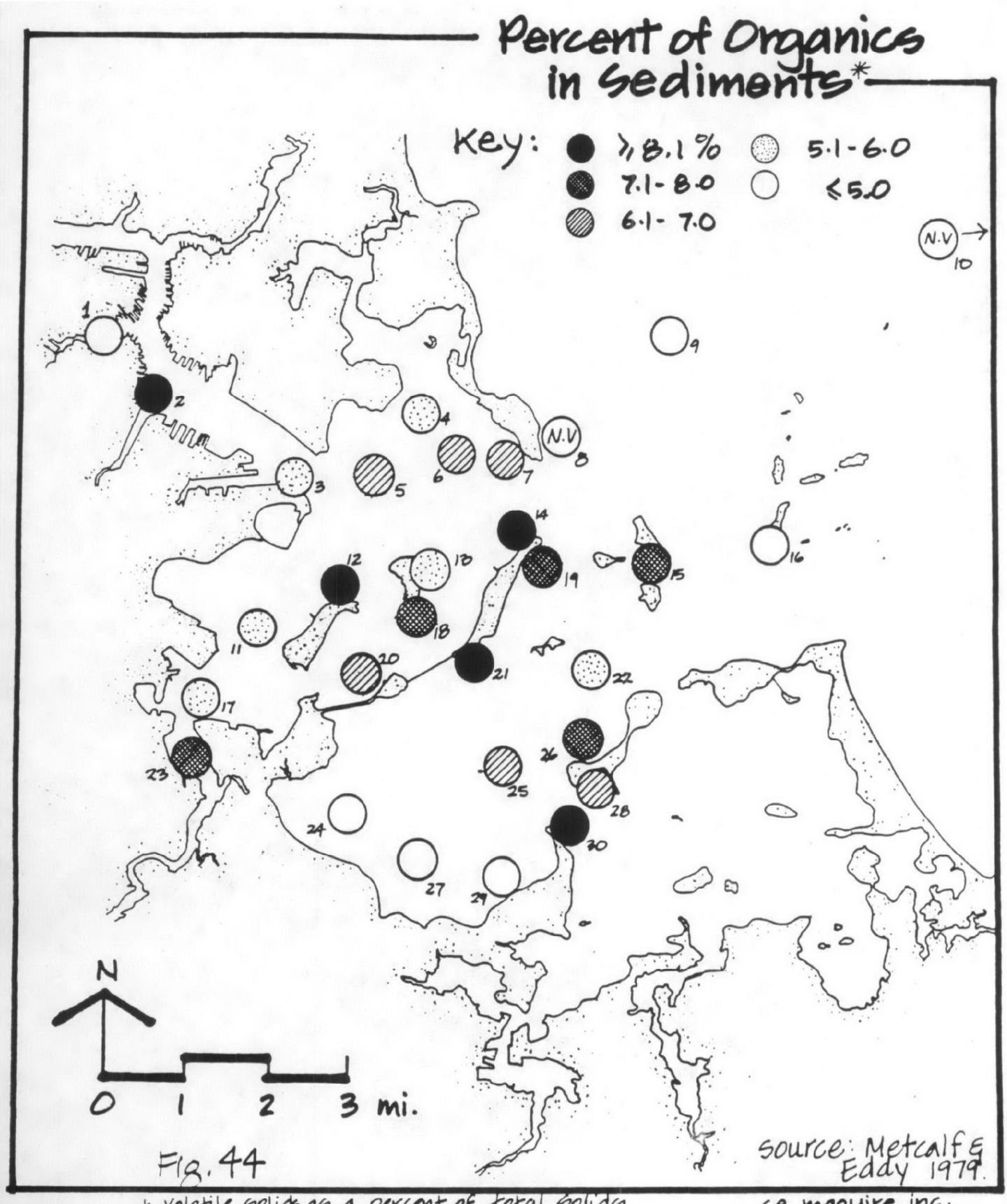


Fig. 44

source: Metcalf & Eddy 1979.

* volatile solids as a percent of total solids.

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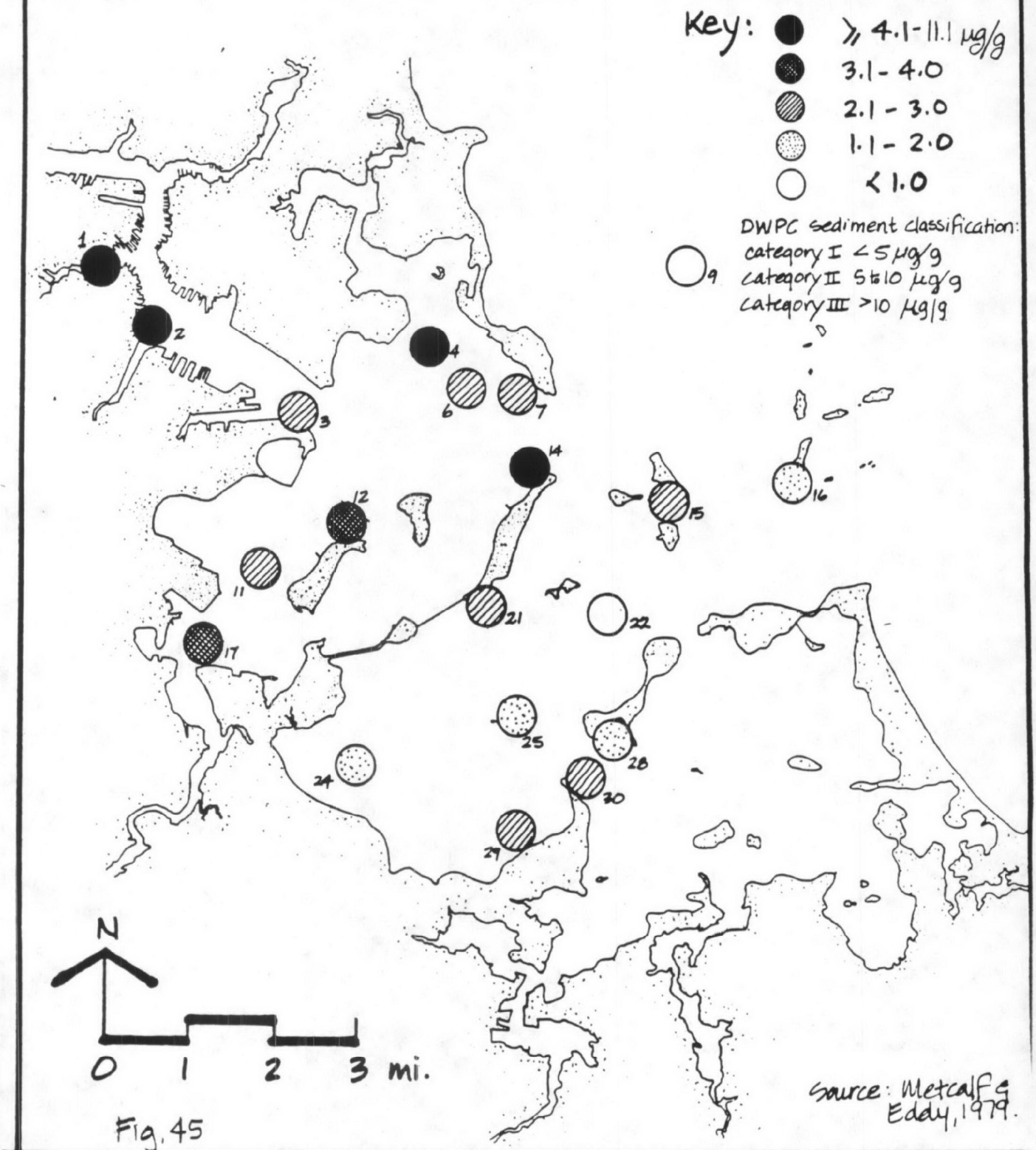
Cadmium in Sediments



Source: Metcalf & Eddy, 1979.

Fig. 45

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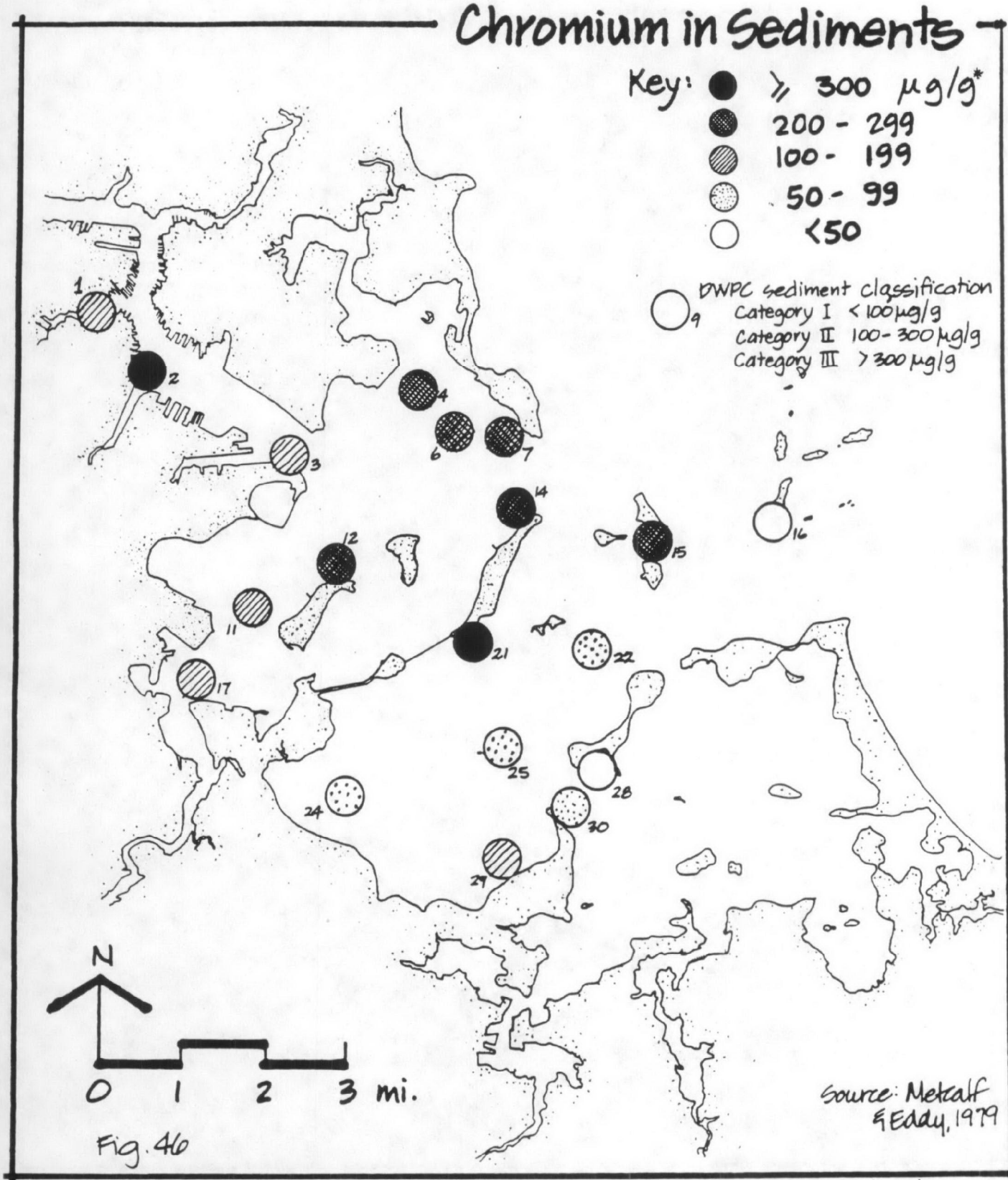
Chromium in Sediments



Source: Metcalf & Eddy, 1979

Fig. 46

* raw data expressed as mg/g

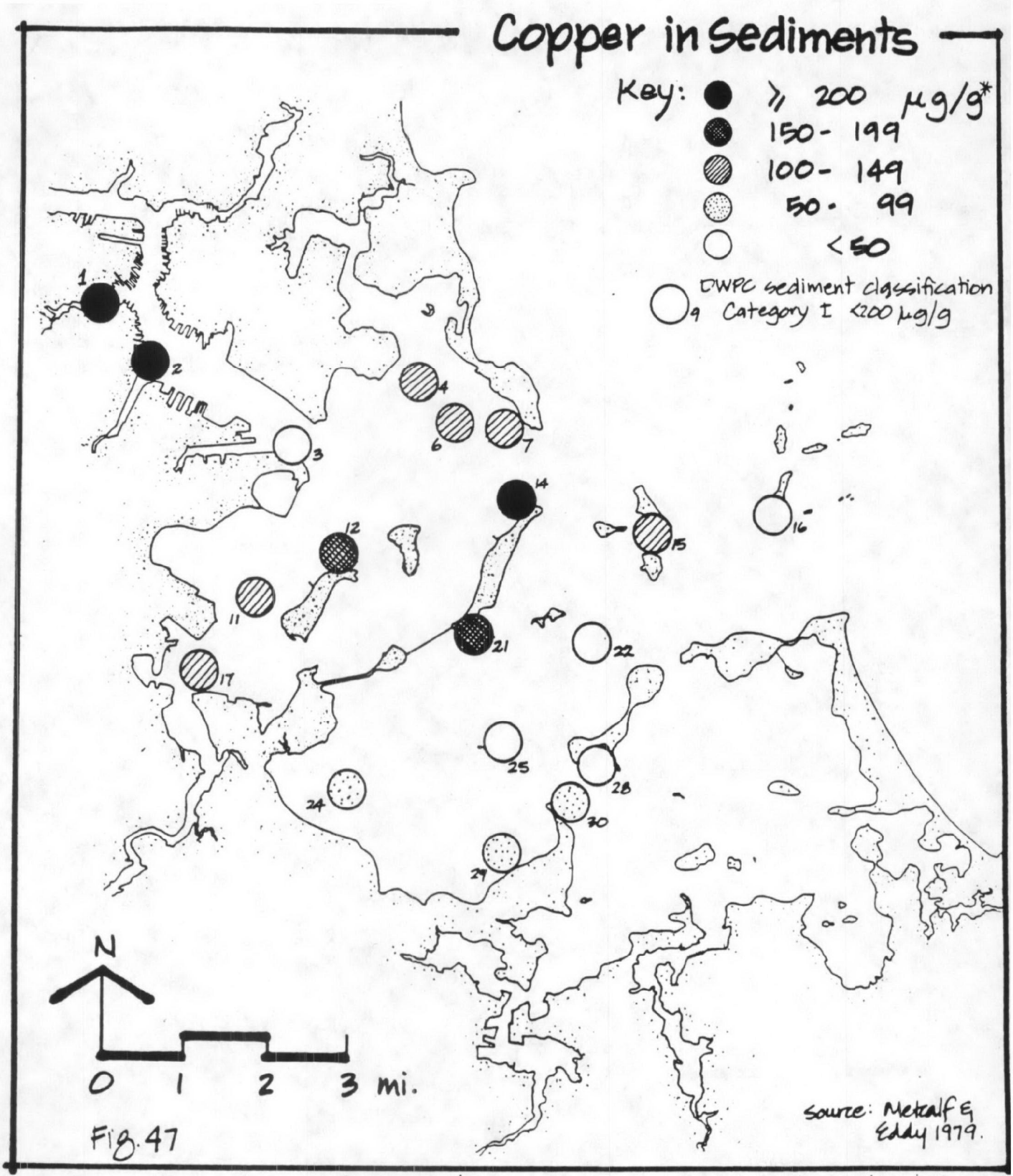


Fig. 47

* raw data expressed as mg/g

Lead in Sediments

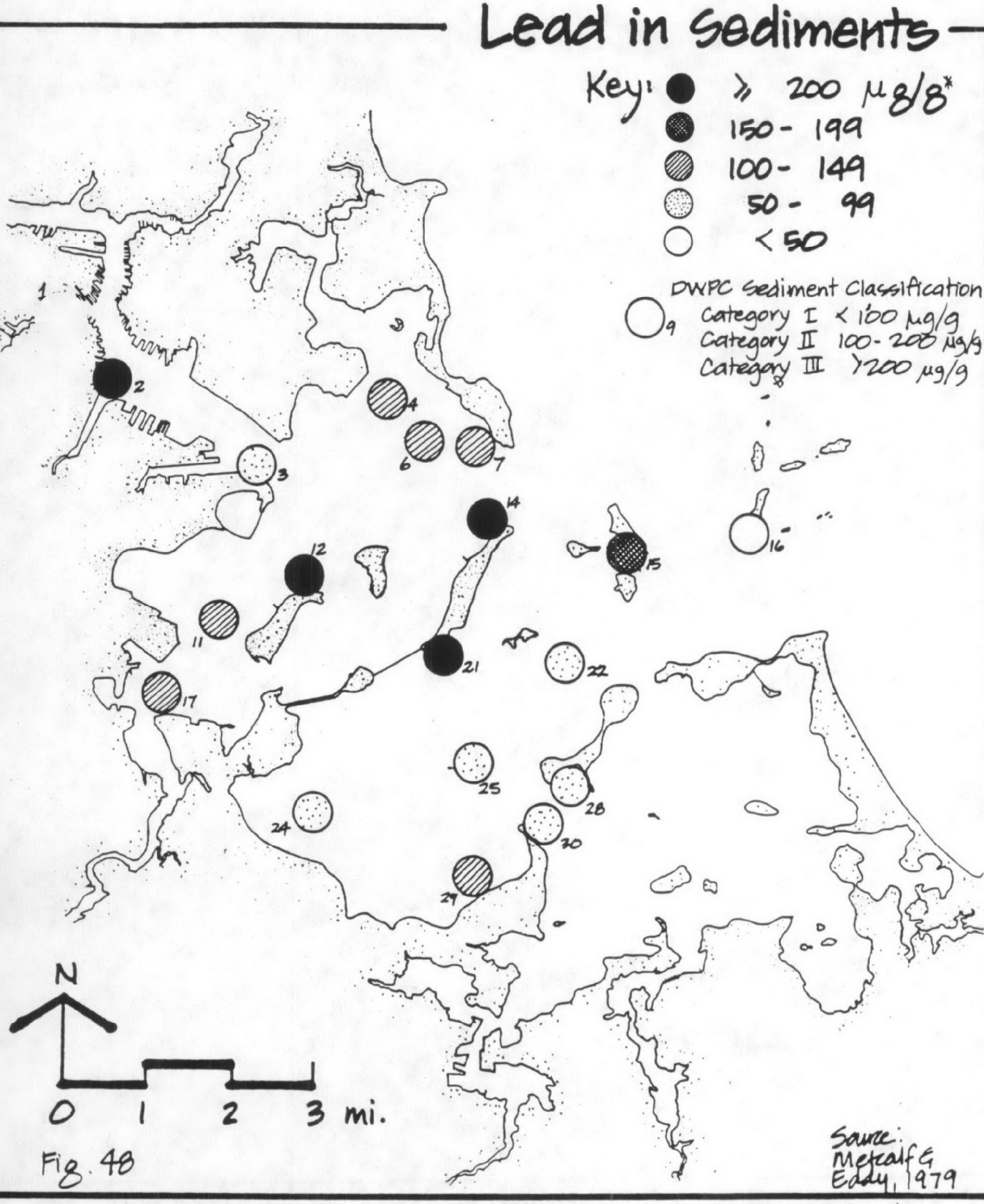


Fig. 48

Source: Metcalf & Eddy, 1979

* raw data expressed as mg/g

ce maguire inc.

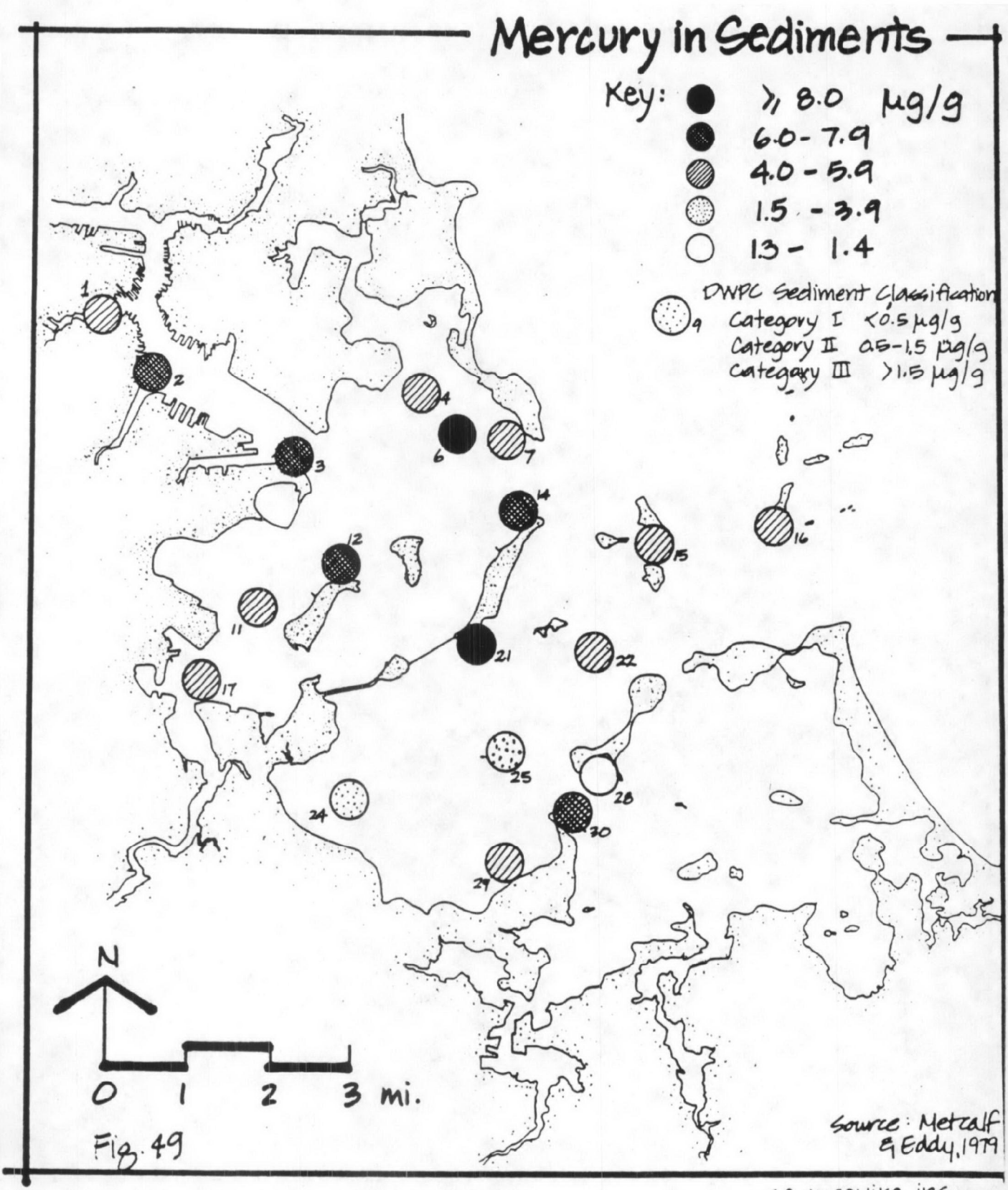
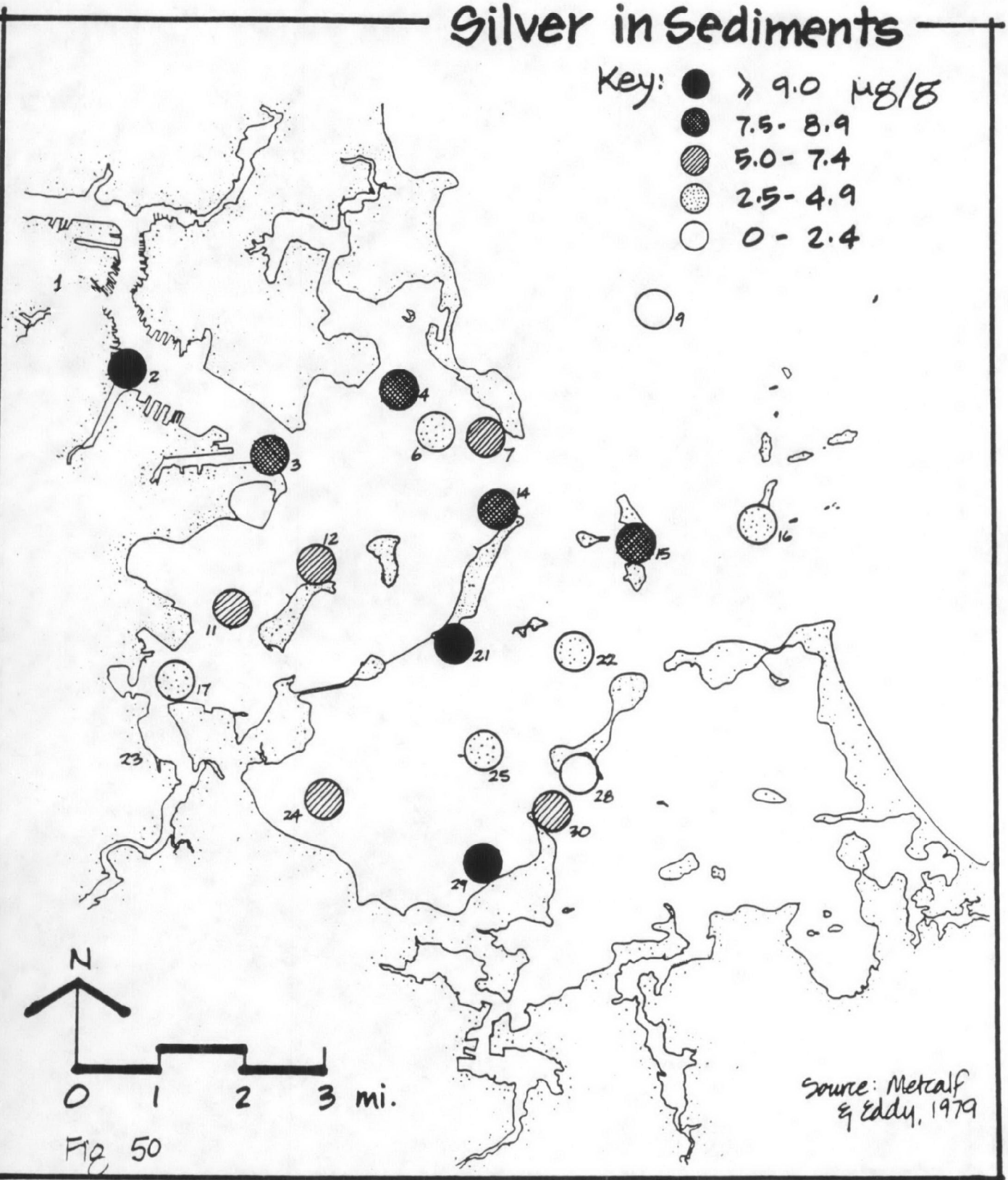


Fig. 49

ce maguire inc.

Silver in Sediments

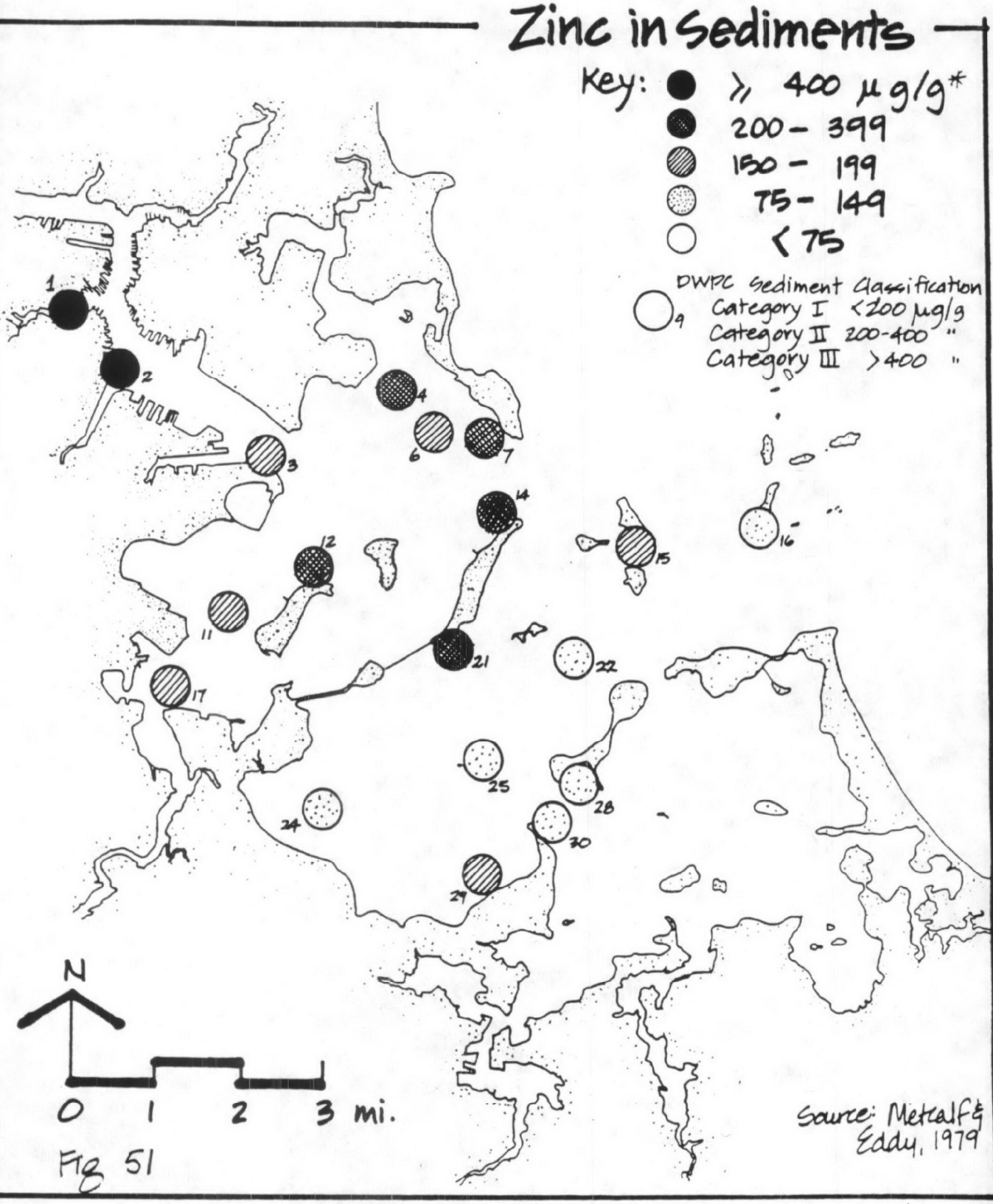


Source: Metcalf & Eddy, 1979

Fig 50

ce maguire inc.

Zinc in Sediments



Source: Metcalf & Eddy, 1979

Fig 51

* raw data expressed as mg/g

ce maguire inc.

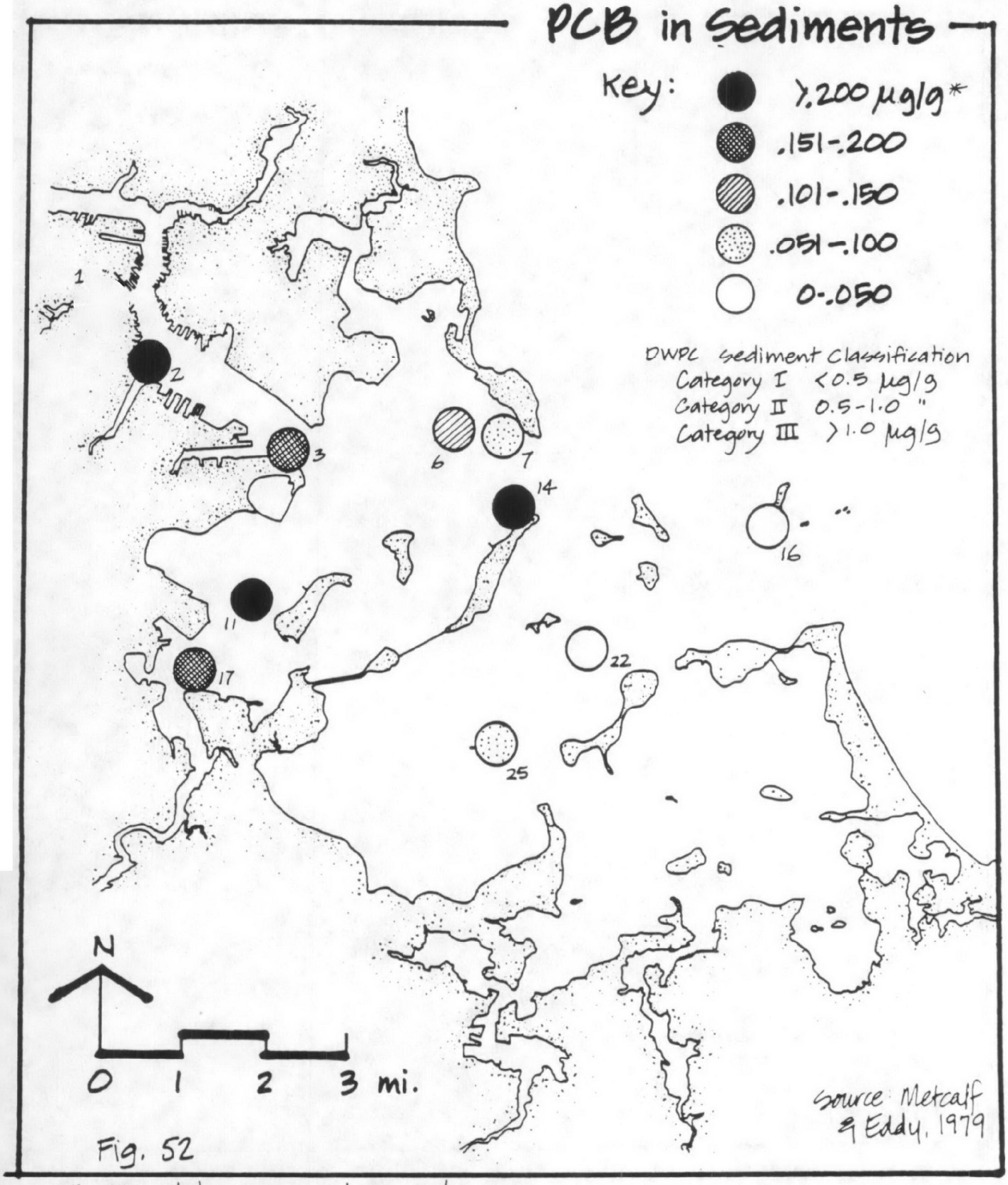


Fig. 52

* raw data expressed as ng/g

Note: PCB concentrations as high as 32 µg/g (mg/kg) have been reported in Neponset River Sediments.

ce maguire inc.

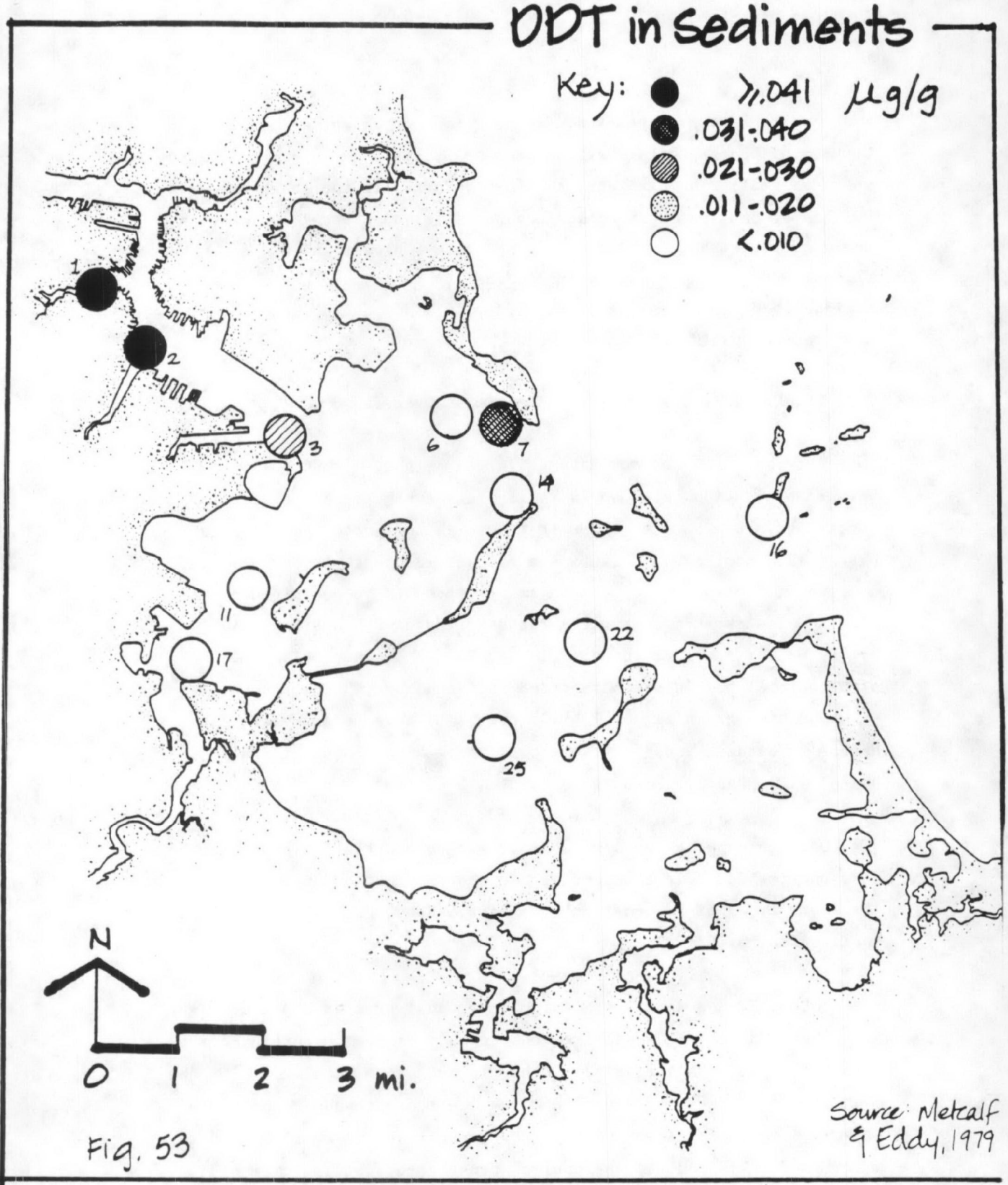


Fig. 53

* raw data expressed in ng/g

D. Biologic Conditions

Boston Harbor supports a diverse community of marine life. Studies of the benthic invertebrate populations show relatively fewer species, smaller populations, and lower biomass in the Inner Harbor, Dorchester Bay, and Deer Island/Governors Island Flats than in other areas of the harbor. Benthic finfish surveys have found winter flounder (Pseudopleuronectes americanus) to be the dominant benthic finfish in these areas (Metcalf & Eddy, 1979 MDC 301(h) Waiver Application, p. INT-29).

1. Planktonic and Intertidal Communities Overview

A summary of plankton data collected as part of MDC's 1979 301(h) Waiver Application is shown in Table 12 (see Figure 54 for sampling locations). Compared to other stations, phytoplankton densities are higher and zooplankton densities are lower in the Inner Harbor. The dominant groups of phytoplankton are reported to be centric diatoms and dinoflagellates at all stations reported (Metcalf & Eddy, MDC 1979 301(h) Waiver Application, p. BXI-5 to 7). "Moderate" blooms of planktonic algae have been reported in the harbor; "dense" concentrations of blue-green algae (10^5-10^6 cells/ml) have been reported in harbor tributaries such as the upper Mystic River (Metcalf & Eddy, 1979 301(h) Waiver Application, Attachment 12, p. 130).

Data on zooplankton are lacking, although Metcalf & Eddy report "the species found in the samples are those commonly found in the nearshore areas of New England" (Metcalf & Eddy, MDC 1979 301(h) Waiver Application, p. BXI-7).

Boston Harbor contains a large intertidal area as shown in Figure 55. These intertidal areas are known to support large populations of softshell clam (Mya arenaria). Other invertebrate populations in the bottom muds of the intertidal zone include those found in the benthic surveys described below. Where a rocky substrate is available, blue mussels (Mytilus edulis), barnacles (crustacean subclass cirripedia),

TABLE 12

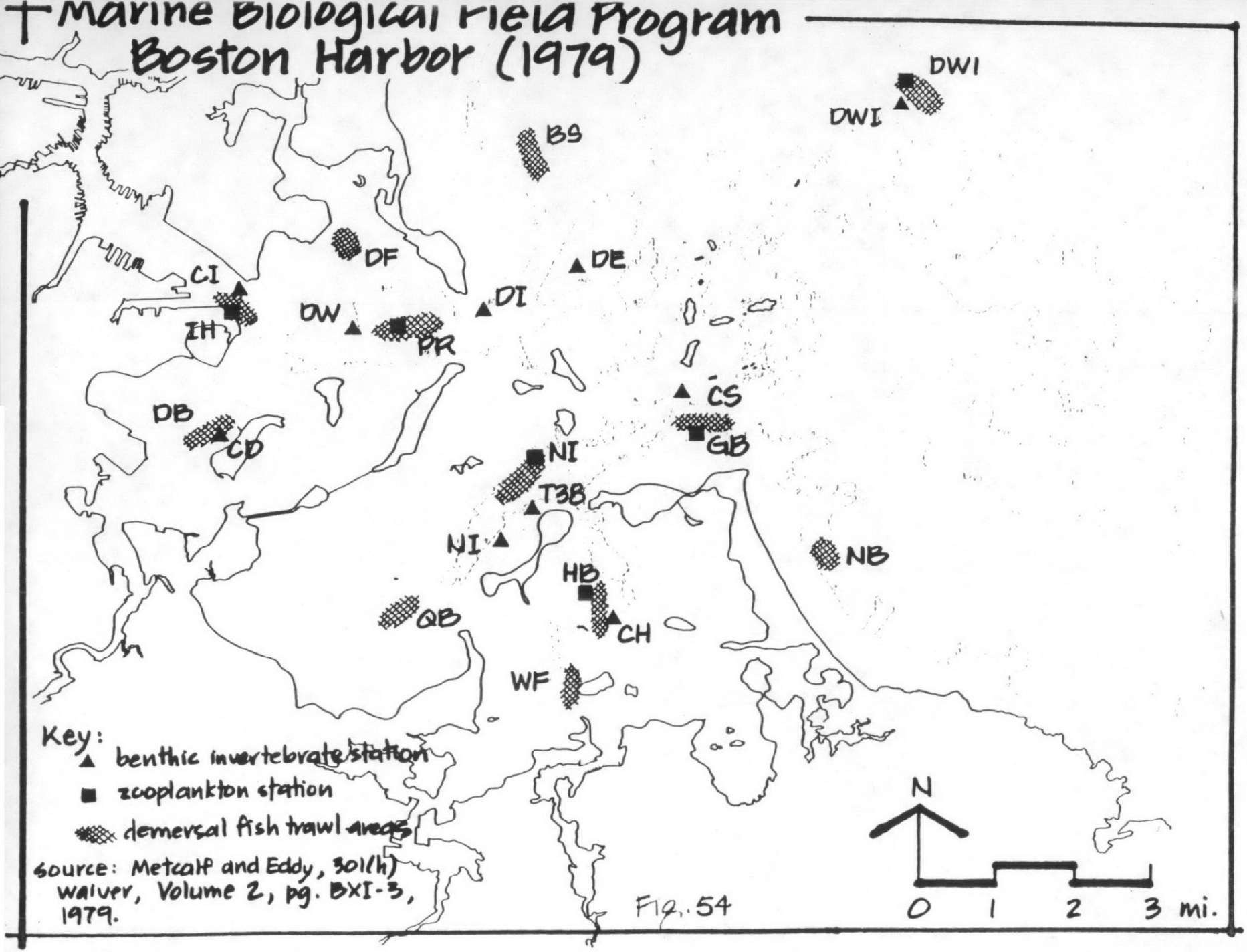
SUMMARY OF PLANKTON DATA

Station	Phytoplankton		Zooplankton[1]	
	Taxa	Density ($\times 10^6$ per liter)	Taxa	Density ($\times 10^3$ per meter^3)
Deer Island	24	3.49	13	9.12
Nut Island	15	1.79	10	7.92
Modified Outfall	18	3.99	13	10.22
Great Brewster	18	2.75	11	8.21
Hull Bay	17	2.26	11	3.52
Inner Harbor	13	6.90	11	1.73

1. Numbers represent the holoplankton group of zooplankton because they remain planktonic throughout their life history.

source: Metcalf & Eddy, 301(h) waiver application, Vol I, page INT-26, 1979.

Marine Biological Field Program
Boston Harbor (1979)



Key:
- ▲ benthic invertebrate station
- ■ zooplankton station
- demersal fish trawl areas

source: Metcalf and Eddy, 301(h) waiver, Volume 2, pg. BXI-3, 1979.

Fig. 54

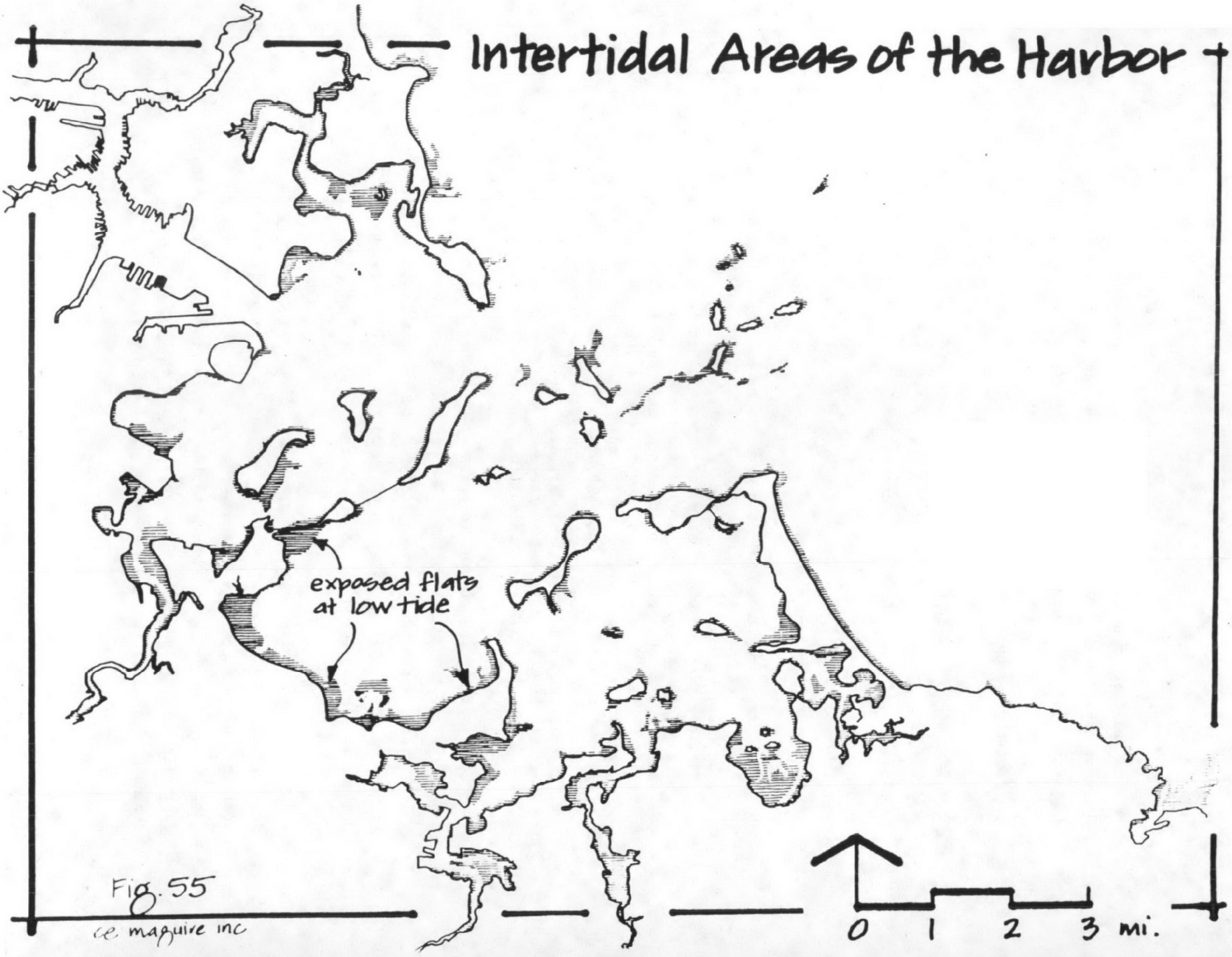


Fig. 55

ce maguire inc

periwinkles (Littorina sp.), and crabs (Crustacean subclass Malacostraca) dominate the macroinvertebrate populations. Rockweed, (Fucus sp.) is the dominant macroalgae in the rocky intertidal areas.

2. Benthic Community Characteristics

Data on benthic invertebrates and finfish were collected during 1978 and 1982 as part of MDC's 301(h) Waiver Application studies. Sampling stations are shown in Figure 54 and 56.

Tables 13 and 14 show the invertebrate biomass at each sampling location by most common classes.

> "With few exceptions, only the three major coastal faunal groups (Polychaeta, Mollusca, Arthropoda) contributed significantly to the total biomass, as presented in Tables [13] and [14]. For two stations (DIB and DIC), there are also significant amounts of Echinodermata. All other groups are present in only trace amounts. Because of the overwhelming influence a single large crab or bivalve may have on biomass results, it is difficult to generalize the information contained within the tables; however, in most cases, the polychaetes constitute the majority of the biomass and also tend to be more consistently represented among the replicates at a station. Molluscs are the group with the next highest biomass, followed by the arthropods." (Metcalf & Eddy, 1982, MDC 301(h) Waiver Application, Addendum 3, p. 5-17).

Note that the invertebrate biomass in the Inner Harbor (Station CI) and Deer Island Flats (Station DOA) is almost entirely made up of polychaetes. These two stations also had the lowest total invertebrate biomass of all stations. Station CD in Dorchester Bay also showed polychaete dominance and low total biomass.

In the Deer Island Flats samples, the polychaete (worm) Capitella spp. was the only genera found in two of the three samples, and was dominant in the third (see Appendix B of this report for species breakdown). In the Inner Harbor samples, the invertebrates were either Capitella spp., Polydora ligni or Polydora aggregata; Capitella dominated in two of the three samples (see Appendix B).

†Benthic Invertebrae and Sediment Sampling Stations (1982)

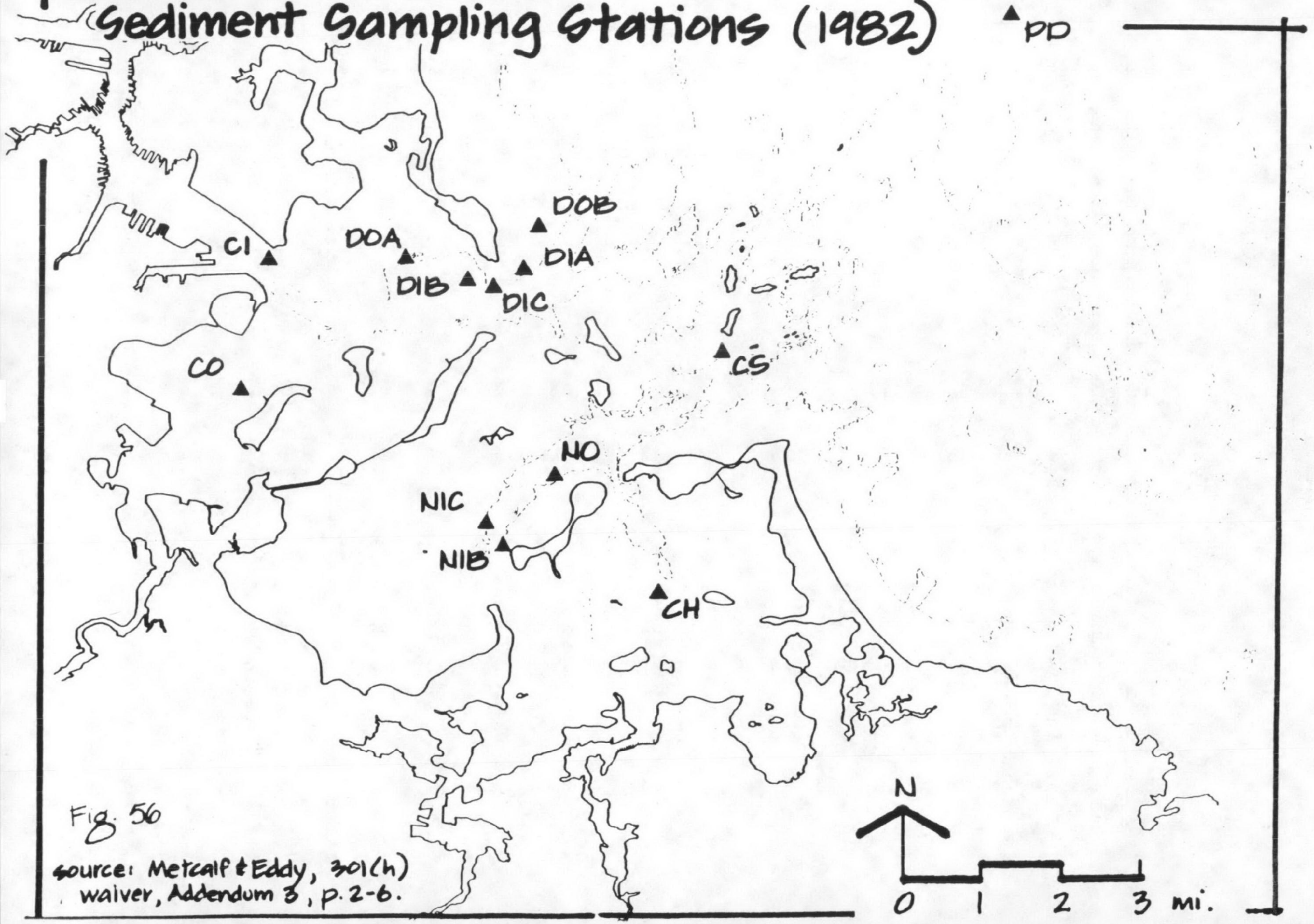


Fig. 56

source: Metcalf & Eddy, 301(h) waiver, Addendum 3, p. 2-6.

Table 13

BIOMASS PER 0.085m^2

BIOMASS DATA 0.085m^2 Station	Rep	Polychaeta	Mollusca	Arthropoda	Echinodermata	Rhynchocoela	Oligochaeta	Hemichordata	Sipunculida	Caldaria	Phoronid	Total
	1	3.309	1.368	1.850	0.005	0.029	0.020	-	0.003	-	-	6 584
NIB	3	3.521	1.153	32.378	0.012	0 036	0.038	-	< 0.001	-	-	37.139
	4	4.932	1.364	2.363	0.020	0.483	0.030	-	+	-	-	9 192
	Ave.											17 638
	3	1.230	0.788	0 609	0.011	.007	0.181	+	-	-	-	2.826
NIC	4	1.988	7.847	0.642	0.002	0.430	0.164	-	-	0.026	-	11.099
	5	1.686	4.898	0.503	0.059	0.009	0 076	-	-	-	-	7 231
	Ave											21.156
	1	2.447	0.562	0.382	0.690	0.309	0.112	-	-	-	-	4.502
NO	2	3.212	1.325	60.880	1.165	0.627	0.464	+	-	-	<0.001	67 677
	3	3.320	1.170	0.368	0 016	0.084	0.060	0.002	-	0.096	-	5.116
	Ave.											25.765
	3	1.960	6:360	0.523	-	-	0 004	-	-	-	-	8.847
OLA	4	1.375	1.755	0.354	< .001	0.100	0.003	-	-	-	-	3.488
	5	1.652	4.381	0.574	-	<.001	0.003	-	-	-	-	6.611
	Ave.											6.315
	3	0.571	2.506	0.140	4.157	-	0.003	-	-	-	-	7.377
OLB	4	1.405	3.693	0.285	-	<.001	0.004	-	-	-	-	5 388
	5	0.683	6.852	0.231	-	-	0.003	-	-	-	-	7.769
	Ave.											6.845
	1	0.460	0.267	0.165	7.055	0.293	0.039	-	-	-	-	8.379
OLC	4	0.646	0.090	0.085	46.700	0.013	0.031	-	-	-	-	47.565
	5	0.542	0.009	0.558	-	0.029	0.083	-	-	-	-	1.221
	Ave.											19.055
	1	0.360	-	< 0.001	-	-	< 0.001	-	-	-	-	0.362
ODA	2	0.954	-	-	-	-	-	-	-	-	-	0.954
	3	2.086	-	-	-	-	-	-	-	-	-	2 086
	Ave.											1.134
	1	3.455	3.999	0 057	-	0.408	0.004	<0.001	-	<0.001	<0.001	7.925
ODB	2	1.972	3.471	0.067	-	-	0.005	-	-	-	-	5.515
	4	7.127	4.230	0.315	< 0.001	< 0.001	0.030	-	-	-	-	11.704
	Ave.											8.381
CD	1	2.153	0.062	0.070	-	-	0.120	-	-	-	-	2.385
	4	1.514	0.637	0.173	-	0.001	0.187	-	-	-	-	2 732
	5	4.837	0.068	0.048	-	0.089	0.058	-	-	-	-	5 100
	Ave.											3.406
	1*	13.750	0.004	2.561	-	1.451	0.026	-	-	-	-	17.792
CB	2	39.663	0.109	3.125	-	0.052	0 065	-	-	-	-	43.014
	4	27.180	0.065	2.113	-	1.365	0.057	-	-	-	-	30.780
	5	15.883	0.171	2.682	-	0.371	0.050	-	-;	-	-	19.157
	Ave.											30.984
	1	1.143	0.032	<0.001	-	< 0.001	< 0.001	-	-	-	-	1.178
CI	3	0.582	<0.001	-	-	-	-	-	-	-	-	0.583
	4	0.846	-	-	-	-	-	-	-	-	-	0 846
	Ave.											0 869
	2	0.399	0.596	0.236	0.233	-	-	-	-	-	-	1.464
CS	3	2.759	0.387	0.475	1.110	0.005	< 0.001	-	-	0.005	0.003	4.745
	4	1.704	0.915	0.234	0.204	-	-	-	-	0.004	-	3.061
	Ave.											1 020
	3	10.845	0.181	0.272	< 0.001	0 211	< 0 001	-	-	0.032	0.008	11.553
PO	4	10.116	0.158	63.579	0.017	0.011	0.003	-	-	0.162	<0.001	74.150
	5	9.350	11.595	0.046	0.006	0.282	0.002	-	-	0.013	-	21.296
	Ave.											35 666

*Sieved on 0.7 mm mesh; not included in average for station.

Source: Metcalf & Eddy, 1982. 301(h) Waiver Application Addendum 3, p. 5-18 & 5-19.

TABLE 14

BIOMASS PER 1.0m²

BIOMASS DATA 0.1m² Station	Rep.	Polychaeta	Mollusca	Arthropoda	Echinodermata	Rhynchocoela	Oligochaeta	Coiderla	Phoronidea	Hemichordata	Sipunculida	Total
DOA	1	0.424	-	0.001	-	-	<0.001	-	-	-	-	0.424
	2	1.122	-	-	-	-	-	-	-	-	-	1.122
	3	2.454	-	-	-	-	-	-	-	-	-	2 454
	Ave.											1.333
DOB	1	4.065	4.705	0.067	-	0.472	0 005	<0 001	<0 001	-	-	9.315
	2	2.320	4.084	0.079	-	-	0.006	-	-	-	-	6.489
	4	8.385	4.976	0.371	<0.001	<0.001	0.035	-	-	-	-	13 767
	Ave.											9 857
CD	1	2.533	0.049	0.082	-	-	0.141	-	-	-	-	2 805
	4	1.781	0.773	0.439	-	<0.001	0.232	-	-	-	-	3.225
	5	5.691	0.080	0.057	-	0.105	0.068	-	-	-	-	6 001
	Ave.											4.000
CH	2	46.662	0.128	3.677	-	0.061	0 077	-	-	-	-	59.535
	3	16.177	0.005	3.013	-	1.707	0.031	-	-	-	-	20 933
	4	31.976	0.076	2.486	-	1.606	0.067	-	-	-	-	36.312
	5	18.686	0.201	3.155	-	0.436	0.059	-	-	-	-	26.316
	Ave.											40.754
CI	1	1.345	0.037	< 0.001	-	<0.001	< 0.001	-	-	-	-	1.384
	3	0.685	< 0.001	-	-	-	-	-	-	-	-	0.685
	4	0.993	-	-	-	-	-	-	-	-	-	0.993
	Ave.											1.021
CE	2	0.669	0.701	0.278	0.274	-	-	-	-	-	-	1.722
	3	3.246	0.455	0.559	1.306	0.006	< 0.001	0.006	0.004	-	-	5.583
	4	2.005	1.077	0.275	0.240	-	-	0.005	-	-	-	3.602
	Ave.											3.636
FD	3	12.729	0.213	0 308	0 001	0.251	< 0.001	0.038	0 009	-	-	13.579
	4	11.901	0.187	74.917	0.020	0.015	0 004	0.191	< 0.001	-	-	87.236
	5	11.000	13.641	0.034	0.007	0.332	0.003	0.018	-	-	-	25 055
	Ave.											41.956
HIB	1	3.893	1.609	2.176	0.006	0.036	0 024	-	-	-	0.004	7.746
	3	4.142	1.356	38.092	0.014	0.062	0 045	-	-	-	<0.001	43.693
	4	5.802	1.605	2.780	0.024	0.568	0.035	-	-	-	<0.001	10.814
	Ave.											20.751
HIC	3	1.450	0.927	0.716	0.013	0.009	0.213	-	-	-	-	3.915
	4	2.339	9.232	0.755	0.003	0.508 •	0.193	0.031	-	<0.001	-	13 058
	5	1.904	5.762	0.592	0.070	0.011	0.089	-	-	-	-	10 009
	Ave.											8.994
HD	1	2.879	0.661	0.449	0.812	0 364	0.132					5.296
	2	3.779	1.359	71.624	1 371	0.738	0.546	-	0.006	<0.001	-	79.420
	3	3.906	1.376	0.433	0.019	0.099	0.071	0.113	-	0.083	-	6 019
	Ave.											30 312
BIA	3	2.306	7.482	0.615	-	-	0 005	-	-	-	-	10.408
	4	1.500	2.065	0.417	<0.001	0.118	0.004	-	-	-	-	4.104
	5	1.944	5.154	0.875	-	<0.001	0.004	-	-	-	-	7 777
	Ave.											7 429
BIB	3	0.672	2.948	0.185	4.891	-	0.004	-	-	-	-	8.680
	4	1.633	4.345	0.335	-	<0.001	0.005	-	-	-	-	6 338
	5	8.804	8.061	0.272	-	-	0 004	-	-	-	-	9 141
	Ave.											8.053
BIC	1	0.541	0.314	0.194	8.300	0 462	0.046	-	-	-	-	9 857
	4	0.760	0.106	0.100	54.941	0 015	0 037	-	-	-	-	55 959
	5	0.638	0.011	0.657	-	0.034	0.098	-	-	-	-	1 438
	Ave.											22 418

source: Metcalf & Eddy, 1982. 301 (h) Waiver Application Addendum 3, p. 5-20, 5-21.

"The polychaete Capitella capitata has been proposed as an indicator species for pollution... It is able to tolerate low-salinity, low-oxygen, and high-organic-content conditions typical of wastewater effluent locations and has often been found in great numbers near outfalls. However, C. capitata is also found in areas remote from outfalls - where, for example, there are rich organic muds or underwater freshwater seeps." (Grace, 1978, p. 528)

Table 15 presents the number of taxa and density of organisms found in each benthic invertebrate sampling. Values shown for both parameters indicate stress in the Inner Harbor and Deer Island Flats.

Table 16 summarizes the demersal (bottom) fish catch obtained with an otter trawl in 1979 (trawling locations are shown in Figure 54). These results show winter flounder as the dominant demersal finfish at 10 of the 12 stations sampled. The largest catches were in President Roads, Broad Sound and Nantasket Roads.

3. Indicators of Biological Health

As discussed above, there is evidence of environmental stress in the composition of benthic communities in the Inner Harbor, Deer Island/Governor's Island Flats, and to a lesser extent, Dorchester Bay. This stress is likely to be related to the generally poorer water and sediment quality found in these areas, compared to Quincy and Hingham Bays and Nantasket Roads.

Widespread fish disease has been reported in winter flounder, the dominant demersal finfish in Boston Harbor. Figure 57 shows the percentage of winter flounder exhibiting fin erosion (necrosis) in Boston Harbor. Looking at these data, two observations can be made:

1. Fin erosion is common in winter flounder from most areas of Boston Harbor, including areas with generally good water quality such as Hingham Harbor.

TABLE 15

BENTHIC COMMUNITY PARAMETERS (ALL REPLICATES)

Station identification	Replicate number	Number of taxa	Density $0.085m^{-2}$
CH	2	44	2,512
CH	4	44	1,919
CH	5	52	2,176
NIB	1	62	3,062
NIB	3	69	4,039
NIB	4	59	3,060
NIC	3	78	3,153
NIC	4	83	3,851
NIC	5	75	3,929
CS	2	39	550
CS	3	48	1,238
CS	4	51	1,165
NO	1	83	3,324
NO	2	88	4,771
NO	3	78	3,716
CD	1	32	1,497
CD	4	39	2,549
CD	5	28	890
CI	1	13	342
CI	3	3	76
CI	4	3	75
DIA	3	49	2,270
DIA	4	46	1,685
DIA	5	46	1,224
DOB	1	42	4,707
DOB	2	40	1,877
DOB	4	52	6,934
PD	3	97	9,521
PD	4	86	6,748
PD	5	69	9,267
DIC	1	61	1,037
DIC	4	44	570
DIC	5	46	550
DOA	1	8	33
DOA	2	2	133
DOA	3	3	194
DIB	3	34	314
DIB	4	28	450
DIB	5	26	575

source: Metcalf & Eddy, 1982. 301(h) Waiver Application, Addendum 3, p. 5-28.

TABLE 16

SUMMARY OF 1979 DEMERSAL FISH TRAWL RESULTS

	Station	Dominant species	No. of fish	% of catch	Taxa
PR	Deer Island	Winter flounder	311	89	6
DF	Deer Island Flats	Winter flounder	210	79	7
IH	Inner Harbor	Winter flounder	32	85	5
DB	Dorchester Bay	Winter flounder	70	77	9
NI	Nut Island	Pollock	171	46	8
		Cod		19	
		Winter flounder		18	
QB	Quincy Bay	Winter flounder	14	43	5
		Skate		21	
WF	Hingham Bay	Winter flounder	28	68	5
		Cummer		18	
HB	Hull Bay	Winter flounder	33	61	7
		Skate		15	
GB	Great Brewster	Silver Hake	9	33	5
		Cod		22	
		Winter flounder		22	
BS	Broad Sound	Winter flounder	254	38	13
		Yellowtail flounder		27	
		Silver Hake		22	
NB	Nantasket Beach	Winter flounder	48	61	10
		Skate		151	
MO	Modified Outfall	Winter flounder	4	50	3
		Cod		25	
		Silver hake		25	

source: Metcalf & Eddy, 1979. 301(h) Waiver Application Volume 2, pg. BXI-16.

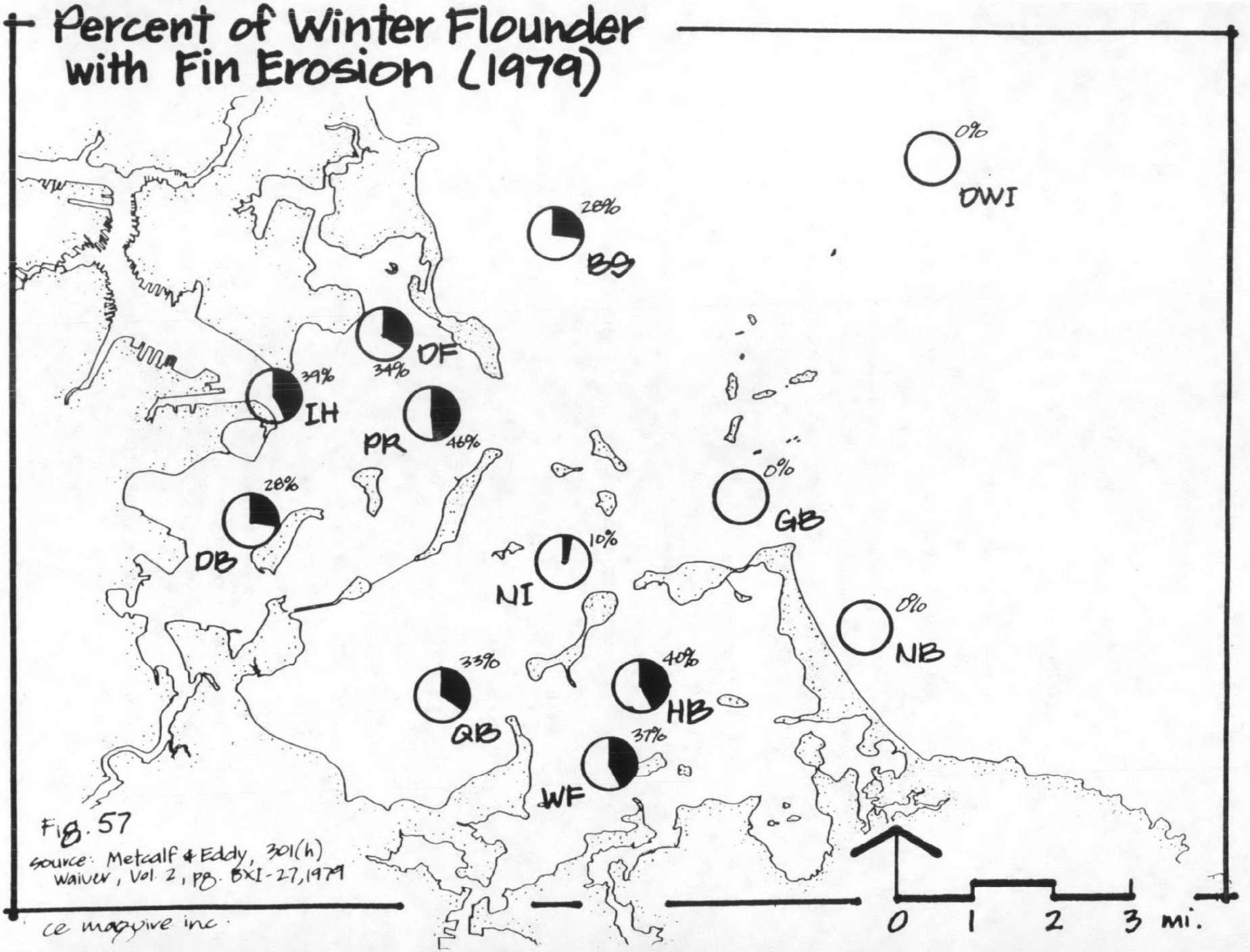


Fig. 57

source: Metcalf & Eddy, 301(h) Waiver, Vol 2, pg. BXI-27, 1979

ce maguire inc.

2. Three of the four stations outside the harbor contained no flounder with fin erosion (however, these stations also had significantly fewer flounder in the catch).

The close association of these organisms to harbor sediments laden with toxic chemicals led researchers to analyze the concentrations of the more common of these toxics in the fish themselves. Analysis of PCBs, DDT and some metals in the winter flounder found no "...close correlation with these and fin eroded fish in Boston Harbor." (1979 301(h) waiver application, Vol. 2, p. BXI-31). The results of these analyses are shown in Table 17, along with lobster tissue analyses. Table 18 shows the results of body burden analyses conducted by Massachusetts Division of Marine Fisheries along with a summary of Metcalf & Eddy's results.

U.S. Food and Drug Administration (FDA) concentration limits for toxicants in fish are shown in Table 19. In comparing this table with Tables 17 and 18 note that the concentrations in edible tissues did not exceed the FDA limits. Other observations which can be made about the body burden data are:

1. As expected, most liver concentrations of toxics exceed the concentrations found in muscle tissues, sometimes by several orders of magnitude.

2. Body burdens of toxics in lobster and flounder taken off Nantasket Beach are generally within the same range as those taken inside Boston Harbor.

3. The body burdens of copper are generally one or two orders of magnitude greater than other metals tested. This may be significant with respect to lead uptake, in light of the similar concentrations of copper and lead in sediments reported for the year this fish sampling took place (see Figures 47 and 48).

TABLE 17

BODY BURDEN ANALYSIS OF FISH AND LOBSTER
IN BOSTON HARBOR AND VICINITY

Location of catch	Species, apparent condition, and type of sample	BODY BURDEN OF TOXICS(1), ppm wet weight Silver	Cadmium	Copper	Lead	Mercury	PCB
Deer Island	Winter flounder						
	Normal, liver	0.18	0.09	1.1	0.40	0.05	4.0
	Fin erosion, liver	0.02-0.12	<0.01	2.1-8.3	0.04-0.25	.01-.03	3.6-6.4
	Fin erosion, tissue	0.01-0.05	<0.01-.02	0.23-2.6	0.04-0.06	.02-.04	0.02-0.3
	Lobster						
	Tissue	.33	.01	9.6	.04	.07	.1
Inner Harbor	Winter flounder						
	Normal, liver	0.14-0.25	0.07-0.14	9.0-9.5	0.34-0.65	.08-.09	3.6-5.2
	Fin erosion, liver	0.04-0.10	0.04-0.05	3-6	0.06-0.18	.04-.09	1.2-2.8
	Lobster						
	Tissue	.28	<.01	4.0	.08	.09	.08
Dorchester Bay	Winter flounder						
	Normal, liver	0.15-0.31	0.10-0.12	0.7-0.9	0.36-0.59	.04-.05	1.7-7.7
	Fin erosion, liver	0.15-0.43	0.11-0.22	11-12	0.57-0.61	.03-.04	11
	Lobster						
	Tissue	.16	.03	13.	.05	.07	.11
Nut Island	Winter flounder						
	Normal, liver	0.04-0.35	0.02-0.06	3.3-16	0.15-0.31	.03-.05	1.4-6.8
	Fin erosion, liver	0.31	0.07	2.5	0.69	.08	15.2
	Lobster						
	Tissue	.3	.01	7.8	.04	.07	.05
Nantasket Beach	Winter flounder						
	Normal, liver	0.2-0.69	<0.05-.10	3.9-10	0.01-0.53	.035-.090	1.3-4.7
	Normal, tissue	<0.01-0.02	<0.02	0.49-0.99	0.01-0.04	.015-.017	0.1
	Lobster						
	Tissue	.29	.01	13.	.07	.09	0.1
FDA Standard for muscle tissue		-	-	-	-	1.0	2.0

(1) No DDT detected

Source: Metcalf & Eddy, 1979. 301(h) Waiver Application Volume 2, pg BXI-34 -35.

TABLE 18

LEVELS OF METALS, PCBs, AND DDT (ppm) IN EDIBLE TISSUES OF WINTER FLOUNDER FROM THE STUDY AREA

	Constituent[3]									
	Chromium	Zinc[2]	Silver[2]	Nickel[2]	Cadmium	Copper	Lead	Mercury	PCBs	DDT[2]
Deer Island	ND[2]	10.1	0.01-0.05	1.0	ND[2]	ND[2]	ND[2]	0.05[2]	0.8[2]	ND
					0.01-0.02[1]	0.23-2.6[1]	0.04-0.06[1]	0.02-0.04[1]	0.02-0.3[1]	
Peddocks Island	ND[2]	8.5		1.5	ND[2]	ND[2]	ND[2]	0.05[2]	0.3[2]	
Hull Gut	ND[2]	17.8		0.7	ND[2]	ND[2]	ND[2]	0.11[2]	0.1[2]	
Nantasket Beach			<0.01-0.02		<0.02	0.49-0.99	0.01-0.04	0.15-0.17[1]	0.1[1]	ND
Bird Island	ND[2]	8.1		0.8	ND[2]	ND[2]	ND[2]	0.14[2]	0.4[2]	
FDA Limits								1	2	

[1]Metcalf and Eddy (1979)

[2]Division of Marine Fisheries (1983)

[3]Detection limits for DMF analysis were as follows: Cr (2 ppm), Cd (2 ppm), Cu (2 ppm), Pb (12 ppm)

Source: EG&G 1984 Oceanographic Study of Various Outfall Siting Options for the Deer Island Treatment Plant, Table 2 5-3.

Table 19

UNITED STATES FOOD AND DRUG ADMINISTRATION LIMITS ON TOXICANTS IN FISH

Source	Concentration limit
Kepone	0.3 ppm
Endrin	0.3 ppm
DDT and its derivatives	5.0 ppm
Aldrin and dealdrin	0.3 ppm
Heptochloroperoxide	0.3 ppm
Mirex	0.1 ppm
Mercury	1.0 ppm
Lead	Discretionary
PCB	2.0 ppm

Source: USFDA, Boston Office.

Note: Concentration is measured as a proportion of the toxic substance to edible portion of the fish by weight.

source: Metcalf & Eddy, 1979. 301 (h) Waiver Application Volume 2 pg. BXII-11.

4. There appears to be little or no difference in body burdens of toxics between the stations sampled, although statistical analysis of a larger sample population might show spatial differences.

A 1984 National Marine Fisheries Service study of winter flounder in Boston Harbor found a high prevalence of neoplasms in liver tissues:

> Lesions designated as cholangiocarcinoma and hepatocarcinoma were found in 8 percent of 200 fish examined. The lesions observed resemble those experimentally induced in rodents exposed to carcinogens, and may be caused by an environmental carcinogen. ... Lesions identifiable as hepatic carcinomas ... were noted in 8 percent of the fish sampled; however, it is likely that the actual percentage of these lesions considerably exceeds 8 percent since serial, "skip" sections of several randomly selected livers revealed the presence of neoplastic foci in fixed tissues with no apparent lesion in the initial section. ... Only flounder from the southern shore of Deer Island had grossly visible hepatic lesions." (Murchelano and Wolke, 1984).

This study is part of a larger study of fish disease in northeast coastal waters. The high prevalence of flounder fin erosion reported in the MDC's 1979 301(h) Waiver Application prompted the National Marine Fisheries Service, with the help of the Massachusetts Division of Marine Fisheries, to collect Boston Harbor winter flounder for examination.

> As a group, and when compared with livers of winter flounder obtained from other areas, the Boston Harbor fish livers are unique. Although focal and diffuse areas of necrosis, inflammation, and vacuolated cells have been seen in livers of winter flounder from other Northeast estuaries (Connecticut, Rhode Island), the lesions were not so abundant, severe, or associated with extensive neoplasia. None of the 93 winter flounder ... collected from unpolluted sites on the south shore of central and eastern Long Island, New York, Casco Bay, Maine and Georges Bank had neoplastic lesions. The high prevalence of MA hyperplasia and vacuolar cell lesions seen in Boston Harbor flounder are consistent with the action of a hepatotoxin. ... Necropsies of fish with the most extensive gross hepatic lesions did not reveal any gross lesions of intestine, heart, kidney, and spleen.

Analyses of hepatic polycyclic aromatic hydrocarbon (PAH) and polychlorinated biphenyl (PCB) content are in progress. Muscle tissue is also being analyzed for its PCB and PAH content (Murchelano and Wolke, 1984).

With the exception of fin erosion and cancer in winter flounder, no diseases in Boston Harbor marine life are reported.

3. BOSTON HARBOR POLLUTANT SOURCES

A. Overview

The major pollutant discharges to Boston Harbor are shown in Figure 58. Estimated annual loads of several conventional pollutants are listed by source in Table 20. Major pollutant sources are described in summary below, followed by a source by source quantification of pollutant loading where such quantification is possible.

Water quality violations found in the Inner Harbor, Dorchester Bay and Belle Isle Inlet are clearly related to bypasses and overflows from the sewer system (Figure 58). Stormwater flowing into the sewers during wet weather causes about 5.7 billion gallons of sewage, industrial wastes and urban runoff to discharge to Boston Harbor annually (MDC, 1982, CSO Study Summary, p. 4). Continuous dry weather overflows discharge over 8 billion gallons of wastewater annually to the Inner Harbor alone (O'Brien and Gere, 1981, p. 1-2). "Dry weather overflow was found to be the single most important pollution influence in ..." the Inner Harbor, Dorchester Bay and the lower reaches of their tributaries (MDC, 1982, CSO Study Summary, p. 4). Together, these pollutant sources contribute bacteria, oxygen demanding matter, suspended solids, toxic chemicals, debris and refuse to harbor waters.

The Deer Island and Nut Island treatment plants also contribute significant pollutant loads to Boston Harbor (Figure 58, Table 20). At Deer Island, average daily flow (325 million gallons per day or mgd) is within the plant's designed average flow capacity (343 mgd). Actual peak daily flows are less than current design flows (848 mgd) due to hydraulic limitations in the sewer system and influent pumping station. Flows to the Nut Island treatment plant (135 mgd average, 310 mgd peak) exceed its treatment capacity (average and peak design flows are 112 mgd and 280 mgd). The hydraulic capacity of the wastewater delivery systems to Deer and Nut Islands are 930 and 310 mgd, respectively. Together, these plants discharge 75 tons of digested sludge solids and 135 tons of effluent solids to the Harbor daily.

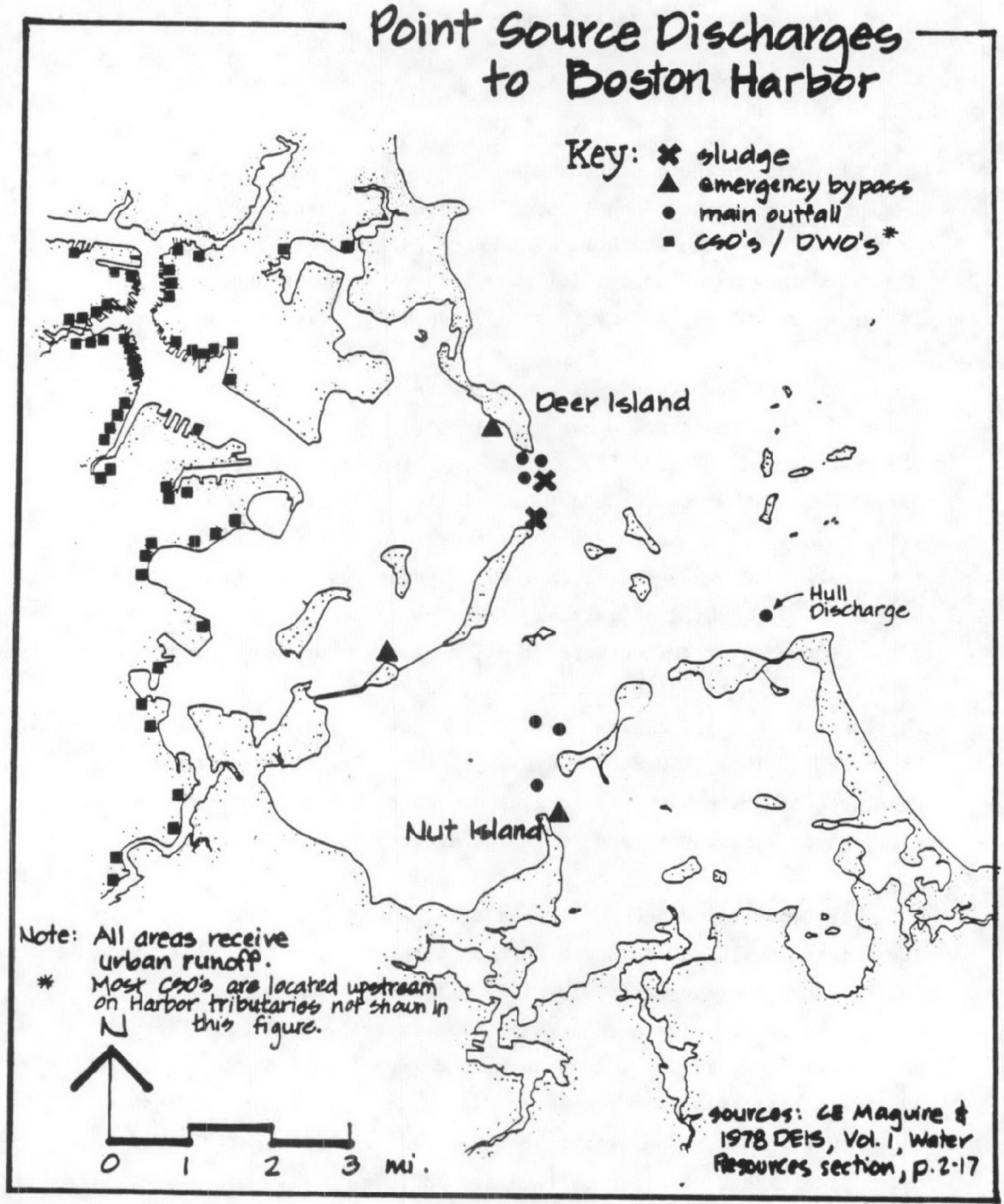

Point Source Discharges to Boston Harbor
Key: sludge
emergency bypass
main outfall
CSO's / DWO's*
Deer Island
Hull Discharge
Nut Island
Note: All areas receive urban runoff.
* Most CSO's are located upstream on Harbor tributaries not shown in this figure.
N
0 1 2 3 mi.
sources: CE Maguire & 1978 DEIS, Vol. I, Water Resources section, p. 2-17

fig. 58

Table 20

POLLUTANT LOADINGS TO BOSTON HARBOR

Source	Annual Loads: Flow (mgal)	BOD_5 (lb x 10^3)	SS (lb x 10^3)	Total Coliform (No x 10^{12})
• Treated Effluent[1]				
- Deer Island	107,800	82,700	80,900	2,000
- Nut Island	45,400	31,000	17,400	4,100
• Sludge[1][2]				
- Deer Island	100	12,600	33,400	7×10^5 (4)
- Nut Island	80	5,800	14,100	3×10^5 (4)
• CSO's	5,700	5,900	19,000	1.1×10^6
• DWO's[3]	8,800	20,200	14,700	10×10^7
• Stormwater	18,000	3,000	60,000	3.4×10^5
• Major Tributaries				
- Charles River	69,400	2,900	5,800	52,500
- Mystic River	7,300	300	600	5,500
- Neponset River	11,000	450	900	8,300
TOTALS	273,580	164,850	246,800	10.3×10^7

(1) Based on fiscal year 1982 records.
(2) Assumes year-round chlorination.
(3) Continuous dry weather overflows (as identified in the late 1970s).
(4) Assumes 1000 billion per pound of raw sludge (some 100% more than digested mass shown) and two log reduction due to digestion and disinfection with final effluent.

Source Havens & Emerson/Parsons Brinckerhoff, 1984.

Capacity limitations and equipment failures, either alone or in combination with high wet weather flows, result in bypassing of untreated wastewater at the treatment plants and points "upstream" in the sewer system (Calf Pasture - Moon Island discharge for example). Flows bypassed at the treatment plants remain unquantified. Bypasses from the treatment plant are reported to Mass. DEQE who then close affected shellfish beds.

President Roads receives effluent discharges from the Deer Island Plant, and sludge discharges from both Nut and Deer Island facilities. Although sludge is discharged on ebb tides, harbor modeling, dye testing, and sediment analyses indicate a substantial amount returns to the harbor on the flood tides (Hydroscience, 1971, p. 148; Metcalf & Eddy, 1981, 301(h) Waiver Application, Addendum 3, p. 6-2). Sludge solids and effluent discharges to President Roads are considered significant sources of high metals concentrations in nearby harbor sediments (Fitzgerald, 1980).

Effluent discharges from both Deer Island and Nut Island facilities are the likely source of locally elevated nutrient levels found in DWPC's summer water sampling (McKechnie). Based on effluent analysis, and estimated initial dilution of effluent at the outfalls, it is possible these discharges occasionally result in receiving water concentrations of bacteria, heavy metals and pesticide compounds in excess of limits contained in DWPC and EPA water quality criteria (Metcalf & Eddy, 1979 and 1982, MDC 301(h) Waiver Applications, Appendix XVIII, Addendum 1, Chapter 3, and Tetra Tech, 1980, p. 53-56). Tidal current dilution appears to bring receiving water quality within applicable water quality criteria within a short distance of the outfalls' mixing zones.

Stormwater runoff is a significant, but poorly quantified pollutant source in Boston Harbor. Stormwater drainage systems which are separate from sanitary sewers discharge to all areas of Boston Harbor. In the CSO study areas (Inner Harbor, Dorchester Bay, etc.), "while dry weather overflow and CSO are the major pollutants, separate

stormwater contributes significantly to violations of the Water Quality Standards at certain locations" (MDC, 1981, CSO Study Summary, p. 5). Storm drains discharging to Wollaston Beach in Quincy contain very high bacterial concentrations and are implicated in periodic posting of this beach (MacKinnon, 1983. Note that sewage discharges from Moon Island and Nut Island are also implicated in Wollaston Beach posting).

Urban runoff, stormwater that has washed over urban lands, is known to contain high concentrations of: microorganisms (including those causing human diseases), oxygen demanding matter, plant nutrients, heavy metals and other toxic chemicals (EPA, 1977, Microorganisms in Urban Stormwater).

Other sources of harbor pollution are listed below. Recent loadings from these sources are largely unquantified and are therefore not discussed further in this section.

- River Discharges - Rivers carry domestic and industrial wastewater, debris and refuse, and the stormwater runoff from over 322 square miles of urban and suburban lands.

- Ships and Pleasure Boats - These contribute various wastes, including oil and sewage.

- Oil Terminals - These terminals have been implicated as a major source of oil pollution (DEIS, p. 2-29).

- Sediments - Although not a primary source for contaminants, sediments are probably a significant intermediate source of contamination of overlying waters due to re-release of accumulated pollutants and represent a primary source for uptake and bioaccumulation in benthic organisms and subsequently higher orders of marine life.

B. Deer Island and Nut Island Wastewater Treatment Plant Effluents

Both Nut and Deer Island treatment plants fail to provide adequate primary treatment on a regular basis. Equipment failures and wet weather sewage flows cause the bypassing of untreated wastewater at a number of emergency overflow points (see Figure 58). Generally, the volumes bypassed are gauged; those which are monitored lie relatively far from the treatment plants and are discussed under "D. CSOs/DWOs" below.

1. Deer Island

At Deer Island, the most frequent cause of untreated wastewater discharges is the failure of influent pumps at the Deer Island Main Pumping Station. As summarized in Table 21, Deer Island was designed to handle peak flows of 848 million gallons per day. The diesel engines which drive eight of the nine influent pumps at the Main Pumping Station are difficult to maintain because the manufacturer went out of business soon after the engines were purchased, making it hard to find replacement parts. Progressive deterioration in the influent pumping capacity at Deer Island led to the dramatic increase in raw sewage bypassing from the Calf Pasture Pumping Station to the discharge point at Moon Island. (See Figures 58 and 59).

Other discharges from Deer Island which fall below the level of primary treatment are sludge, scum and skimmings discharges. Sludge discharges to President Roads routinely occur on the ebb (outgoing) tides (Figure 58). Sludge discharges to President Roads are held partly responsible for high metals concentrations in sediments in the vicinity of Deer Island Flats, and some have alleged that stress exhibited in the benthic community is partly due to sludge discharges (Metcalf & Eddy, 1979 301(h) Waiver Application p. BXI-13, Havens & Emerson/Parsons Brinkerhoff, 1984 Deer Island Facilities Plan p. E1.21).

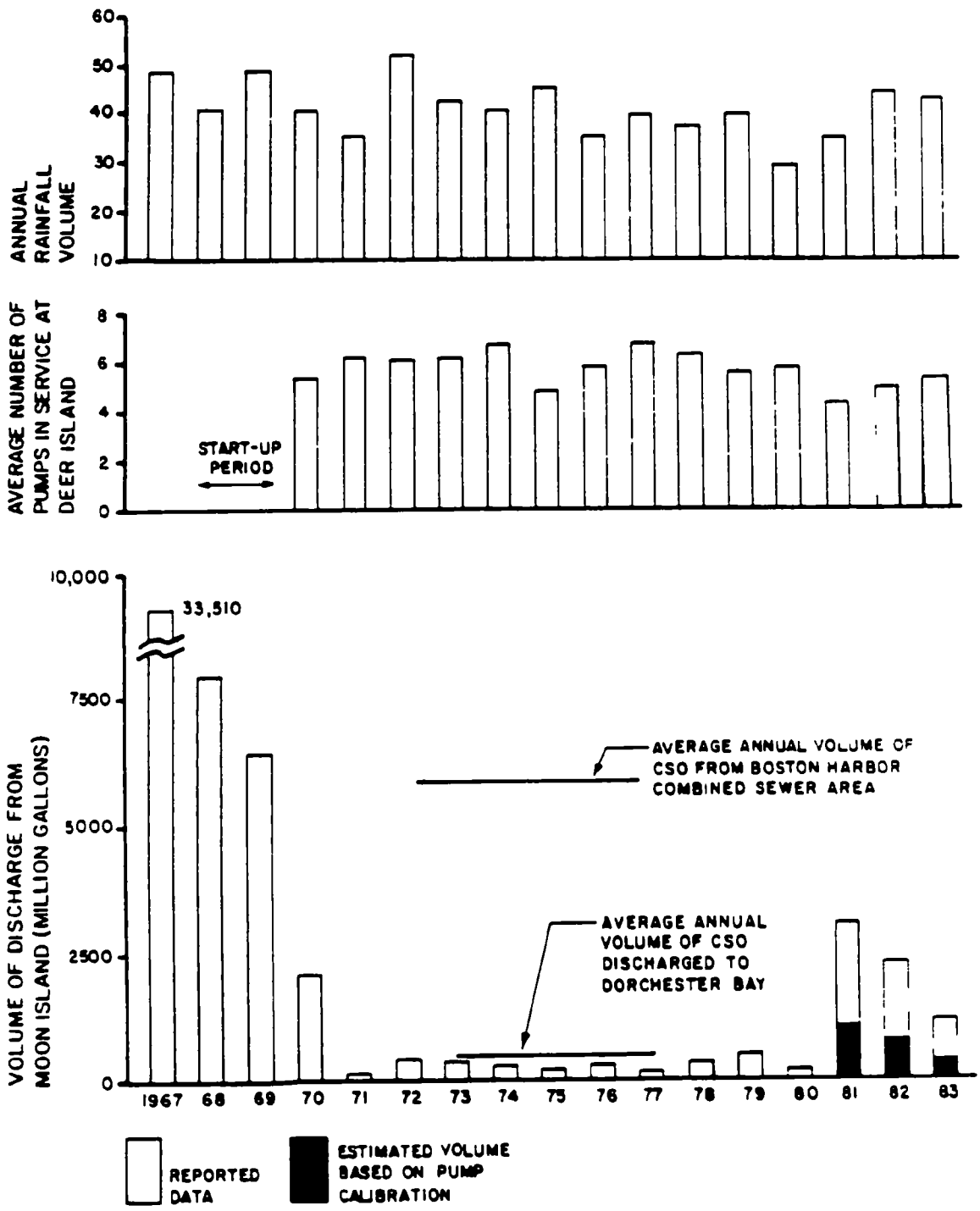
TABLE 21

CHARACTERISTICS OF THE DEER ISLAND AND
NUT ISLAND WASTEWATER TREATMENT AND DISPOSAL FACILITIES

PARAMETER	DEER ISLAND	NUT ISLAND
Year Completed	1968	1952
Original Design Flow		
Average	343 mgd*	112 mgd
Peak	848 mgd	280 mgd
Mean of Monthly Avg. Flows, 1971 to mid-1984	310 mgd	130 mgd
Current Average Flow	325 mgd	135 mgd
Flow Projections for 2005		
Average	350 mgd	150 mgd
Peak	930 mgd	310 mgd

*mgd = million gallons per day

Sources: Metcalf & Eddy 1979, 1982, 1984; Havens & Emerson/Parons Brinkerhoff, 1984; and Jean Haggerty (MDC) pers. comm..



Source Camp Dresser & McKee, Moon Island Study for M.D.C, Fig 2-5

DISCHARGE VOLUME FROM MOON ISLAND

FIG. 59

Scum and skimmings from the primary settling tanks are routinely discharged through the outfalls to President Roads. Because these skimmings float, these discharges are one of the most apparent failures of the Deer Island plant. Harbor waters occasionally fail to meet the State's water quality criterion for aesthetics because of these discharges. Drogues released at the outfalls in President Roads have been shown to travel towards and along Winthrop shorelines under certain wind and tide conditions (Figure 60).

2. Nut Island

The Nut Island treatment plant likewise fails to achieve adequate primary treatment on many occasions. Before it went into operation, the primary settling tanks at Nut Island subsided due to inadequate site and foundation preparation. This subsidence decreased the amount of flow which could pass through the treatment works. This becomes a major problem when peak wet weather flows occur, particularly when they coincide with high tides. High tides further reduce flow through the long outfalls, which are themselves hydraulically limiting because of long term deterioration. When peak flows coincide with high tides the long outfalls to Nantasket Roads cannot handle all the flow, and the excess is discharged through the short outfall (104) less than 700 feet offshore (Figure 61). Although discharges from outfall 104 do receive some treatment, the combination of peak flows and the subsidence of settling tanks results in insufficient primary settling of solids. Discharge through outfall 104 is thought to be the major source of near shore pollution described by residents of Houghs Neck.

Bypassing also occurs when influent headworks are incapacitated. For example, bar racks at Nut Island are frequently taken out of commission by debris hitting the racks at high velocities during peak wet weather flows. Cleaning or repair of either of the two bar racks requires that it be taken out of service. When one bar rack is out of service, the capacity of the remaining rack is insufficient to accept peak flows entering the plant. Flow in excess of bar rack capacity is discharged directly to the outfall system without any solids removal

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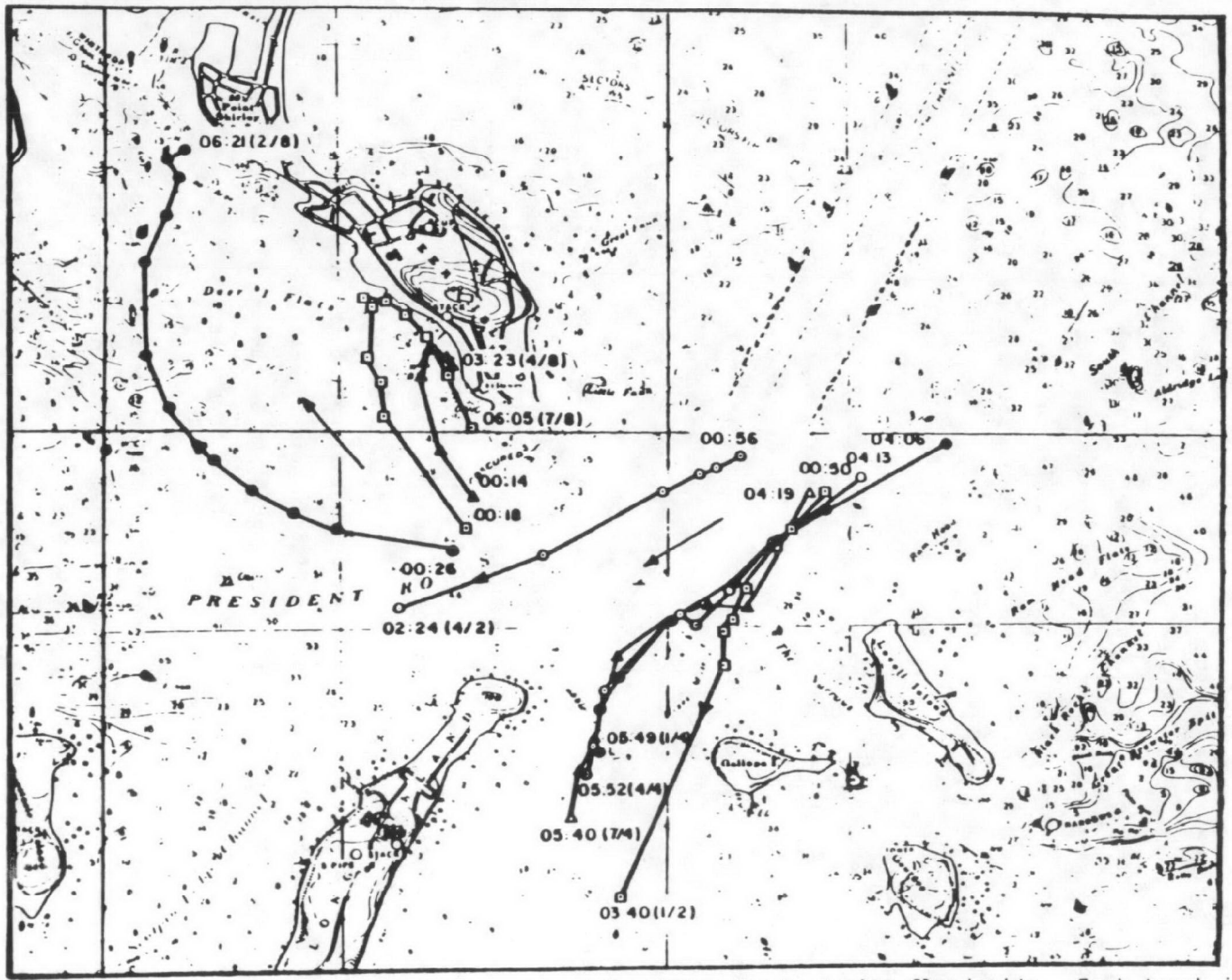
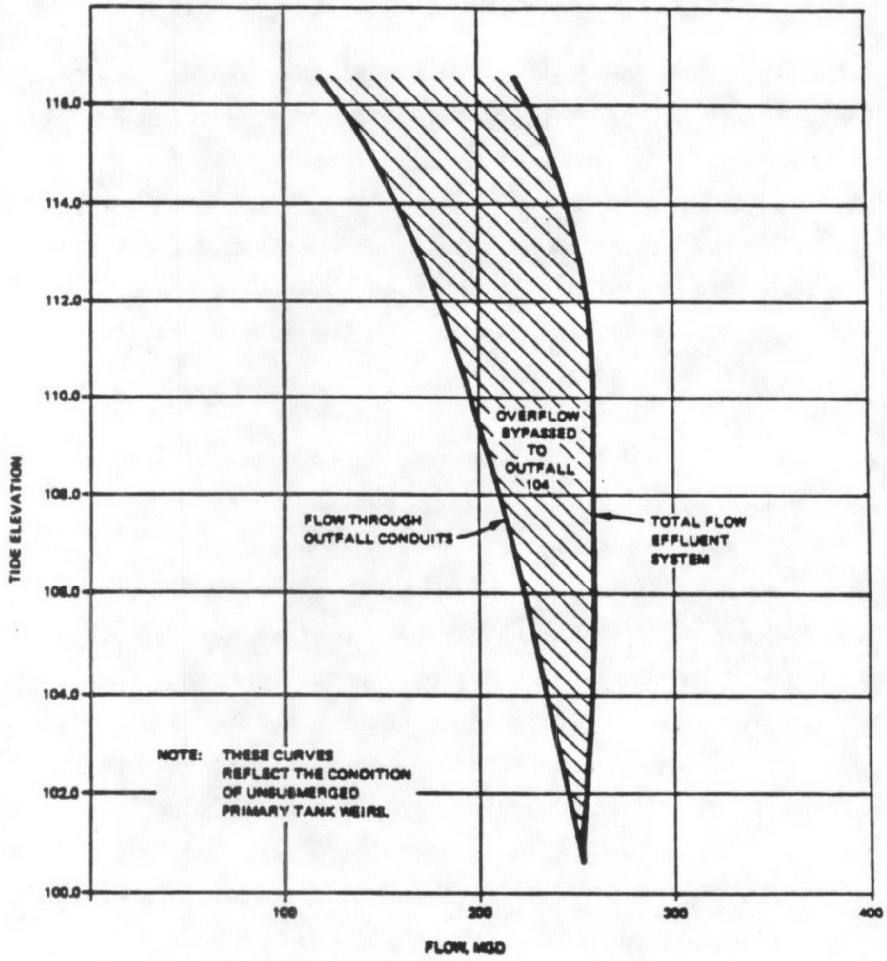
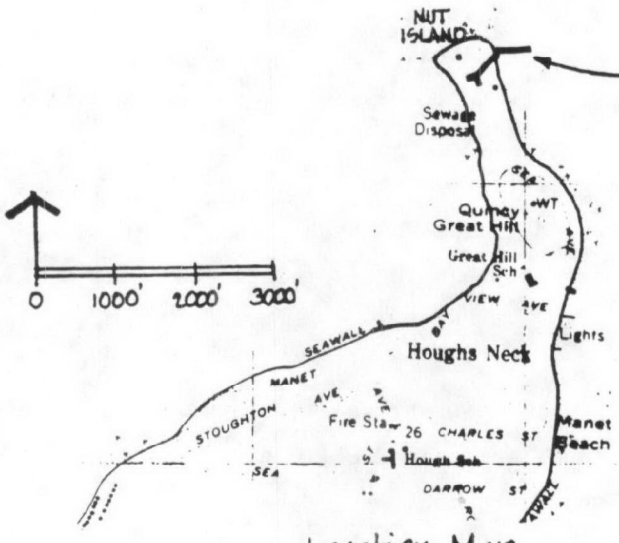


Drogue tracks in the South Channel and President Roads during flood tide. Each track is labeled with the time of release and retrieval (hh:mm) relative to the predicted time of slack current at Deer Island Light. The numbers in parentheses denote the drogue identification number and set number, respectively.

Source: EG&G, 1984 Oceanographic Study of Various outfall siting options for the Deer Is. Treatment Plant, Table 2.5-3.

FIG. 60





Location Map

CAPACITY OF EFFLUENT SYSTEM

3. Treatment Plant Effluent Data

Figures 62 through 67 summarize the monthly average and maximum pollutant loadings reported by plant operators at Nut and Deer Islands. Several observations can be made from this data:

1. With the exception of total suspended solids, all parameters reported are highly variable on a month to month basis. This should be taken into account in the interpretation of receiving water quality data.

2. Seasonal flow trends are pronounced. Low flows occur in late summer/early fall and high flows in the early spring and late fall/early winter.

3. For all parameters, the highest maximum values coincide in time with the highest average values. Recognizing the magnitude of the difference between average and maximum values, it appears that occasional incidents of high pollutant loading have a significant effect on the monthly averages. (Note that bacterial figures are portrayed on a logarithmic vertical scale and that the differences between maximum and average values are orders of magnitude differences.)

4. At Deer Island, the concentrations of both fecal and total coliform bacteria appear to be inversely related to monthly average flow.

5. At Nut Island, the concentrations of both fecal and total coliform bacteria appear to be directly related to monthly average flow.

6. Total coliform bacteria concentrations at both plants are typically about one order of magnitude (10 times) greater than fecal coliform concentrations.

Monthly Flow and Effluent Data - Deer Island

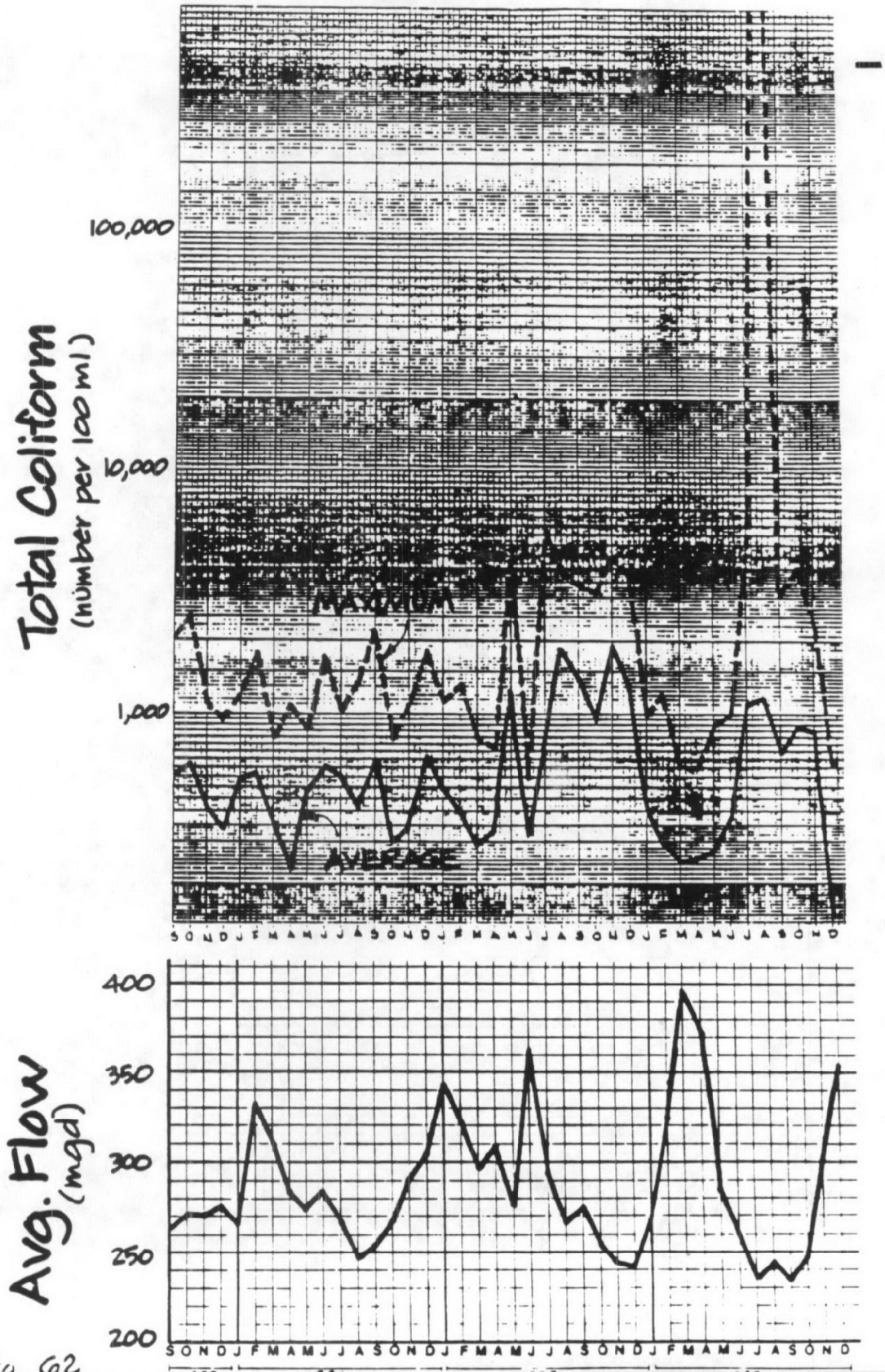


Fig. 62

Monthly Flow and Effluent Data - Deer Island

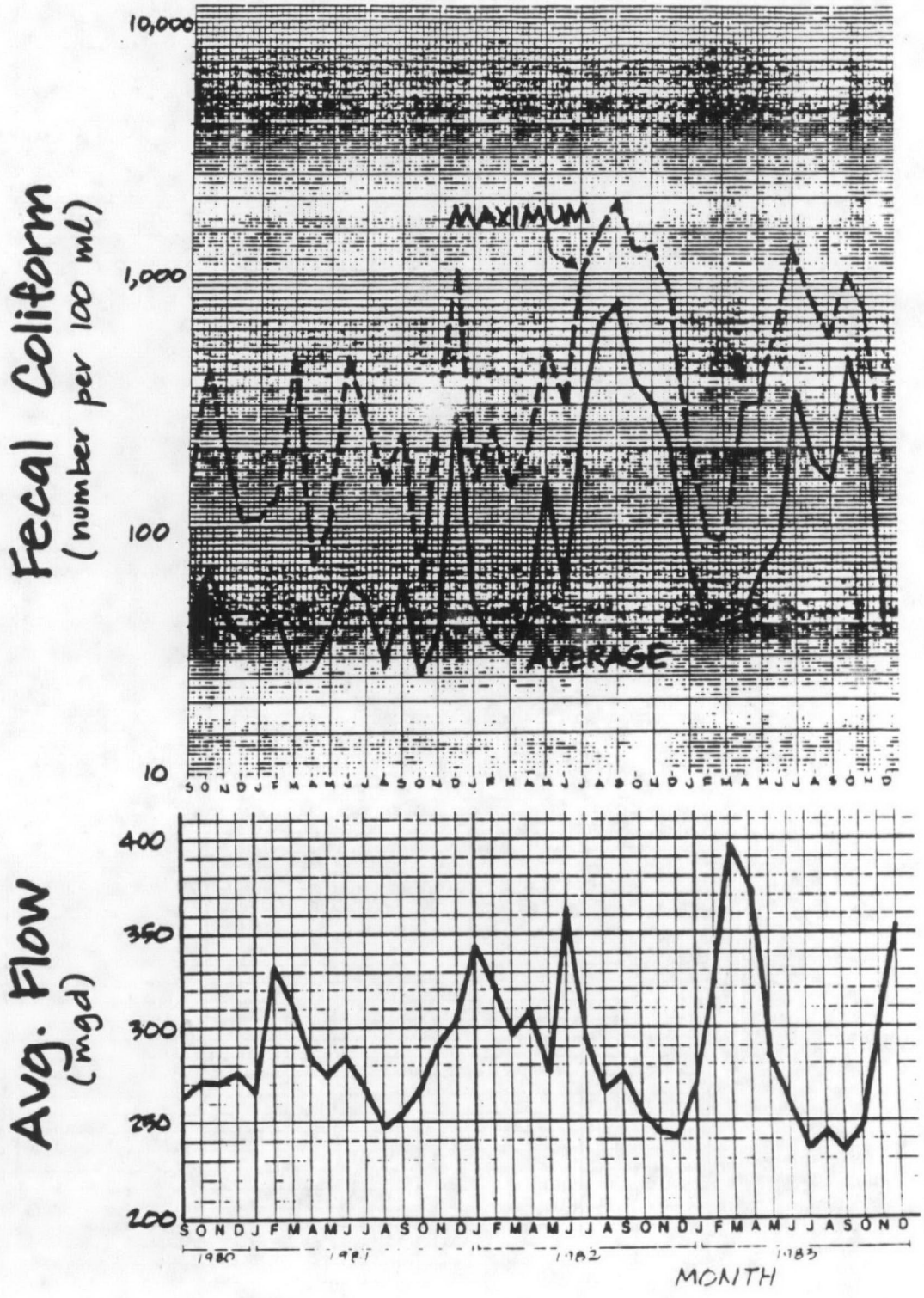


Fig. 63

Monthly Flow and Effluent Data - Deer Island

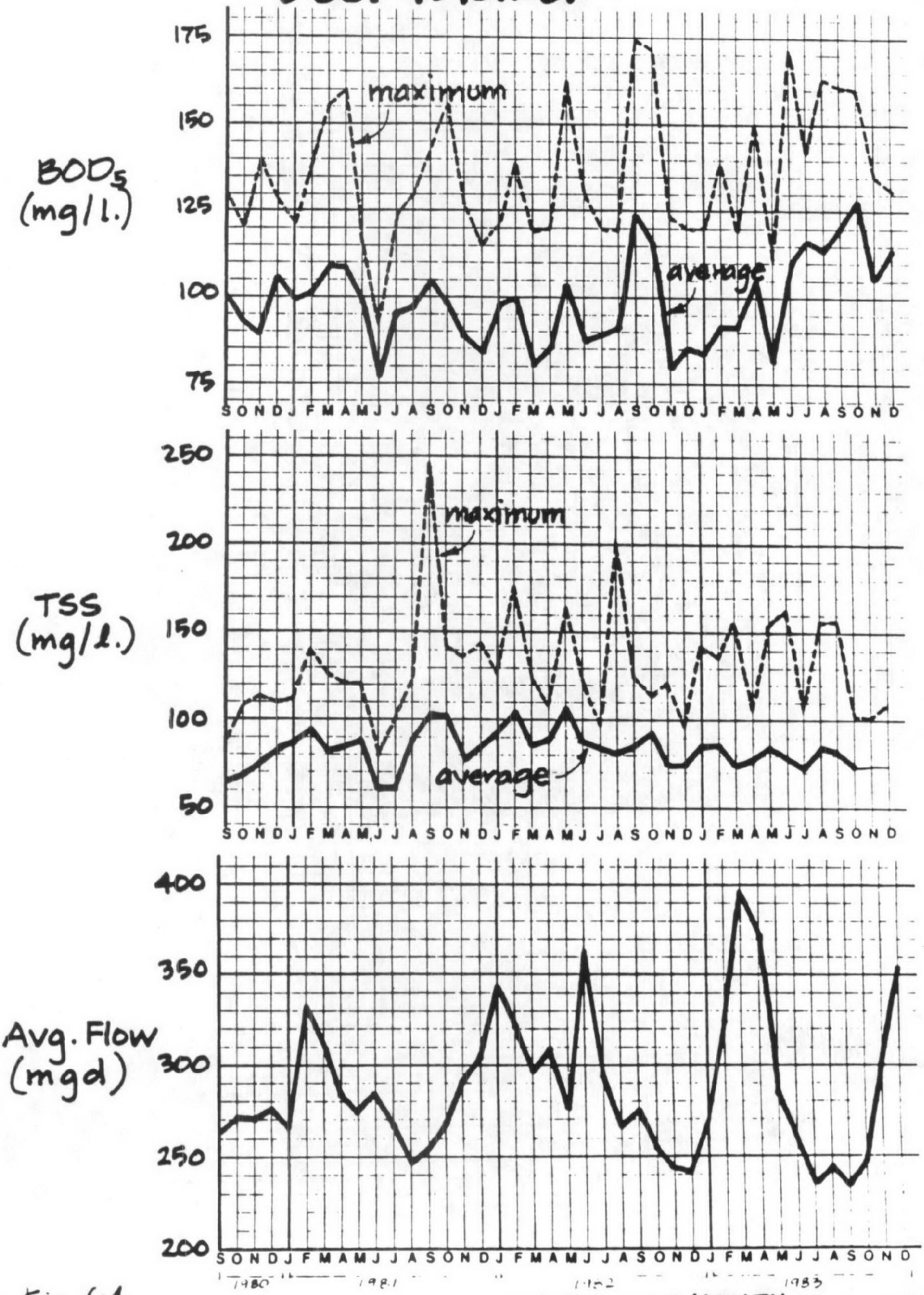


Fig. 64

Monthly Flow and Effluent Data - Nut Island

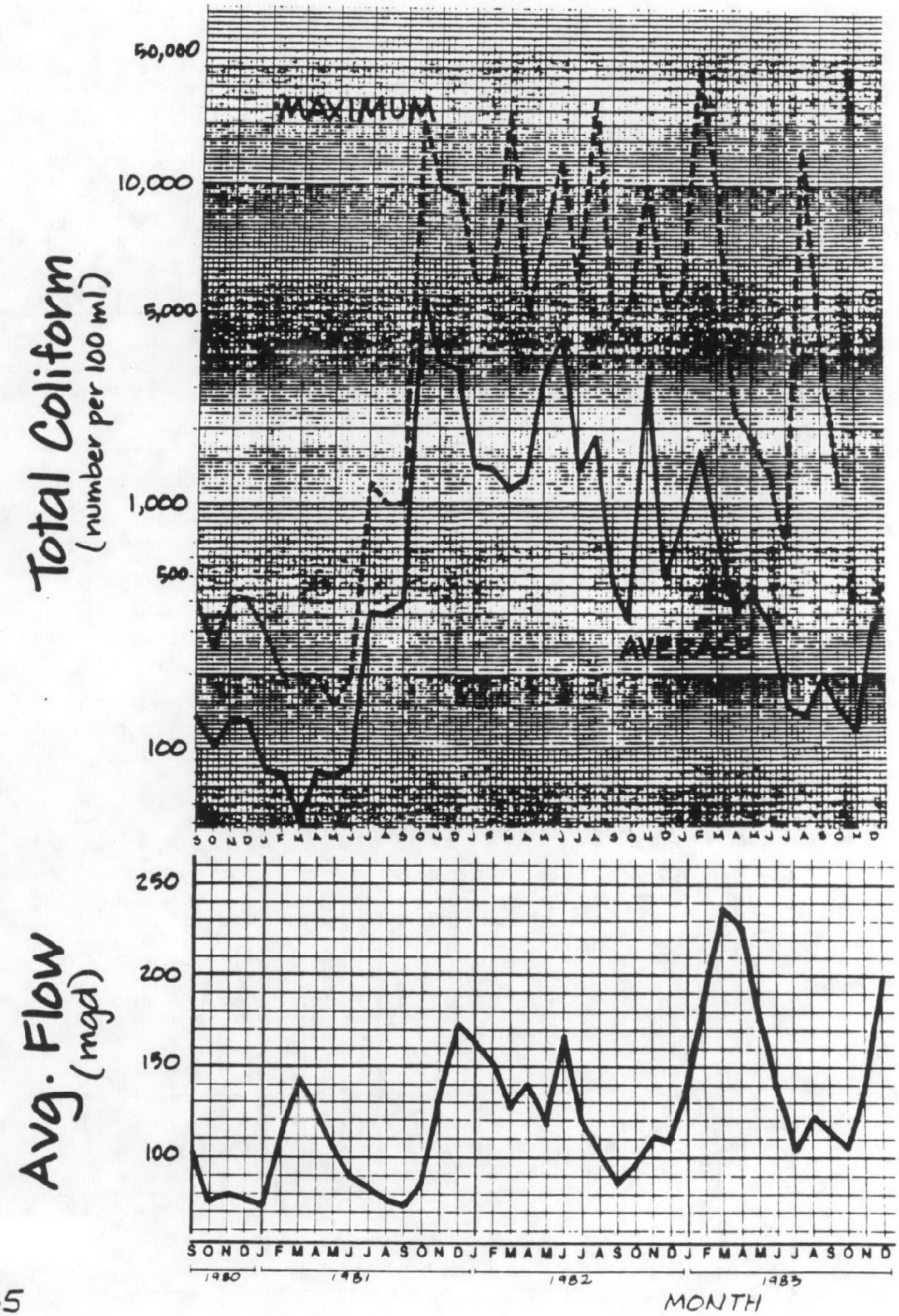
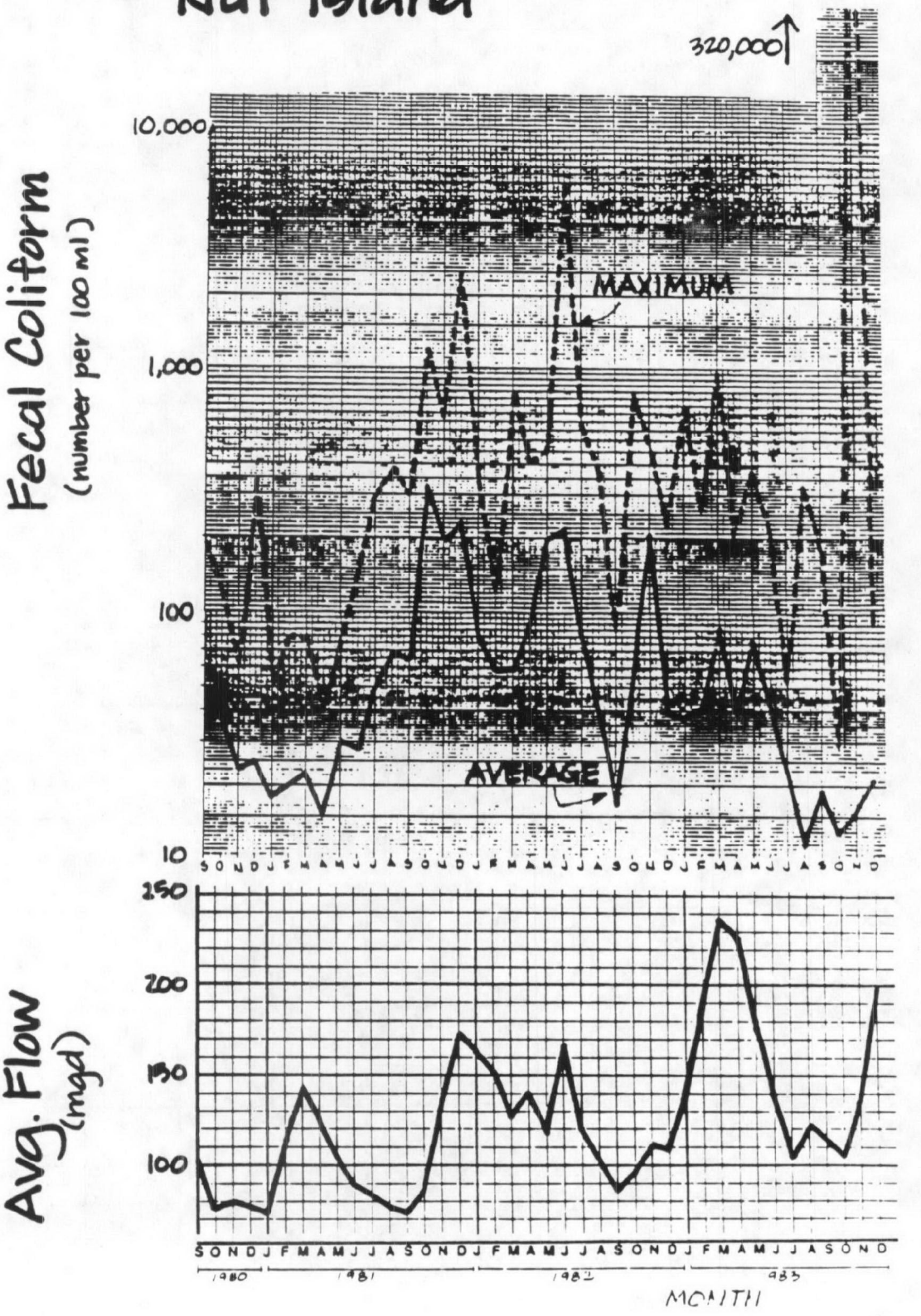


Fig. 65

Monthly Flow and Effluent Data - Nut Island



Monthly Flow and Effluent Data - Nut Island

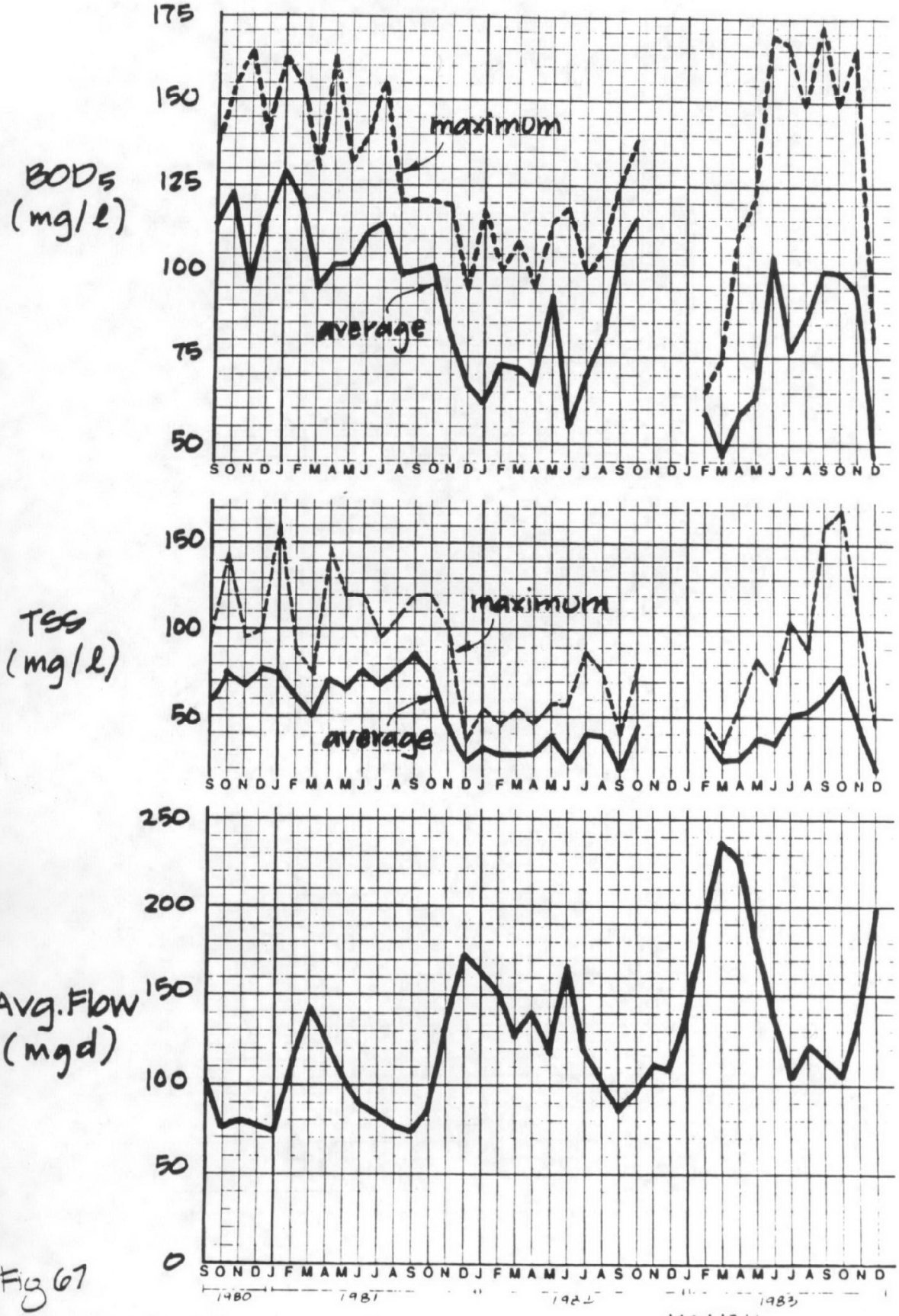


Fig 67

7. At both treatment plants, BOD_5 and TSS appear directly related. However, neither of these parameters appears to correlate well with average flow.

The effluents from both treatment plants were analyzed in 1978, 1979, 1982, and 1984 for 129 "priority pollutants" listed by EPA. The results of these tests are analyzed in Section 11.3 of the SDEIS. Analysis of these data in light of estimated initial dilutions reported by MDC's consultants (Table 22) indicates that the following priority pollutants may occur in concentrations which exceed EPA criteria for the protection of saltwater aquatic life:

PCBs
Heptachlor
Dieldrin
Endrin
DDT
Endosulfan
Cadmium
Chromium
Lead
Copper
Mercury
Nickel
Silver
Zinc
Cyanide

Note that the concentrations of these toxicants may exceed the EPA criteria beyond the mixing zone during low current conditions; i e., slack tide. Also note that chromium would not exceed EPA criteria (beyond the mixing zone) under the proposed revisions to the current criteria (Federal Register, 2/7/84, p. 4552).

In evaluating the priority pollutant results, the MDC's waiver application states: "No violations of the base neutral, volatile or

TABLE 22. INITIAL DILUTION RESULTS - CRITICAL ENVIRONMENTAL PERIODS

Critical Period	Effluent	Flow rate m³/sec	Flow rate mgd	Minimum average initial dilutions current percentile 0	10	50	90
March 1979	Deer Island	18.6	425	7	11	29	43
	Nut Island	8.5	195	4	9	13	15
1985	Deer Island	21.5	490	7	11	28	42
	Nut Island	9.8	225	4	9	13	15
August 1979	Deer Island	16.5	365	8	12	30	45
	Nut Island	5.0	115	4	9	13	15
1985	Deer Island	18.4	420	7	11	27	42
	Nut Island	5.9	135	4	9	13	15

Source: Metcalf & Eddy, 1979 301 (h) Waiver Application Table B1-10.

acid compounds were discovered.... The pesticide data are inconclusive with respect to water quality criteria violations because no quantifiable measure of concentration was obtained.... PCB concentrations measured during the 1978 and 1979 sampling exceeded the new water quality criteria." (1982 Addendum 1 to 301(h) waiver application, p. 3-20).

The applicant does not comment on toxic metals compliance for the existing outfalls. However, several of the applicant's comments on metals are of interest: "Concentrations of metals are generally higher at the Deer Island treatment plant....Metals concentrations are relatively small when compared with average metals concentration for other treatment plants....Metals concentration data from the limited priority pollutant sampling in 1978, 1979 and 1982 is generally much lower than the average annual values derived from monthly composites." (1982 Addendum 1 to 301(h) waiver application, p. 3-21 and 3-24). The applicant does mention that the average annual data for metals shows a trend of decreasing concentrations for copper, nickel, cadmium, and zinc at Deer Island, and decreases in zinc, copper, cadmium, lead and silver at Nut Island.

Deer Island effluent discharges contribute to the concentrations of heavy metals and PCBs in sediments in the Deer Island Flats area. Indirectly, Deer Island's effluent discharge is implicated in the stress exhibited in the benthic communities to the west, although Inner Harbor sources, sludge discharges and CSO/DWO inputs to this area are probably more significant. The effluent discharges from both plants are also implicated in nutrient enrichment of water and sediments near their outfalls.

Plant bypassing causes shellfish bed closings and obnoxious plumes of raw sewage in the vicinity of overflow points. With the probable interference of suspended solids with disinfection effectiveness, treatment plant bypassing is likely to contribute to bacteria levels which cause local shellfish bed closures, and beach postings

C. Sewage Sludge Discharges from Deer Island and Nut Island Treatment Plants

Sewage solids captured in the primary treatment processes at Nut and Deer Island are digested on site, with varying levels of effectiveness. At Deer Island, sludge is thickened prior to anaerobic digestion, and skimmings are added to digestors. Digested sludge is mixed with plant effluent and discharged on the ebb (outgoing) tide (see Figure 58). Skimmings are also digested at Nut Island, although an incinerator is available. Nut Island sludge is pumped to the northern tip of Long Island and discharged to President Roads on the ebb tide.

Harbor modeling, dye testing, and sediment analyses indicate substantial amounts of sludge discharged on the outgoing tide return to the harbor (Hydroscience, 1971, p. 148; Metcalf & Eddy, 1982, 301(h) Waiver Application, Addendum 3, p. 6-2). Citing the Hydroscience modeling, Havens & Emerson report "....about 20 percent of the sludge discharged in the Harbor on outgoing tides returned when the tide reversed and settled in areas of natural deposition west of Deer Island" (Havens & Emerson, 1982, p. 2.2). Dye studies of ebb tide discharges in 1969 led to the conclusion that "....digested sludge solids that remain in suspension return to the Harbor proper" (Hydroscience, 1971, p. 148).

Results of recent chemical analyses of Deer Island and Nut Island sludges are shown in Tables 23 through 28.

The following observations can be made from this data:

1. "The raw sludges are very similar in terms of their elemental makeup, although Deer Island sludges consistently show higher levels of COD [chemical oxygen demand] and oil and grease than those at Nut" (Havens & Emerson, 1982, p. 4.10).

TABLE 23

VOLATILITY, NUTRIENTS, AND CHLORIDES: PLANT DATA

Annual Average Sludge Volatility - Percent

		1973	1974	1975	1976	1977	1978	1979	1980	1981	Avg.
Deer Island	- Raw	70	72	73	71	72	72	74	74	71	72 ± 2
	- Digested	48	48	50	48	48	48	51	50	46	48 ± 3
Nut Island	- Raw	78	78	79	79	79	78	77	76	76	78 ± 2
	- Digested	53	59	57	59	59	57	58	59	54	56 ± 3

Average TS Destruction = 46% at Deer Island
= 50% at Nut Island
Average VS Destruction = 64% at Deer Island
= 64% at Nut Island

Source: Havens & Emerson, Wastewater Sludge Management Report, 1982
Table 4-6

TABLE 24

VOLATILE AND FIXED SOLIDS CHARACTERIZATIONS: SPECIAL STUDIES

	Unthickened Raw Solids			Thickened Raw Solids			Digested Solids			
Deer Island	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Scum
Constituent % of VS										
- Carbon	54	57	52	57	59	55	64	68	58	-
- Oxygen	33	36	29	30	33	27	21	27	17	-
- Hydrogen	8	9	7	9	9	8	9	10	8	-
- Nitrogen	4	4	4	3	3	3	3	4	3	-
- Phosphorus	2	3	2	1	1	1	2	3	1	-
- Sulfur	1	2	1	1	1	1	2	3	2	-
- COD	340	460	250	230	260	180	220	240	190	-
- Oil and Grease	20	28	10	17	19	15	5	8	1	-
1000 BTU/Lb VS	11	11	10	11	12	11	13	15	11	-
Nut Island										
Constituent % of VS										
- Org. Carbon	54	56	52	-	-	-	53	55	52	75
- Oxygen	33	36	31	-	-	-	34	35	33	12
- Hydrogen	8	9	8	-	-	-	8	8	7	12
- Nitrogen	3	3	3	-	-	-	4	5	2	< 1
- Phosphorus	1	1	1	-	-	-	3	3	3	1
- Sulfur	1	1	1	-	-	-	2	2	1	< 1
- COD	210	220	200	-	-	-	180	230	140	-
- Oil and Grease	11	13	9	-	-	-	2	3	1	31
1000 BTU/Lb VS	11	11	10	-	-	-	10	11	10	15

Source: Havens & Emerson, 1982
Table 4-9

TABLE 25

SELECTED INORGANICS AND NUTRIENTS: SPECIAL STUDIES

	Unthickened Raw Solids			Thickened Raw Solids			Digested Solids			
Selected Inorganics	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Scum
Deer Island - mg/l										
Chloride	2200	2600	1600	2000	2200	1900	1900	2100	1800	1300
Magnesium	280	300	240	430	470	360	580	740	380	170
Calcium	140	160	150	350	500	180	270	280	260	250
Potassium	90	100	80	140	150	110	160	220	110	60
Nut Island - mg/l										
Chloride	360	480	250	-	-	-	410	430	400	160
Magnesium	170	200	140	-	-	-	100	100	90	120
Calcium	160	220	80	-	-	-	50	70	40	460
Potassium	100	100	90	-	-	-	90	90	90	70
Nutrients										
Deer Island										
TKN/TS	0.026	0.032	0.022	0.024	0.026	0.023	0.020	0.021	0.019	0.008+
% Soluble TKN	45	72	11	47	50	46	63	82	53	100
Total P/TS	0.005	0.007	0.003	0.007	0.008	0.007	0.010	0.011	0.008	0.008
% Soluble P	17	29	5	26	33	19	35	41	29	7
Nut Island										
TKN/TS	0.021	0.022	0.019	-	-	-	0.020	0.025	0.013	0.006+
% Soluble TKN	52	63	46	-	-	-	-	-	-	100
Total P/TS	0.007	0.008	0.007	-	-	-	0.012	0.014	0.010	0.008
% Soluble P	36	38	35	-	-	-	-	-	9	19

source: Havens & Emerson, 1982.
Table 4-7

TABLE 26

HEAVY METALS: SPECIAL STUDIES (MG/KG DRY WEIGHT BASIS)

	Unthickened Raw Solids			Thickened Raw Solids			Digested Solids			
Deer Island	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Scum
As	18	25	6	7	10	3	4	5	2	3
Cd	39	46	29	49	64	22	52	73	39	16
Cu	1200	1500	1100	1300	1900	760	1500	1700	1300	120
Cr	770	930	650	1200	1400	1100	1200	1500	700	180
Pb	290	360	200	290	350	220	280	450	84	120
Hg	3	7	0.4	8	19	1.5	5	6	4	0.3
Ni	53	83	4	67	100	4	50	130	8	29
Ag	60	76	44	63	96	39	61	83	26	12
Zn	1300	1700	870	1800	2500	1100	2700	3800	1400	630
Nut Island										
As	12	25	3	-	-	-	18	26	7	4
Cd	31	61	14	-	-	-	23	30	18	24
Cu	850	1100	500	-	-	-	1100	1800	540	160
Cr	86	110	74	-	-	-	130	140	120	380
Pb	200	240	120	-	-	-	300	410	220	890
Hg										
Ni										
Ag	32	34	30	-	-	-	76	58	88	24
Zn	900	950	810	-	-	-	1200	1300	1000	320

source: Havens & Emerson, 1982
Table 4-8

TABLE 27

EP TOXICITY CONTAMINANTS: SPECIAL STUDIES*

Parameter - ug/l	RCRA** Allowable Limit	Deer Island				Nut Island		
		Screenings		Grit	Digested Sludge	Screenings	Grit	Digested Sludge
		Chelsea	Ward St.	Chelsea				
Arsenic	5,000	1	1	<1	11	< 1	< 1	6
Barium	100,000	710	350	530	670	360	720	950
Cadmium	1,000	< 20	< 20	<20	<20	< 20	< 20	< 20
Chromium	5,000	< 50	< 50	<50	<50	< 50	460	140
Lead	5,000	< 100	< 100	100	<100	<100	< 100	<100
Mercury	200	< 0.2	0.5	1.2	1.0	<0.2	0.2	1.0
Selenium	1,000	1	< 7	11	14	9	17	10
Silver	5,000	< 10	< 10	20	30	< 10	< 10	20
Lindane	400	< 1	< 1	<1	<1	< 1	< 1	< 1
Endrin	20	< 1	< 1	<1	<1	< 1	< 1	< 1
Methoxychlor	10,000	< 1.5	1.5	<1.5	<1.5	<1.5	<1.5	<1.5
Toxaphene	500	< 4	< 4	<4	<4	< 4	< 4	< 4
2.4-D	10,000	< 1	< 1	<1	<1	< 1	< 1	< 1
Silvex	1,000	< 1	< 1	<1	<1	< 1	< 1	< 1

*Analyses performed by Interex Corporation and Cambridge Analytical Associates.

source: Havens & Emerson, 1982
Table 4-10.

** Resource Conservation and Recovery Act

TABLE 28

LIQUID PHASE PRIORITY POLLUTANTS: SPECIAL STUDIES(1)

POLLUTANT, ug/l	DIGESTED SOLIDS		
	Deer Island		Nut Island
	5/18/81	10/4/81	5/18/81
Heavy Metals			
Arsenic	6	<12	<5
Beryllium	<0.5	<1.2	< 0.5
Cadmium	11	< 25	7
Chromium	27	890	8
Copper	5	590	5
Nickel	110	< 50	72
Lead	80	250	40
Antimony	<2	<12	4
Selenium	27	< 25	<5
Thallium	<2	<12	<2
Zinc	51	1,300	130
Silver	<0.5	27	< 0.5
Mercury	<0.1	<0.01	< 0.1
Organics			
Bis (2-ethylhexyl) phthalate	<1	-(2)	130
Chlorobenzene	23	-	4
1,2-trans-dichloroethylene	39	-	< 1
Ethylbenzene	13	-	< 1
Methylene chloride	14	-	9,100 -
Methyl chloride	<1	-	620
Toluene	350	-	34

(1) Analyses performed by ERCO, Cambridge, Massachusetts
(2) Sample destroyed during processing

source: Havens & Emerson, 1982
Table 4-11

2. When operative, sludge digestion at Deer Island results in a greater percent reduction in COD, although the resultant levels are still higher than at Nut Island because of the higher initial values.

3. For receiving waters, sludge discharges are likely to be significant sources of oxygen demanding matter, nutrients, and heavy metals, and periodic sources of several of the toxic organic chemicals tested for (e.g., methylene chloride, see Table 28).

The priority pollutant results reported in these tables compare favorably with results obtained by CE Maguire in its 1983 sampling (CE Maguire, 1983).

As mentioned, sludge discharges are highly implicated in nutrient and metals enrichment found in the Deer Island/Governors Island Flats area.

D. CSOs/DWOs

The areas of Boston Harbor directly affected by combined sewer overflows (CSOs) and dry weather overflows (DWOs) are the Inner Harbor Dorchester Bay, and East Boston (Belle Isle Inlet) (Figure 58). Activation of overflows in Dorchester Bay and East Boston lead to beach posting there (see Figure 2). In addition, Quincy Bay receives occasional discharges from the Moon Island emergency discharge and raw sewage overflows at the Nut Island Treatment Plant (Figure 58). Reports of these discharges lead to shellfish area closings.

In 1983, Hingham Bay received raw sewage overflows from the Hingham Pumping Station; these overlows led to the closure of clam beds in Hingham Harbor.

In recent studies of CSO problems in four study areas (Charles River, Inner Harbor, Dorchester Bay, and the Neponset River), "dry weather overflow was found to be the singlemost important pollution

influence on water quality in the planning area" (MDC, 1982, CSO Study Summary Report, p. 4). Continual discharges were observed at 34 sites during the study. The number of DWOs active at any time is variable, since a common cause of DWO is temporary blockages in sewers (CDM, 1981, CSO Report for Dorchester Bay, Vol. 1, p. V-23).

In the Inner Harbor, which received the greatest quantities of sewage overflows, continuous overflows (DWOs) accounted for 75% of the 11 billion gallons of overflows discharged to the Inner Harbor annually (O'Brien & Gere, 1981, p. 1-2). Some of these DWO discharges are listed in Table 29. Of the storm activated CSO discharges to the Inner Harbor, an estimated 38% is from one discharge in Fort Point Channel and another 10% from a CSO in Somerville and one in East Boston (O'Brien & Gere, 1981, p. 1-7).

O'Brien & Gere estimated that all of the Inner Harbor waters designated as Class SC would meet the fecal coliform criteria if all DWOs and the Fort Point and Somerville CSOs were eliminated (O'Brien & Gere, 1981, p. 1-4). CSOs/DWOs were also identified as significant contributors to low dissolved oxygen in the Inner Harbor, although removal of all CSOs/DWOs to this area would not, by itself, bring DO levels above 6.0 mg/l (O'Brien & Gere, 1981, p. 1-4).

Other major CSOs affecting the Inner Harbor are the Cottage Farm Station on the Charles River and the Prison Point Station which discharges below the Charles River Dam.

Observed DWOs to Dorchester Bay are reported in Table 30. However, as indicated in the following excerpts, CSOs are considered more significant with respect to water quality. "...At the present time, Dorchester Bay waters do not consistently meet SB water quality standards, especially along shoreline areas immediately following significant rainfall events" (CDM, 1981, Vol. I, p. III-10).

> "Coliform bacteria appears to be the most serious contaminant affecting the quality of the Bay waters. Although the data reported varies widely with sampling location and information

Table 29

DRY WEATHER OVERFLOWS
1978 & 1979 SURVEILLANCE

NPDES Discharge Number	Location	1978 Estimated* Discharge Rate (MGD)	1979 Estimated* Discharge Rate (MGD)	Harbor Segment
BOS/060	Central Ave @ Aquarium, Boston	14.1	1.54	4
BOS/004	Maverick St near Airport, East Boston	1.0	0.55	5
BOS/011	Lexington and Meridian Sts., East Boston	0.3	0.00	2
BOS/013	Meridian & Condor Sts., East Boston	0.3	0.00	221
CHE/007	Highland and Maryinal Sts., Chelsea	0.1	0.50	220
BOS/017	Medford and Short Sts., Charlestown	0.5	1.34	225
SOM/008	Shure Drive and Bailey Sts., Somerville	0.3	0.05	223
BOS/076	E. 1st and "I" Sts , South Boston	0.3	0.00	11
BOS/078	W. 1st and "F" Sts., South Boston	2.5	2.33	11
BOS/058	Waterfront Wharf, Boston	-	.005	3
BOS/057	Sargent Wharf, Boston		1.56	3
BOS/027	Bunkerhill Community College, Charlestown	4.3	0.00	226
	Totals (MGD)	23.7	7.875	

* Rates determined from periodic field measurements of depths of flow.

Source: O'Brien & Gere, CSO Report, Table 5-9. 1981.

TABLE 30

SUMMARY OF KNOWN DIRECT DRY WEATHER DISCHARGES TO DORCHESTER BAY

LOCATION	OBSERVED PROBLEM	ESTIMATED TRIBUTARY AREA CONTRIBUTING DWF (acres)	ESTIMATED DWF DISCHARGED TO DORCHESTER BAY* (gpd)	CSO DISCHARGE OUTLET NUMBER
South Boston - E. First Street, between Farragut Road and P Street	Blocked regulator	10	24,500	BOS - 080
South Boston - E. Second Street, near Farragut Road	Low Overflow weir	37	unknown	BOS - 080
South Boston - Farragut Road, near E. Sixth Street	Blocked regulator	74	396,300 (plus oil)	BOS - 081
Dorchester - Savin Hill Avenue, at Auckland Street	Blocked regulator	9	58,200	BOS - 089
Dorchester - Bay Street, at Auckland Street	Blocked regulator	65	283,500	BOS - 089
Dorchester - Auckland Street, near Hoyt Street (Dorchester Interceptor)	Overflow weir on interceptor**	1,589	unknown	BOS - 089
Dorchester - Leroy Street, near Ditson Street	Blocked regulator	1	11,400	BOS - 090
Dorchester - Storm drain near Victory Road and Morrissey Blvd.	Oil observed in overflow conduit (possible direct connection)	-	0 (oil only)	BOS - 090
		TOTAL	773,900	

*Represents estimated dry weather flow, including infiltration.
**Potential problem only - flow observed to be within two inches of weir crest during dry weather.

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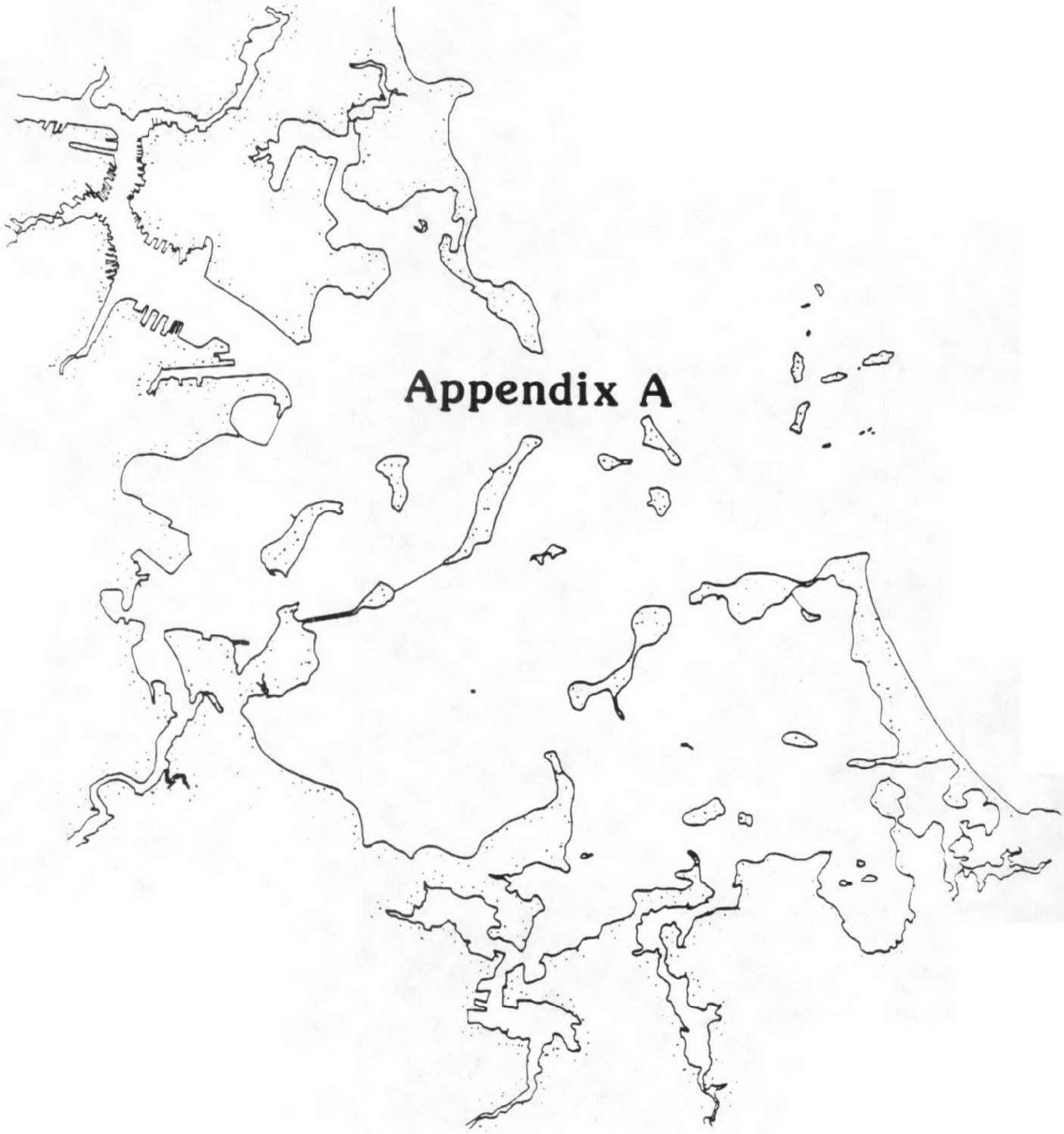

Appendix A

TABLE 11

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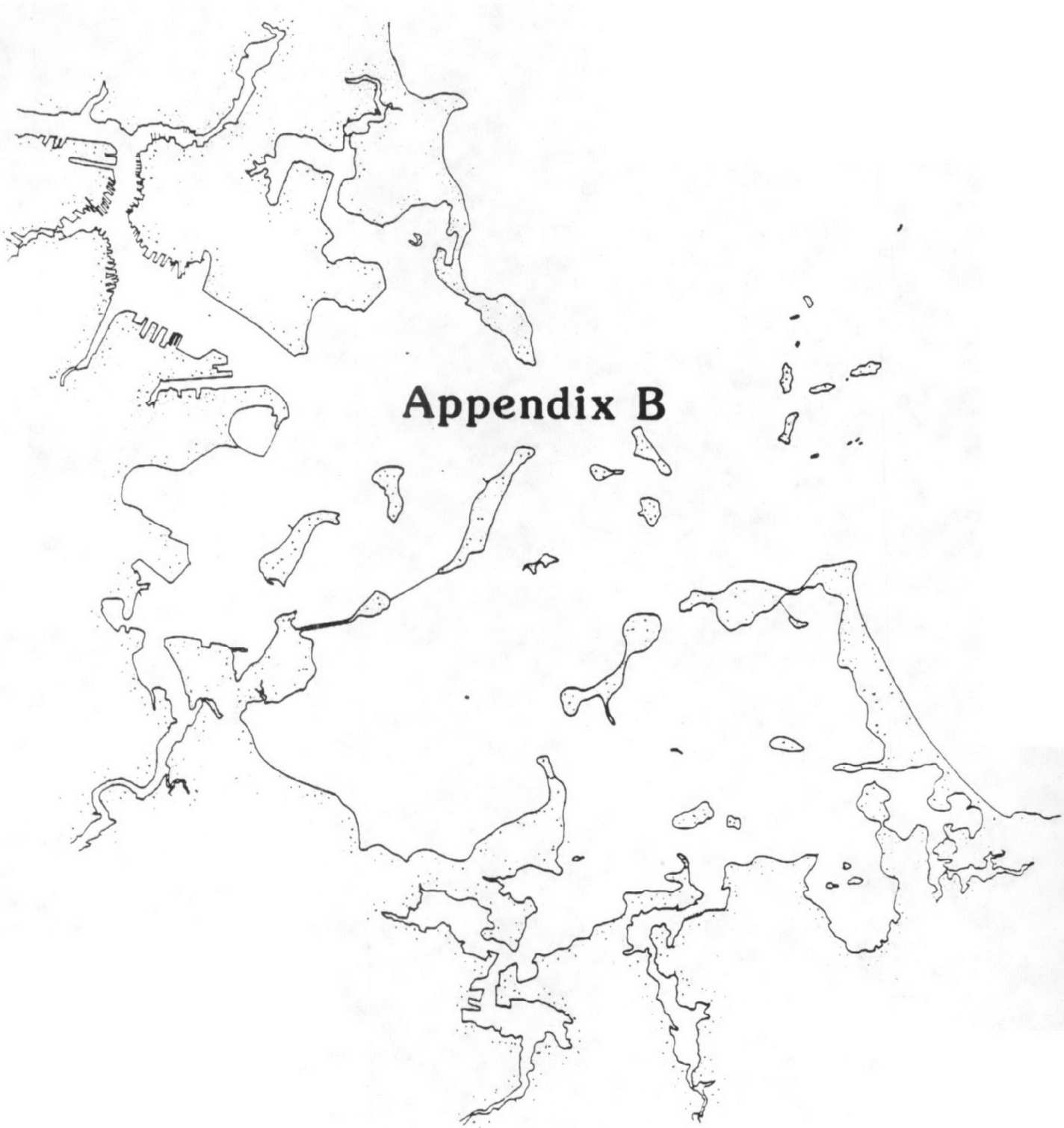


Appendix B

TABLE C-3. DOMINANT SPECIES IN BOSTON HARBOR BENTHIC SAMPLES

Station/ Replicate	Species	No. of Individuals	Percent Total	Cumulative Percent
NIB-1	Aricidea catherinae	724	23.65	23.65
	Ampelisca vadorum	613	20.02	43.67
	Phoxocephalus holbolli	274	8.95	52.62
	Edotea sp. A	121	3.95	56.57
	Tellina agilis	113	3.69	60.26
	Polydora quadrilobata	110	3.59	63.85
	Oligochaeta	106	3.46	67.31
	Polydora ligni	104	3.40	70.71
	Orchomenella minuta	103	3.36	74.07
	Spio cf. armata	102	3.33	77.40
	Phoronis sp.	80	2.61	80.01
	Spio limicola	67	2.19	82.20
	Tharyx acutus	65	2.12	84.32
	Polydora socialis	54	1.76	86.08
NIB-3	Aricidea catherinae	1,112	27.53	27.53
	Ampelisca vadorum	584	14.46	41.99
	Orchomenella minuta	293	7.25	49.24
	Oligochaeta	280	6.93	56.17
	Phoxocephalus holbolli	270	6.69	62.86
	Polydora ligni	265	6.56	69.42
	Spio cf. armata	147	3.64	73.06
	Polydora quadrilobata	128	3.17	76.23
	Tellina agilis	125	3.10	79.33
	Edotea nr. montosa	110	2.72	82.05
	Polydora socialis	79	1.96	84.01
	Spio limicola	72	1.78	85.79
NIB-4	Aricidea catherinae	928	30.33	30.33
	Ampelisca vadorum	418	13.66	43.99
	Oligochaeta	212	6.93	50.92
	Tellina agilis	192	6.28	57.20
	Phoxocephalus holbolli	184	6.01	63.21
	Orochomenella minuta	169	5.52	68.73
	Polydora quadrilobata	152	4.97	73.70
	Spio limicola	102	3.33	77.03
	Edotea nr. montosa	87	2.84	79.87
	Polydora socialis	74	2.42	82.29
	Polydora ligni	72	2.35	84.64

source: Metcalf & Eddy, 1982. Addendum 3 to 301(h) waiver application.

TABLE C-3 (Continued). DOMINANT SPECIES IN BOSTON HARBOR BENTHIC SAMPLES

Station/ Replicate	Species	No. of Individuals	Percent Total	Cumulative Percent
NIC-4	Aricidea catherinae	1,453	37.73	37.73
	Oligochaeta	605	15.71	53.44
	Phoxocephalus holbolli	307	7.97	61.41
	Spio cf. armata	263	6.83	68.24
	Ampelisca vadorum	147	3.82	72.07
	Tharyx acutus	93	2.42	74.48
	Tanais cavolini	91	2.36	76.84
	Nassarius vibex	63	1.64	78.48
	Harmothoe extenuata	54	1.40	79.88
	Tellina agilis	50	1.30	81.18
	Spio filicornis	45	1.17	82.35
	Aeginina longicornis	45	1.17	83.52
	Jassa falcata	39	1.01	84.53
NIC-3 ($0.1m^2$)	Aricidea catherinae	1,202	32.35	32.35
	Oligochaeta	982	26.43	58.78
	Phoxocephalus holbolli	211	5.68	64.46
	Ampelisca vadorum	192	5.17	69.63
	Spio cf. armata	191	5.14	74.77
	Polydora aggregata	101	2.72	77.49
	Cirratulid anterior	61	1.64	79.13
	Edotea nr. montosa	44	1.18	80.31
	Tharyx acutus	42	1.13	81.44
	Harmothoe imbricata	40	1.08	82.52
	Polynoidae spp.	39	1.05	83.57
	Exogone hebes	37	1.00	84.57
	Polydora quadrilobata	32	0.86	85.43
NIC-5 ($0.1m^2$)	Aricidea catherinae	1,372	34.92	34.92
	Oligochaeta	659	16.77	51.69
	Spio cf. armata	219	5.57	57.26
	Phoxocephalus holbolli	206	5.24	62.50
	Exogone hebes	173	4.40	66.90
	Ampelisca vadorum	133	3.38	70.28
	Hiatella striata	96	2.44	72.72
	Aeginina longicornis	85	2.16	74.88
	Tharyx acutus	78	1.98	76.86
	Harmothoe imbricata	73	1.86	78.72
	Polydora concharum	54	1.37	80.09
	Jassa falcata	52	1.32	81.41
	Spio filicornis	49	1.25	82.66
	Polydora aggregata	47	1.20	83.86
	Chaetozone sp.	42	1.07	84.93
	Unciola irrorata	41	1.04	85.97

TABLE C-3 (Continued). DOMINANT SPECIES IN BOSTON HARBOR BENTHIC SAMPLES

Station/ Replicate	Species	No. of Individuals	Percent Total	Cumulative Percent
NIC-3 ($0.085m^2$)	Aricidea catherinae	1,022	32.41	32.41
	Oligochaeta	835	26.48	58.89
	Phoxocephalus holbolli	179	5.68	64.57
	Ampelisca vadorum	163	5.17	69.74
	Spio cf. armata	162	5.14	74.88
	Polydora aggregata	86	2.73	77.61
	Cirratulid anterior	52	1.65	79.26
	Edotea nr. montosa	37	1.17	80.43
	Tharyx acutus	36	1.14	81.57
	Harmothoe imbricata	34	1.08	82.65
	Polynoidae spp.	33	1.05	83.70
	Exogone hebes	31	0.98	84.68
	Polydora quadrilobata	27	0.86	85.54
NIC-5 ($0.085m^2$)	Aricidea catherinae	1,166	34.88	34.88
	Oligochaeta	560	16.75	51.63
	Spio cf. armata	186	5.56	57.19
	Phoxocephalus holbolli	175	5.23	62.42
	Exogone hebes	147	4.40	66.82
	Ampelisca vadorum	113	3.38	70.20
	Hiatella striata	82	2.45	72.65
	Aeginina longicornis	72	2.15	74.80
	Tharyx acutus	66	1.97	76.77
	Harmothoe imbricata	62	1.85	78.62
	Polydora concharum	46	1.37	79.99
	Jassa falcata	44	1.31	81.30
	Spio filicornis	42	1.26	82.56
	Polydora aggregata	40	1.20	83.76
	Chaetozone sp.	36	1.08	84.84
	Unciola irrorata	35	1.05	85.89
NO-1	Oligochaeta	955	28.73	28.73
	Aricidea catherinae	780	23.47	52.20
	Phoxocephalus holbolli	266	8.00	60.20
	Tharyx acutus	259	7.79	67.99
	Spio cf. armata	121	3.64	71.63
	Polydora quadrilobata	90	2.71	74.34
	Harmothoe imbricata	87	2.62	76.96
	Tellina agilis	73	2.20	79.16
	Hiatella striata	69	2.08	81.24
	Polydora aggregata	66	1.99	83.23
	Tharyx annulosus	53	1.60	84.83

TABLE C-3 (Continued). DOMINANT SPECIES IN BOSTON HARBOR BENTHIC SAMPLES

Station/ Replicate	Species	No. of Individuals	Percent Total	Cumulative Percent
NO-2	Aricidea catherinae	1,483	31.08	31.08
	Oligochaeta	1,131	23.71	54.79
	Chaetozone setosa	403	8.45	63.24
	Spio cf. armata	187	3.92	67.16
	Phoxocephalus holbolli	186	3.90	71.06
	Polydora quadrilobata	159	3.33	74.39
	Tharyx annulosus	112	2.35	76.74
	Harmothoe extenuata	105	2.20	78.94
	Tellina agilis	85	1.78	80.72
	Hiatella striata	80	1.68	82.40
	Aeginina longicornis	79	1.66	84.06
	Procerea faciatus	73	1.53	85.59
NO-3	Aricidea catherinae	788	24.81	24.81
	Spio cf. armata	447	14.07	38.88
	Tharyx acutus	446	14.04	52.92
	Oligochaeta	254	8.00	60.92
	Polydora quadrilobata	196	6.17	67.09
	Phoxocephalus holbolli	145	4.57	71.66
	Tellina agilis	118	3.72	75.38
	Harmothoe imbricata	64	2.02	77.40
	Nermetean sp. A	60	1.89	79.29
	Polydora socialis	58	1.83	81.12
	Polydora aggregata	42	1.32	82.44
	Harmothoe extenuata	40	1.26	83.70
	Spio limicola	36	1.13	84.83
DIA-3	Edotea nr. montosa	571	25.15	25.15
	Tellina agilis	547	24.10	49.25
	Nassarius vibex	193	8.68	57.93
	Nephtyidae juv.	164	7.22	65.15
	Spio limicola	104	4.58	69.73
	Unciola irrorata	102	4.49	74.22
	Photis pollex	95	4.19	78.41
	Spiophanes bombyx	63	2.78	81.19
	Diastyis spp.	40	1.76	82.95
	Unciola sp. C (inermis?)	40	1.76	84.71

TABLE C-3 (Continued). DOMINANT SPECIES IN BOSTON HARBOR BENTHIC SAMPLES

Station/ Replicate	Species	No. of Individuals	Percent Total	Cumulative Percent
DIA-4	Polydora ligni	362	21.48	21.48
	Polydora aggregata	201	11.93	33.41
	Edotea nr. montosa	169	10.03	43.44
	Nephtyidae juv.	118	7.00	50.44
	Spio cf. armata	97	5.76	56.20
	Tellina agilis	93	5.52	61.72
	Nassarius vibex	84	4.99	66.71
	Unciola irrorata	84	4.99	71.70
	Capitella spp.	75	4.45	76.15
	Phoxocephalus holbolli	74	4.39	80.54
	Spio limicola	41	2.43	82.97
	Eteone longa	41	2.43	85.40
DIA-5	Edotea nr. montosa	209	17.08	17.08
	Tharyx acutus	155	12.66	29.74
	Nephtyidae juv.	121	9.89	39.63
	Unciola unciola	102	8.33	47.96
	Tellina agilis	83	6.78	54.74
	Spio limicola	77	6.29	61.03
	Oligochaeta	69	5.64	66.67
	Nassarius vibex	49	4.00	70.67
	Polydora ligni	45	3.68	74.35
	Photis pollex	44	3.60	77.95
	Unciola sp. B	40	3.27	81.22
	Spiophanes bombyx	39	3.19	84.41
	Phoxocephalus holbolli	25	2.04	86.45
DIB-3	Nassarius vibex	75	23.89	23.89
	Tellina agilis	52	16.56	40.45
	Edotea nr. montosa	31	9.87	50.32
	Nephtyidae juv.	27	8.60	58.92
	Eteone longa	20	6.37	65.29
	Spio cf. armata	17	5.41	70.70
	Harmothoe imbricata	9	2.87	73.57
	Modiolus modiolus	9	2.87	76.44
	Oligochaeta	8	2.55	78.99
	Orchomenella minuta	7	2.23	81.22
	Polydora ligni	5	1.59	82.81
	Phoxocephalus holbolli	5	1.59	84.40
	Kellia suborbicularis	5	1.59	85.99

TABLE C-3 (Continued). DOMINANT SPECIES IN BOSTON HARBOR BENTHIC SAMPLES

Station/ Replicate	Species	No. of Individuals	Percent Total	Cumulative Percent
DIB-4	Nassarius vibex	108	24.00	24.00
	Tellina agilis	78	17.33	41.33
	Edotea nr. montosa	71	15.78	57.11
	Spio cf. armata	23	5.11	62.22
	Orchomenella minuta	22	4.89	67.11
	Oligochaeta	17	3.78	70.89
	Diastylis polita	16	3.56	74.45
	Nephtyidae juv.	15	3.33	77.78
	Eteone longa	15	3.33	81.11
	Unciola sp. C (inermis?)	12	2.67	83.78
	Capitella spp.	10	2.22	86.00
DIB-5	Nassarius vibex	172	29.91	29.91
	Tellina agilis	133	23.13	53.04
	Diastylis polita	56	9.74	62.78
	Diastylis spp.	46	8.00	70.78
	Edotea nr. montosa	34	5.91	76.69
	Nephtyidae juv.	27	4.70	81.39
	Spio cf. armata	13	2.26	83.65
	Tharyx acutus	12	2.09	85.74
DIC-1	Oligochaeta	196	18.90	18.90
	Polydora ligni	121	11.67	30.57
	Spio cf. armata	94	9.07	39.64
	Phoxocephalus holbolli	93	8.97	48.61
	Proboloides holmesi	55	5.30	53.91
	Eteone longa	54	5.21	59.12
	Procerea cornuta	49	4.73	63.85
	Harmothoe extenuata	28	2.70	66.55
	Polydora ligni	21	2.03	68.58
	Harmothoe imbricata	19	1.83	70.41
	Corophium bonelli	19	1.83	72.24
	Tellina agilis	17	1.64	73.83
	Polydora aggregata	17	1.64	75.52
	Tharyx acutus	15	1.45	76.97
	Edotea nr. montosa	15	1.45	78.42
	Nemertean sp. F	14	1.35	79.77
	Jassa falcata	14	1.35	81.12
	Polydora quadrilobata	12	1.16	82.28
	Ischyrocerus anguipes	12	1.16	83.44
	Modiolus modiolus	11	1.06	84.50

TABLE C-3 (Continued). DOMINANT SPECIES IN BOSTON HARBOR BENTHIC SAMPLES

Station/ Replicate	Species	No. of Individuals	Percent Total	Cumulative Percent
DIC-4	Oligochaeta	174	30.53	30.53
	Eteone longa	57	10.00	40.53
	Caprella linearis	46	8.07	48.60
	Jassa falcata	38	6.67	55.27
	Procerea cornuta	30	5.26	60.53
	Capitella spp.	28	4.91	65.44
	Corophium insidiosum	28	4.91	70.35
	Proboloides holmesi	22	3.86	74.21
	Spio cf. armata	20	3.51	77.72
	Asterias vulgaris	11	1.93	79.65
	Polydora aggregata	10	1.75	81.40
	Ponotogenia inermis	9	1.58	82.98
	Tellina agilis	7	1.23	84.21
	Orchomenella	6	1.05	85.26
DIC-5	Oligochaeta	302	54.91	54.91
	Eteone longa	43	7.82	62.73
	Nemertean sp. A	33	6.00	68.73
	Modiolus modiolus	22	4.00	72.73
	Proboloides holmesi	12	2.18	74.91
	Spio cf. armata	12	2.18	77.09
	Capitella spp.	10	1.82	78.91
	Harmothoe extenuata	9	1.64	80.55
	Edotea nr. montosa	8	1.46	82.01
	Corophium bonelli	7	1.27	83.28
	Spio filicornis	7	1.27	84.55
DOA-1	Capitella spp.	24	72.73	72.73
	Eteone longa	2	6.06	78.79
	Tharyx acutus	2	6.06	84.85
DOA-2	Capitella spp.	132	99.25	99.25
DOA-3	Capitella spp.	191	98.45	98.45
DOB-1	Polydora aggregata	2,270	48.23	48.23
	Polydora ligni	1,037	22.03	70.26
	Tharyx acutus	311	6.61	76.87
	Tellina agilis	284	6.03	82.90
	Capitella spp.	97	2.06	84.96

TABLE C-3 (Continued). DOMINANT SPECIES IN BOSTON HARBOR BENTHIC SAMPLES

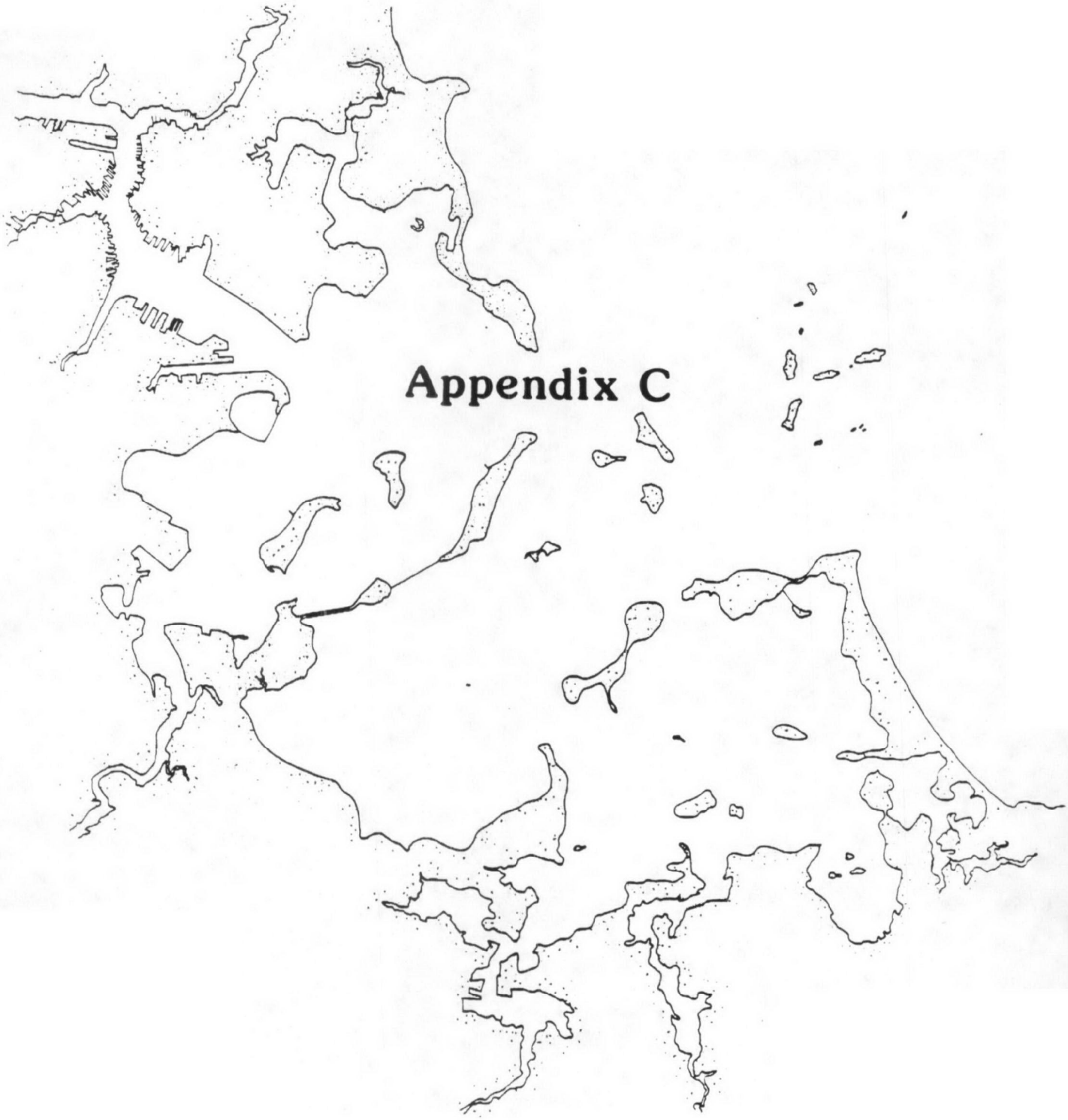
Station/ Replicate	Species	No. of Individuals	Percent Total	Cumulative Percent
DOB-2	Polydora ligni	581	30.95	30.95
	Tharyx acutus	517	27.54	58.49
	Tellina agilis	235	12.52	71.01
	Capitella spp.	109	5.81	76.82
	Spio cf. armata	65	3.46	80.28
	Nephtyidae juv.	62	3.30	83.58
	Oligochaeta	51	2.72	86.30
DOB-4	Polydora aggregata	4,473	64.51	64.51
	Tharyx acutus	501	7.23	71.74
	Polydora ligni	356	5.13	76.87
	Paraonid	240	3.46	80.33
	Edotea nr. montosa	217	3.13	83.46
	Tellina agilis	193	2.78	86.24
CD-1	Oligochaeta	599	40.01	40.01
	Polydora ligni	435	29.06	69.07
	Polydora aggregata	124	8.28	77.35
	Lumbrineris impatiens	99	6.61	83.96
	Nephtyidae juv.	60	4.01	87.97
CD-4	Oligochaeta	1,117	43.82	43.82
	Polydora ligni	823	32.29	76.11
	Nephtyidae juv.	115	4.51	80.62
	Lumbrineris impatiens	100	3.92	84.54
CD-5	Oligochaeta	339	38.09	38.09
	Polydora ligni	298	33.48	71.57
	Nephtyidae juv.	72	8.09	79.66
	Lumbrineris impatiens	56	6.29	85.95
CH-4	Oligochaeta	485	25.27	25.27
	Ampelisca vadorum	294	15.32	40.59
	Aricidea catherinae	276	14.38	54.97
	Leptocheirus pinguis	144	7.50	62.47
	Orchomenella minuta	107	5.58	68.05
	Polydora ligni	86	4.48	72.53
	Polydora quadrilobata	83	4.33	76.86
	Ciratulis grandis	74	3.86	80.72
	Nephtyidae juv.	68	3.54	84.26
	Lumbrineris impatiens	36	1.88	86.14

TABLE C-3 (Continued). DOMINANT SPECIES IN BOSTON HARBOR BENTHIC SAMPLES

Station/ Replicate	Species	No. of Individuals	Percent Total	Cumulative Percent
CH-2 ($0.1m^2$)	Oligochaeta	812	27.52	27.52
	Leptocheirus pinguis	610	20.68	48.20
	Ampelisca vadorum	298	10.10	58.30
	Aricidea catherinae	290	9.83	68.13
	Polydora quadrilobata	188	6.37	74.50
	Cirratulis grandis	149	5.05	79.55
	Orchomenella minuta	140	4.74	84.29
	Phoxocephalus holbolli	63	2.13	86.42
CH-5 ($0.1m^2$)	Oligochaeta	500	19.52	19.52
	Ampelisca vadorum	438	17.10	36.62
	Aricidea catherinae	377	14.72	51.34
	Polydora quadrilobata	271	10.58	61.92
	Ampelisca spp.	144	5.62	67.54
	Leptocheirus pinguis	120	4.68	72.22
	Lumbrineris impatiens	97	3.79	76.01
	Nephtyidae juv.	94	3.67	79.68
	Orchomenella minuta	87	3.40	83.08
	Polydora ligni	77	3.00	86.08
CH-2 ($0.085m^2$)	Oligochaeta	690	27.47	27.47
	Leptocheirus pinguis	519	20.66	48.13
	Ampelisca vadorum	253	10.07	58.20
	Aricidea catherinae	247	9.83	68.03
	Polydora quadrilobata	160	6.37	74.40
	Cirratulis grandis	127	5.05	79.45
	Orchomenella minuta	119	4.74	84.19
	Phoxocephalus holbolli	54	2.15	86.34
CH-5 ($0.085m^2$)	Oligochaeta	425	19.53	19.53
	Ampelisca vadorum	372	17.09	36.62
	Aricidea catherinae	320	14.70	51.32
	Polydora quadrilobata	230	10.57	61.89
	Ampelisca spp.	122	5.61	67.50
	Leptocheirus pinguis	102	4.69	72.19
	Lumbrineris impatiens	82	3.77	75.96
	Nephtyidae juv.	80	3.68	79.64
	Orchomenella minuta	74	3.40	83.04
	Polydora ligni	65	2.99	86.03

TABLE C-3 (Continued). DOMINANT SPECIES IN BOSTON HARBOR BENTHIC SAMPLES

Station/ Replicate	Species	No. of Individuals	Percent Total	Cumulative Percent
CI-1	Polydora ligni	169	49.42	49.42
	Capitella spp.	84	24.56	73.98
	Polydora aggregata	41	11.99	85.97
CI-3	Capitella spp.	55	72.37	72.37
	Polydora ligni	16	21.05	93.42
CI-4	Capitella spp.	52	69.33	69.33
	Polydora ligni	19	25.33	94.66
CS-2	Photis pollex	101	18.36	18.36
	Tellina agilis	65	11.82	30.18
	Edotea nr. montosa	55	10.00	40.18
	Phoxocephalus holbolli	49	8.91	49.09
	Unciola irrorata	46	8.36	57.45
	Unciola spp.	36	6.55	64.00
	Spiophanes bombyx	28	5.09	69.09
	Ensis directus	18	3.27	72.36
	Spio cf. armata	15	2.73	75.09
	Polydora socialis	14	2.55	77.64
	Orchomenella minuta	14	2.55	80.19
	Rhepoxynius epistomus	12	2.18	82.37
	Diastylis sculpta	11	2.00	84.37
	Nephtyidae juv.	10	1.82	86.19
CS-3	Photis pollex	164	13.25	13.25
	Spiophanes bombyx	138	11.15	24.40
	Spio limicola	130	10.50	34.90
	Polydora socialis	105	8.48	43.38
	Diastylis spp.	86	6.95	50.33
	Tellina agilis	78	6.30	56.63
	Nephtyidae juv.	76	6.14	62.77
	Unciola sp. C (inermis?)	69	5.57	68.34
	Edotea nr. montosa	65	5.25	73.59
	Orchomenella minuta	52	4.20	78.79
	Phoxocephalus holbolli	39	3.15	81.94
	Diastylis sculpta	26	2.10	84.04
	Tharyx acutus	24	1.94	85.98



Appendix C

MASSACHUSETTS DIVISION OF WATER POLLUTION CONTROL

1984 BOSTON HARBOR SURVEY

PRELIMINARY RESULTS

SAMLING LOCATIONS

STATION NUMBER	
BH01	Tidal portion of Mystic River mid-channel near confluence of Island End River, Boston
BH02	Boston Inner Harbor at confluence of Chelsea and Mystic Rivers, Boston
BH03	Boston Inner Harbor north of mouth of Charles River near U.S. Naval Reserve, Boston
BH04	Tidal portion of Charles River downstream of Charlestown Bridge, Boston
BH05	Main channel of Boston Inner Harbor near mouth of Fort Point Channel, Boston
BH06	Main channel of Boston Inner Harbor near mouth of Reserved Channel, Boston
BH07	Main shipping channel of Boston Harbor north of Spectacle Island, Boston
BH08	President Roads at mid-channel near lighthouse south of Deer Island, Boston
BH09	Dorchester Bay in Old Harbor south of L Street Beach, Boston
BH10	Dorchester Bay midway between Squantum Point and Columbia Point, Boston
BH10A	Dorchester Bay midway between Squantum Point and Malibu Beach
BH10B	Tidal portion of Neponset River upstream of Neponset Bridge
BH11A	Boston Harbor, ¼ mile north of Moon Island, Boston
BH12	Quincy Bay, midway between Hangman Island and the mouth of Blacks Creek, Quincy
BH12A	Quincy Bay, near Wollaston Beach at buoy N2, Quincy
BH13	Quincy Bay, midway between Hangman Island and Nut Island, Quincy
BH13A	Quincy Bay, ½ mile south of point midway between Bass Point, Long Island and Rainsford Island

LOCATION OF SAMPLING STATIONS
CONT.

STATION NUMBER	DESCRIPTION
BH14	Hingham Bay, midway between Nut Island and Grape Island
BH18	Nantasket Roads, midway between Rainsford Island and Hull Gut
BH22	Winthrop Bay, off Constitution Beach, Boston
CR01	Meridan Street, Boston/Chelsea, River Mile = 0.2
CR02	Chelsea Street, Boston/Chelsea, River Mile = 1.2
CR03	Mill Creek at Broadway, Chelsea/Revere, River Mile = 3.0

1984 BOSTON HARBOR SURVEY
RAINFALL DATA (Inches)

DATE	PRECIPITATION
June 24, 1984	.08
June 25, 1984	.23
June 26, 1984	Trace
July 15, 1984	0
July 16, 1984	.07
July 17, 1984	0
August 26, 1984	0
August 27, 1984	0
August 28, 1984	0

1984 BOSTON HARBOR SURVEY
TIDAL INFORMATION (Military Time)

DATE	LOW TIDE	HIGH TIDE
June 25, 1984	1400	0800
June 26, 1984	1500	0900
July 16, 1984	0730	1330
July 17, 1984	0815	1415
August 27, 1984	0515	1115
August 28, 1984	0615	1215

1984 BOSTON HARBOR SURVEY

STATION		25 Jun 84	26 Jun 84	16 Jul 84	17 Jul 84	27 Aug 84	28 Aug 84	9 Oct 84	10 Oct 84
BH01	*	1	1	1	1	1	1	1	1
Mystic River	**	1315	1105	1130	1030	1126	1119		
	***	65	66	66	68	71	75		
	****	A	6.0	7.5	7.0	5.4	4.7		
		5	7.5	6	5.5	7	7		
		1315	1105	1130	1030	1126	1119		
		62	57	62	63	70	71		
		5.9	5.1	6.5	7.3	2.9	4.0		
		10	15	12	11	14	14		
		1315	1105	1130	1030	1126	1119		
		57	56	60	60	68	68		
		4.0	4.9	6.2	6.7	2.2	3.0		
BH02		1	1	1	1	1	1	1	1
Mystic River		1350	1115	1135	1035	1135	1130		
		65	66	66	68	71	72		
		A	5.9	7.5	7.1	5.6	6.3		
		5.5	6	6	6	7	7.5		
		1350	1115	1135	1035	1135	1130		
		61	58	61	62	69	69		
		6.8	6.3	6.5	7.3	4.4	3.6		
		11	12	12	12	14	15		
		1350	1115	1135	1035	1135	1130		
		68	57	60	60	68	69		
		4.6	5.9	7.1	7.7	3.1	3.5		

* Depth in meters
** Time in hours-minutes
*** Temperature (°F)
**** Dissolved Oxygen (mg/l)

A = Data suspect; laboratory error
B = Bad weather
C = No sample collected

1984 BOSTON HARBOR SURVEY (CONTINUED)

TATION	25 Jun 84	26 Jun 84	16 Jul 84	17 Jul 84	27 Aug 84	28 Aug 84	9 Oct 84	10 Oct 84
H03	1	1	1	1	1	1	1	1
ıner Harbor	1340	1150	1145	1045	1147	1138		
	64	66	63	67	70	72		
	A	6.3	7.3	8.5	5.3	6.2		
	6	5.5	7	7	6	8		
	1340	1150	1145	1045	1147	1138		
	61	60	61	61	70	71		
	7.0	6.7	6.6	7.2	4.2	5.0		
	12	11	14	14	12	16		
	1340	1150	1145	1045	1147	1138		
	58	58	59	60	69	71		
	5.1	5.7	7.1	7.6	3.5	5.0		
04	1	1	1	1	1	1	1	1
arlee River Locks	1350	1200	1155	1055	1210	1216		
	64	65	64	67	70	76		
	A	5.8	6.9	5.7	4.5	4.4		
	5	3.7	6.5	5.5	5.5	6.5		
	1350	1200	1155	1055	1210	1216		
	61	60	59	62	71	68		
	6.9	6.3	5.5	6.5	3.3	3.5		
	10	7.5	13	11	11	13		
	1350	1200	1155	1055	1210	1216		
	59	59	58	61	71	67		
	4.9	4.3	5.7	6.5	3.1	2.2		
05	1	1	B	1	1	1	1	1
. Point Channel	1405	1215	B	1105	1226	1226		
	63	66	B	65	71	71		
	A	6.6	B	6.7	7.0	6.1		

1984 BOSTON HARBOR SURVEY (CONTINUED)

STATION	25 Jun 84	26 Jun 84	16 Jul 84	17 Jul 84	27 Aug 84	28 Aug 84	9 Oct 84	10 Oct 84
BH05 (Continued)	3.5	5	B	C	C	C		
	1405	1215	B	C	C	C		
	64	60	B	C	C	C		
	7.6	6.7	B	C	C	C		
	7	10	B	7	9	9		
	1405	1215	B	1105	1226	1226		
	60	58	B	60	72	67		
	5.9	6.1	B	7.5	5.7	4.2		
BH06	1	1	B	1	1	1	1	1
Inner Harbor	1420	1230	B	1117	1241	1238		
	62	65	B	66	69	73		
	A	6.5	B	7.7	6.7	5.7		
	5.5	6	B	6.5	7.5	8		
	1420	1230	B	1117	1241	1238		
	60	60	B	61	69	71		
	6.9	6.2	B	8.1	5.3	5.6		
	11	12	B	13	15	16		
	1420	1230	B	1117	1241	1238		
	57	58	B	61	66	72		
	7.2	6.9	B	8.3	5.8	6.1		
BH07	1	1	B	1	1	1	1	1
Spectacle Island	1540	1355	B	1220	1347	1342		
	61	62	B	65	65	66		
	A	7.0	B	9.6	6.1	6.3		
	7.5	10	B	6.5	7.5	8		
	1540	1355	B	1220	1347	1342		
	58	58	B	59	67	63		
	7.3	7.4	B	8.9	5.9	6.5		

1984 BOSTON HARBOR SURVEY (CONTINUED)

STATION	25 Jun 84	26 Jun 84	16 Jul 84	17 Jul 84	27 Aug 84	28 Aug 84	9 Oct 84	10 Oct 84
BH07 (Continued)	15	20	B	13	15	16		
	1540	1355	B	1220	1347	1342		
	57	58	B	58	67	61		
	7.6	7.9	B	9.2	5.9	6.7		
BH08	1	1	B	1	1	1	1	1
Deer Island Light	1525	1330	B	1207	1332	1327		
	58	58	B	62	66	68		
	A	7.7	B	9.3	6.3	6.5		
	12.5	C	B	7	11	9		
	1525	C	B	1207	1332	1327		
	60	C	B	59	65	63		
	7.7	C	B	10.0	5.7	7.0		
	25	20	B	16	22	18		
	1525	1330	B	1207	1332	1327		
	57	58	B	57	62	60		
	7.7	7.5	B	9.3	5.6	6.5		
BH09	1	1	1	1	1	1	1	1
Dorchester Bay	1243	1030	1030	1000	1056	1045		
	63	63	61	63	68	67		
	A	6.9	8.1	8.7	6.1	5.7		
	2	C	C	C	C	C		
	1243	C	C	C	C	C		
	62	C	C	C	C	C		
	7.1	C	C	C	C	C		
	3.5	3.5	1.75	1.5	3.5	3		
	1243	1030	1030	1000	1056	1045		
	64	61	64	65	67	66		
	6.6	6.0	8.3	8.8	5.7	6.1		

1984 BOSTON HARBOR SURVEY (CONTINUED)

CATION	25 Jun 84	26 Jun 84	16 Jul 84	17 Jul 84	27 Aug 84	28 Aug 84	9 Oct 84	10 Oct 84
110	1	1	1	1	1	1	1	1
rchester Bay	1230	1020	1020	0955	1046	1033		
	62	62	60	63	68	71		
	A	7.2	7.9	8.3	6.0	5.9		
	2.5	3.25	C	C	C	C		
	1230	1020	C	C	C	C		
	67	60	C	C	C	C		
	6.9	7.2	C	C	C	C		
	4.5	6.5	4	4	6	5.5		
	1230	1020	1020	0955	1046	1030		
	57	60	62	63	66	69		
	6.6	7.7	8.1	7.9	5.3	5.7		
10A	1	1	1	1	1	1	1	1
rchester Bay	1221	1008	0955	0940	1038	1019		
	63	63	64	65	70	72		
	A	6.5	6.7	7.2	5.5	5.0		
	C	3	C	C	C	C		
	C	1008	C	C	C	C		
	C	62	C	C	C	C		
	C	6.5	C	C	C	C		
	4	6	3.5	3	6	5		
	1221	1008	0955	0940	1038	1019		
	69	60	70	65	68	72		
	4.1	6.2	7.1	6.7	5.3	5.0		
10B	1	1	1	1	1	1	1	1
onnect River	1205	0950	0940	0930	1016	0957		
	61	64	65	66	71	73		
	A	5.9	5.5	6.2	4.8	4.6		

1984 BOSTON HARBOR SURVEY (CONTINUED)

TATION	25 Jun 84	26 Jun 84	16 Jul 84	17 Jul 84	27 Aug 84	28 Aug 84	9 Oct 84	10 Oct 84
H10B (Continued)	1.5	1.75	C	C	C	C		
	1205	0948	C	C	C	C		
	62	62	C	C	C	C		
	6.4	5.4	C	C	C	C		
	3	3.5	3.5	3	4.5	2		
	1205	0948	0940	0930	1016	0957		
	63	62	70	69	68	73		
	6.5	5.5	5.8	6.3	4.6	4.1		
11A	1	1	B	1	1	1	1	1
on Island	1600	1410	B	1235	1403	1358		
	62	63	B	69	70	72		
	A	6.8	B	8.2	6.5	7.3		
	2.5	2.5	B	C	C	C		
	1600	1410	B	C	C	C		
	62	62	B	C	C	C		
	6.7	6.1	B	C	C	C		
	5	5	B	5	5	6		
	1600	1410	B	1235	1403	1358		
	62	60	B	64	68	65		
	6.9	6.5	B	8.7	4.9	5.5		
12	B	B	B	1	1	1	1	1
incy Bay	B	B	B	1305	1430	1426		
	B	B	B	65	68	71		
	B	B	B	8.9	6.1	6.1		
	B	B	B	4	6	6		
	B	B	B	1305	1430	1426		
	B	B	B	64	69	72		
	B	B	B	8.9	5.7	6.9		

1984 BOSTON HARBOR SURVEY (CONTINUED)

STATION	25 Jun 84	26 Jun 84	26 Jul 84	17 Jul 84	27 Aug 84	28 Aug 84	9 Oct 84	10 Oct 84
BH12A	B	B	B	1	1	1	1	1
Quincy Bay	B	B	B	1250	1419	1415		
	B	B	B	65	69	72		
	B	B	B	8.9	8.4	7.7		
	B	B	B	4	4	5		
	B	B	B	1255	1419	1415		
	B	B	B	64	71	67		
	B	B	B	9.2	6.0	6.1		
BH13	B	B	B	1	1	1	1	1
Quincy Bay	B	B	B	1315	1440	1437		
	B	B	B	62	67	71		
	B	B	B	8.7	7.5	6.9		
	B	B	B	6	6.5	7		
	B	B	B	1315	1440	1437		
	B	B	B	63	64	64		
	B	B	B	8.8	6.3	6.6		
BH13A	B	B	B	1	1	1	1	1
Quincy Bay	B	B	B	1355	1513	1509		
	B	B	B	63	66	72		
	B	B	B	9.0	6.4	7.1		
	B	B	B	7	6.5	7		
	B	B	B	1355	1513	1509		
	B	B	B	61	64	64		
	B	B	B	8.8	5.8	6.3		
BH14	B	B	B	1	1	1	1	1
Hingham Bay	B	B	B	1335	1458	1452		
	B	B	B	60	65	69		
	B	B	B	8.7	6.5	6.9		

1984 BOSTON HARBOR SURVEY (CONTINUED)

STATION	25 Jun 84	26 Jun 84	16 Jul 84	17 Jul 94	27 Aug 84	28 Aug 84	9 Oct 84	10 Oct 84
BH14 (Continued)	B	B	B	6	5.5	5.5		
	B	B	B	1335	1458	1452		
	B	B	B	63	65	65		
	B	B	B	8.7	6.2	A		
	B	B	B	12	11	11		
	B	B	B	1335	1458	1452		
	B	B	B	62	64	63		
	B	B	B	9.0	5.9	A		
BH18	B	B	B	1	1	1	1	1
Hantasket Roads	B	B	B	1410	1530	1522		
	B	B	B	59	65	70		
	B	B	B	8.9	6.6	7.0		
	B	B	B	6	7.5	8.5		
	B	B	B	1410	1530	1522		
	B	B	B	60	63	63		
	B	B	B	8.8	6.5	6.1		
	B	B	B	12	15	17		
	B	B	B	1410	1530	1522		
	B	B	B	59	60	63		
	B	B	B	9.8	7.0	7.0		
BH22	1	1	B	1	1	1	1	1
Orient Heights	1500	1300	B	1145	1308	1302		
	64	63	B	66	70	71		
	A	7.4	B	8.5	6.6	5.1		
	3	3.5	B	C	C	C		
	1500	1300	B	C	C	C		
	65	63	B	C	C	C		
	6.7	6.9	B	C	C	C		

1984 BOSTON HARBOR SURVEY (CONTINUED)

STATION	25 Jun 84	26 Jun 84	16 Jul 84	17 Jul 84	27 Aug 84	28 Aug 84	9 Oct 84	10 Oct 84
BH22 (Continued)	6	7	B	7	8	8.5		
	1500	1300	B	1145	1308	1302		
	64	62	B	67	71	69		
	5.9	6.1	B	8.1	4.9	5.6		
CR01	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Chelsea River	1253	1145	1143	1205	1145	1120		
	67	68	65	69	73	73		
	7.9	6.5	8.1	10.2	6.0	6.5		
CR02	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Chelsea River	1310	1210	1200	1220	1200	1130		
	65	67	66	69	72	72		
	5.6	7.7	9.2	11.3	5.2	5.5		
CR03	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Chelsea River	1320	1225	1210	1235	1208	1140		
	67	66	74	79	74	74		
	7.8	7.4	11.3	17.8	4.2	4.8		

1984 BOSTON HARBOR SURVEY
FECAL COLIFORM BACTERIA DATA (per 100 ml)

STATION	JUNE 25	JUNE 26	JULY 16	JULY 17	AUGUST 27	AUGUST 28	OCTOBER 9	OCTOBER 10
BH01	A	300	300	370	40	290		
BH02	A	520	110	450	10	A		
BH03	A	400	90	—	10	A		
BH04	A	60	100	—	10	A		
BH05	A	6,000	B	500	20	A		
BH06	A	450	B	<5	20	A		
BH07	A	60	B	90	440	90		
BH08	A	40	B	<5	60	400		
BH09	A	60	5	<5	10	A		
BH10	A	20	40	—	20	A		
BH10A	A	80	30	230	10	A		
BH10B	A	120	130	440	20	A		
BH11A	A	40	B	<5	<10	A		
BH12	B	B	B	<5	10	A		
BH12A	B	B	B	<5	10	A		
BH13	B	B	B	5	10	A		
BH13A	B	B	B	<5	10	<10		
BH14	B	B	B	—	<10	A		
BH18	B	B	B	<5	<10	10		
BH22	A	5	B	<5	<10	<10		
CR01	60	200	150	10	10	20		
CR02	20	10	460	5	100	<20		
CR03	15,000	1,200	12,000	8,000	100	1,200		

A = Frozen B = Bad Weather

1984 BOSTON HARBOR SURVEY
TOTAL COLIFORM BACTERIA DATA (per 100 ml)

STATION	JUNE 25	JUNE 26	JULY 16	JULY 17	AUGUST 27	AUGUST 28	OCTOBER	OCTOBER
BH01	A	9,200	2,500	3,800	440	1,600		
BH02	A	18,000	900	4,000	180	A		
BH03	A	20,000	1,100	—	100	A		
BH04	A	1,000	1,000	—	520	A		
BH05	A	65,000	B	3,500	140	A		
BH06	A	9,500	B	40	560	A		
BH07	A	900	B	1,100	3,800	2,000		
BH08	A	800	B	40	860	6,000		
BH09	A	700	60	60	20	A		
BH10	A	800	180	—	160	A		
BH10A	A	1,800	600	2,000	<20	A		
BH10B	A	4,400	1,400	5,000	240	A		
BH11A	A	200	B	40	<20	A		
BH12	B	B	B	10	20	A		
BH12A	B	B	B	5	<20	A		
BH13	B	B	B	40	160	A		
BH13A	B	B	B	<5	460	<20		
BH14	B	B	B	—	80	A		
BH18	B	B	B	20	<20	<20		
BH22	A	60	B	20	60	400		
CR01	500	6,400	1,600	100	2,300	1,900		
CR02	400	300	4,500	30	100	200		
CR03	200,000	18,000	150,000	50,000	1,200	18,000		

1984 BOSTON HARBOR SURVEY

SECCHI DISK TRANSPARENCY DATA (m)

STATION	25 Jun	26 Jun	16 Jul	17 Jul	27 Aug	28 Aug	9 Oct	10 Oct
BH01	1.2	1.6	1.2	1.4	2.1	2.0		
BH02	1.2	1.4	1.4	1.5	2.2	2.0		
BH03	1.3	1.3	1.4	1.6	2.0	2.1		
BH04	1.5	2.4	1.6	1.8	2.2	2.4		
BH05	1.2	1.6	A	2.3	1.4	2.2		
BH06	1.8	1.3	A	2.2	2.0	2.0		
BH07	0.7	B	A	2.3	2.6	2.0		
BH08	1.8	B	A	2.0	2.0	1.8		
BH09	1.8	2.0	1.4	B	1.7	1.5		
BH10	1.2	2.0	1.6	1.8	1.9	1.6		
BH10A	1.3	1.6	1.2	1.2	1.5	1.2		
BH10B	1.1	1.2	0.6	0.8	1.0	0.8		
BH11A	1.4	B	A	2.2	1.4	0.9		
BH12	A	A	A	2.2	1.2	1.1		
BH12A	A	A	A	2.0	1.2	0.9		
BH13	A	A	A	2.2	1.2	1.0		
BH13A	A	A	A	2.0	1.6	C		
BH14	A	A	A	2.0	2.0	2.2		
BH18	A	A	A	2.5	2.0	C		
BH22	2.0	1.4	A	2.0	1.6	1.4		

A - Bad weather

B - Windy conditions

C - Lost disk

1984 BOSTON HARBOR SURVEY
NUT ISLAND WWTP DISCHARGE DATA*

PARAMETER**	AUGUST 27	AUGUST 27/28		AUGUST 28/29	
		INFLUENT	EFFLUENT	INFLUENT	EFFLUENT
Chloride			560		
COD		423	478	520	450
BOD_5		174	93	142	129
pH (Standard Units)		7.1	6.9	6.9	6.9
Alkalinity (as $CaCO_3$)					
Suspended Solids		1102	72	1564	232
Settleable Solids (ml/l)			1.5		
Total Solids		1464	1392	2304	1556
Total Kjeldahl-Nitrogen		25	21	30	28
Ammonia-Nitrogen		14	11	14	11
Nitrate-Nitrogen		0.0	0.0	0.0	0.0
Total Phosphorus (as P)		6.0	55	7.8	7.2
Aluminum		1.2	0,7		
Cadmium		0.0	0.00		
Chromium, Total		0.03	0.00		
Copper		0.14	0.10		
Iron		1.6	1.2		
Mercury		0.0000	0.0000		
Manganese		--	--		
Nickel		0.00	0.00		
Lead		0.04	0.02		
Silver		0.01	0.00		
Tin		<0.5	<0.5		
Zinc		0.20	0.12		
Arsenic		0.000	0.012		
Total Coliform (#/100 ml)	600		2400		46000
Fecal Coliform (#/100 ml)	<20		430		1500
Flow (MGD)	--		91		94.3
Residual Chlorine	--		—		--
Total Chlorine	>4.0		—		0.9

* Sludge not tested
** in mg/l unless stated otherwise

1984 BOSTON HARBOR SURVEY
DEER ISLAND WWTP DISCHARGE DATA*

PARAMETER**	JUNE 25	JUNE 25/26		JUNE 26/27	
		INFLUENT	EFFLUENT	INFLUENT	EFFLUENT
Chloride			1420		1500
COD		860	583	630	558
BOD_5		198	66	150	81
pH (Standard Units)		7.0	6.9	6.9	6.8
Alkalinity (as $CaCO_3$)					
Suspended Solids		240	129	390	93
Settleable Solids (ml/l)			2.5		2.0
Total Solids		3588	4068	4138	4206
Total Kjeldahl-Nitrogen		30	22	32	25
Ammonia-Nitrogen		6.8	9.8	6.5	7.5
Nitrate-Nitrogen		***	***	***	***
Total Phosphorus (as P)		4.5	3.7	6.0	4.2
Aluminum		0.65	0.39		
Cadmium		0.02	0.02		
Chromium, Total		0.18	0.14		
Chromium, Hexavalent		0.00	0.00		
Iron		2.3	1.9		
Mercury		0.0007	0.0005		
Manganese		0.14	0.15		
Nickel		0.17	0.14		
Lead		0.10	0.08		
Silver		0.01	0.01		
Arsenic		0.001	0.001		
Zinc		0.41	0.30		
Copper		0.14	0.09		
Total Coliform (#/100 ml)	$2.4(10^6)$	--	430,000	--	430,000
Fecal Coliform (#/100 ml)	430,000	--	240,000	--	4,300
Flow (MGD)			284		271
Residual Chlorine			0.1		0.5
Total Chlorine			>2.0		2.8

---

* Sludge not tested
** mg/l unless stated otherwise
*** Interference

1984 BOSTON HARBOR SURVEY
NUT ISLAND WWTP DISCHARGE DATA*
(CONT.)

PARAMETER**	JUNE 25	JUNE 25/26		JUNE 26/27	
		INFLUENT	EFFLUENT	INFLUENT	EFFLUENT
Flow (MGD)			122		107
Residual Chlorine			0.3		0.2
			72.0		1.8

Total Chlorine

* Sludge not tested
** in mg/l unless stated otherwise
*** Interference

1984 BOSTON HARBOR SURVEY
NUT ISLAND WWTP DISCHARGE DATA*

PARAMETER**	JULY 16	JULY 16/17		JULY 17/18	
		INFLUENT	EFFLUENT	INFLUENT	EFFLUENT
Chloride			475		170
COD		392	313	426	329
BOD_5		126	75	120	96
pH (Standard Units)		7.1	7.0	7.2	7.2
Alkalinity (as $CaCO_3$)		110	83	112	99
Suspended Solids		136	48	162	78
Settleable Solids (ml/l)			5.0		
Total Solids		975	682	1000	920
Total Kjeldahl-Nitrogen		65	54	26	18
Ammonia-Nitrogen		10	9.3	12	12
Nitrate-Nitrogen		***	***	0.0	0.0
Total Phosphorus (as P)		4.0	3.2	4.8	3.8
Aluminum		1.2	0.60		
Cadmium		0.00	0.00		
Chromium		0.03	0.02		
Copper		0.11	0.11		
Iron		1.5	1.1		
Mercury		0.0009	0.0008		
Manganese		0.19	0.18		
Nickel		0.00	0.04		
Lead		0.04	0.01		
Silver		0.01	0.00		
Tin		<0.5	0.5		
Zinc		0.17	0.12		
Arsenic		0.001	0.003		
Total Coliform (#/100 ml)	9300	--	200		
Fecal Coliform (#/100 ml)	930	--	10		
Flow (MGD)	--		91.4		102
Residual Chlorine	0.0		0.1		0.2
Total Chlorine	>3.5		1.1		2.0

* Sludge not tested
** in mg/l unless stated otherwise
*** Interference

1984 BOSTON HARBOR SURVEY

TOTAL PHOSPHORUS DATA (mg/l as P)

STATION	25 Jun	26 Jun	16 Jul	17 Jul	27 Aug	28 Aug	9 Oct	10 Oct
BH01	0.22	0.16	0.13	0.12	0.23	0.21		
BH02	0.39	0.17	0.12	0.13	0.23	0.17		
BH03	0.18	0.15	0.11	0.11	0.19	0.18		
BH04	0.19	0.14	0.12	0.17	0.19	0.18		
BH05	0.19	0.17	A	0.13	0.19	0.17		
BH06	0.15	0.15	A	0.12	0.20	0.16		
BH07	0.14	0.12	A	0.09	0.14	0.14		
BH08	0.30	0.13	A	0.12	0.14	0.15		
BH09	0.18	0.12	0.11	0.14	0.15	0.16		
BH10	0.16	0.12	0.11	0.11	0.18	0.15		
BH10A	0.16	0.14	0.11	0.10	0.21	0.17		
BH10B	0.18	0.15	0.15	0.15	0.20	0.25		
BH11A	0.16	0.14	A	0.11	0.18	0.15		
BH12	A	A	A	0.10	0.15	0.19		
BH12A	A	A	A	0.11	0.16	0.17		
BH13	A	A	A	0.09	0.19	0.14		
BH13A	A	A	A	0.09	0.15	0.13		
BH14	A	A	A	0.13	0.13	0.11		
BH18	A	A	A	0.10	0.13	0.10		
BH22	0.19	0.16	A	0.12	0.18	0.18		
CR01	0.18	0.18	0.12	0.15	0.28	0.20		
CR02	0.12	0.20	0.16	0.13	0.06	0.17		
CR03	0.26	0.04	0.28	0.42	0.58	0.26		

A - Bad weather

1984 BOSTON HARBOR SURVEY
NUT ISLAND WWTP DISCHARGE DATA*

PARAMETER**	JUNE 25	JUNE 25/26		JUNE 26/27	
		INFLUENT	EFFLUENT	INFLUENT	EFFLUENT
Chloride			540		560
COD		456	427	476	284
BOD_5		132	90	105	93
pH (Standard Units)		7.1	7.0	7.0	6.8
Alkalinity (as $CaCO_3$)					
Suspended Solids		84	98	183	120
Settleable Solids (ml/l)			3.5		2.0
Total Solids		1442	1314	1992	1654
Total Kjeldahl-Nitrogen		32	16	17	13
Ammonia-Nitrogen		8.6	7.8	3.5	9.1
Nitrate-Nitrogen		***	***	***	***
Total Phosphorus (as P)		5.0	2.7	4.0	3.8
Aluminum		0.91	0.59	0.91	
Cadmium		0.00	0.02	0.00	
Chromium, Total		0.03	0.00	0.03	
Chromium, Hexavalent		0.00	0.00	--	
Iron		1.5	1.2	1.5	
Mercury		0.0003	0.0002	0.0003	
Manganese		0.20	0.17	0.20	
Nickel		0.05	0.05	0.05	
Lead		0.05	0.01	0.05	
Silver		0.01	0.07	0.01	
Copper		0.13	0.17	0.13	
Zinc		0.20	0.29	0.20	
Arsenic		0.002	0.001	0.002	
Total Coliform (#100 ml)	430		40		24,000
Fecal Coliform (#100 ml)	36		5		430

1984 BOSTON HARBOR SURVEY

TOTAL KJELDAHL-NITROGEN DATA (mg/l)

STATION	25 Jun	26 Jun	16 Jul	17 Jul	27 Aug	28 Aug	9 Oct	10 Oct
BH01	2.4	1.0	1.6	1.5	0.97	0.9		
BH02	5.4	1.4	1.6	0.93	1.0	0.82		
BH03	2.8	1.3	1.3	1.4	0.83	0.9		
BH04	2.8	1.2	1.1	1.5	0.71	0.97		
BH05	2.5	1.7	A	1.5	0.72	0.83		
BH06	2.2	1.5	A	1.4	0.6	0.82		
BH07	2.5	1.5	A	1.4	0.67	0.72		
BH08	4.2	1.3	A	1.4	0.65	1.2		
BH09	2.2	1.4	1.3	0.90	0.71	1.8		
BH10	1.6	1.3	4.6	1.3	0.65	2.0		
BH10A	1.6	1.5	5.7	0.77	0.79	2.0		
BH10B	1.6	1.7	4.0	1.5	0.83	2.0		
BH11A	1.5	1.6	A	1.0	0.77	1.9		
BH12	A	A	A	1.0	0.89	1.9		
BH12A	A	A	A	0.7	0.78	2.0		
BH13	A	A	A	0.96	0.86	1.7		
BH13A	A	A	A	1.8	0.76	2.0		
BH14	A	A	A	0.98	0.7	2.0		
BH18	A	A	A	0.81	0.68	2.0		
BH22	1.6	2.0	A	1.8	0.77	0.67		
CR01	2.2	2.1	1.6	3.6	1.2	0.88		
CR02	1.6	2.6	1.5	1.9	0.43	0.87		
CR03	4.4	0.16	4.0	4.0	2.3	1.2		

A - Bad weather

1984 BOSTON HARBOR SURVEY

AMMONIA-NITROGEN DATA (mg/l)

STATION	25 Jun	26 Jun	16 Jul	17 Jul	27 Aug	28 Aug	9 Oct	10 Oct
BH01	0.22	0.10	0.45	0.11	0.35	0.24		
BH02	0.08	0.08	0.44	0.08	0.32	0.39		
BH03	0.06	0.11	0.08	0.05	0.34	0.37		
BH04	0.31	0.13	0.16	0.27	0.40	0.32		
BH05	0.02	0.10	A	0.08	0.40	0.28		
BH06	0.03	0.12	A	0.14	0.36	0.80		
BH07	0.37	0.07	A	0.09	0.35	0.25		
BH08	0.54	0.12	A	0.17	0.34	0.27		
BH09	0.03	0.05	0.04	0.06	0.35	0.26		
BH10	0.02	0.03	0.02	0.08	0.40	0.26		
BH10A	0.04	0.06	0.09	0.08	0.40	0.39		
BH10B	0.03	0.13	0.11	0.17	0.38	0.38		
BH11A	0.10	0.04	A	0.04	0.38	1.1		
BH12	A	A	A	0.05	0.39	0.35		
BH12A	A	A	A	0.02	0.33	0.26		
BH13	A	A	A	0.04	0.37	0.30		
BH13A	A	A	A	0.04	0.38	0.30		
BH14	A	A	A	0.05	0.35	0.57		
BH18	A	A	A	0.03	0.36	0.31		
BH22	0.01	0.14	A	0.09	0.38	0.34		
CR01	0.18	0.25	0.08	0.20	0.07	0.14		
CR02	0.31	0.13	0.34	0.17	0.16	0.22		
CR03	0.74	0.15	0.46	0.53	0.15	0.26		

A - Bad weather

1984 BOSTON HARBOR SURVEY

pH DATA (Standard Units)

STATION	25 Jun	26 Jun	16 Jul	17 Jul	27 Aug	28 Aug	9 Oct	10 Oct
BH01	8.3	7.8	8.0	7.8	7.9	7.7		
BH02	8.2	7.8	8.0	8.1	7.8	8.0		
BH03	8.1	7.9	7.6	8.0	7.7	7.8		
BH04	7.7	7.8	7.9	7.7	7.8	7.9		
BH05	8.1	7.9	A	7.9	7.9	7.8		
BH06	8.2	7.9	A	7.9	8.0	7.9		
BH07	8.0	8.1	A	8.0	7.8	7.9		
BH08	8.0	8.0	A	8.0	8.0	8.0		
BH09	8.1	7.7	8.1	8.0	7.9	B		
BH10	8.0	8.0	8.0	8.0	7.9	7.8		
BH10A	7.9	8.0	8.0	7.8	7.8	7.7		
BH10B	7.9	7.8	7.9	7.6	7.8	7.5		
BH11A	7.9	7.9	A	8.0	7.8	7.9		
BH12	A	A	A	8.1	8.0	7.8		
BH12A	A	A	A	8.1	8.1	8.1		
BH13	A	A	A	8.1	8.1	7.9		
BH13A	A	A	A	8.1	7.9	7.9		
BH14	A	A	A	8.0	8.1	7.8		
BH18	A	A	A	8.0	7.9	7.9		
BH22	7.8	8.0	A	8.1	7.8	7.7		
CR01	8.3	7.8	8.0	8.2	7.8	7.9		
CR02	8.4	8.0	8.2	8.3	7.7	7.8		
CR03	7.5	7.9	8.1	8.8	7.6	7.6		

A - Bad weather

B - Broken in transit

1984 BOSTON HARBOR SURVEY

SUSPENDED SOLIDS DATA (mg/l)

STATION	25 Jun	26 Jun	16 Jul	17 Jul	27 Aug	28 Aug	9 Oct	10 Oct
BH01	10	5.5	6.5	8	8.5	3.5		
BH02	13	5.5	9	9	4	4		
BH03	8	2.5	13	9.5	3	2		
BH04	6.5	2.5	12	6.5	0.5	1		
BH05	10	13	A	8	4	0.5		
BH06	14	4	A	9.5	4	4		
BH07	4	10	A	34	4.9	7		
BH08	13	7	A	7.5	4	12		
BH09	10	6	16	24	5.5	B		
BH10	7.5	15	10	12	7	9.5		
BH10A	15	9.5	11	10	8.5	13.5		
BH10B	30	12	10	16	12.5	42		
BH11A	8	8.5	A	7	14	8		
BH12	A	A	A	6.5	7	8.5		
BH12A	A	A	A	6.5	10	12.5		
BH13	A	A	A	6	6	5.5		
BH13A	A	A	A	7.5	7.5	8		
BH14	A	A	A	7.5	4	10		
BH18	A	A	A	9	6.5	10		
BH22	6.5	14	A	13	6.5	7.5		
CR01	9	5	8	17	56	5.5		
CR02	12	8	8.5	14	3.5	11		
CR03	14	9	21	12	17	12		

A - Bad weather

1984 BOSTON HARBOR SURVEY

CHLORIDE DATA (mg/l)

STATION	25 Jun	26 Jun	16 Jul	17 Jul	27 Aug	28 Aug	9 Oct	10 Oct
BH01	14,500	15,000	15,000	16,300	16,000	17,500		
BH02	14,000	14,500	14,375	15,900	15,500	15,000		
BH03	14,250	14,500	15,625	14,400	15,500	15,500		
BH04	9,000	15,000	14,375	10,900	15,000	16,000		
BH05	14,750	14,000	A	15,300	16,000	15,500		
BH06	15,750	14,000	A	15,100	16,500	16,000		
BH07	16,750	15,000	A	16,600	17,500	16,500		
BH08	16,500	16,000	A	16,900	17,500	17,000		
BH09	13,750	15,000	16,875	17,200	17,000	B		
BH10	15,250	16,000	18,125	16,900	17,000	17,000		
BH10A	15,750	15,000	15,625	15,900	16,500	16,500		
BH10B	16,000	13,500	12,500	16,300	16,500	16,500		
BH11A	16,250	15,000	A	16,600	17,000	17,500		
BH12	A	A	A	16,900	17,500	17,000		
BH12A	A	A	A	17,200	17,000	17,500		
BH13	A	A	A	17,500	17,000	17,000		
BH13A	A	A	A	17,500	17,000	17,000		
BH14	A	A	A	17,200	17,500	17,500		
BH18	A	A	A	17,500	17,500	17,500		
BH22	18,000	16,000	A	16,900	16,500	17,000		
CR01	13,750	14,500	13,500	14,700	14,400	13,600		
CR02	16,000	14,750	15,000	15,300	15,600	16,400		
CR03	1,750	14,250	8,500	7,190	16,400	15,200		

A - Bad weather

B - Broken in transit

1984 BOSTON HARBOR SURVEY

SPECIFIC CONDUCTANCE DATA (μmhos/cm)

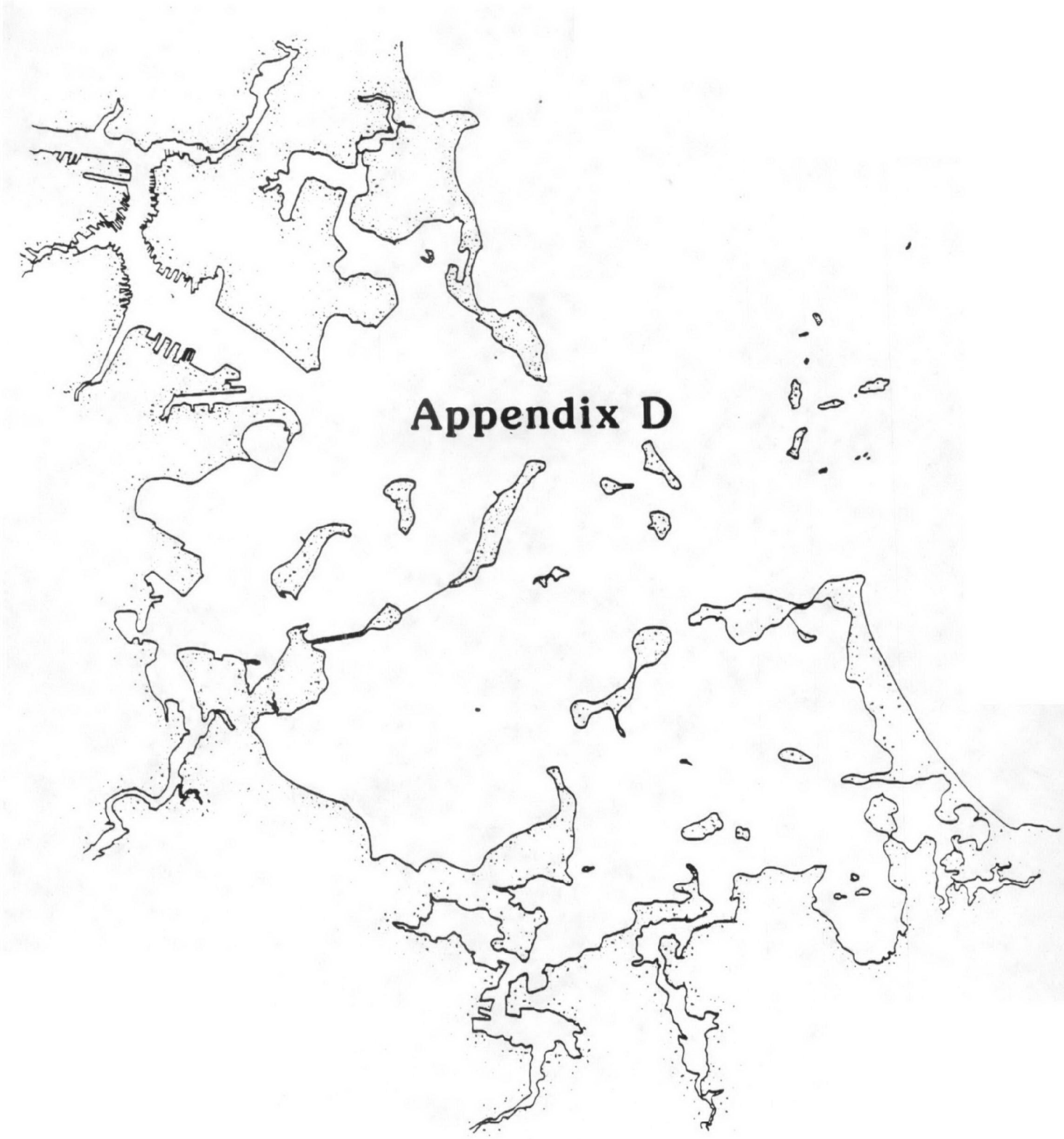
STATION	25 Jun	26 Jun	16 Jul	17 Jul	27 Aug	28 Aug	9 Oct	10 Oct
BH01	30,000	36,000	34,000	36,000	36,000	35,000		
BH02	30,000	35,000	30,000	35,000	34,000	34,000		
BH03	30,000	36,000	33,000	34,000	36,000	34,000		
BH04	20,000	35,000	30,000	28,000	34,000	34,000		
BH05	33,000	34,000	A	29,000	35,000	35,000		
BH06	36,000	35,000	A	29,000	35,000	35,000		
BH07	35,000	36,000	A	26,000	39,000	36,000		
BH08	36,000	34,000	A	35,000	38,000	35,000		
BH09	34,000	38,000	38,000	38,000	38,000	B		
BH10	36,000	36,000	38,000	36,000	38,000	36,000		
BH10A	34,000	37,000	34,000	36,000	36,000	34,000		
BH10B	36,000	36,000	29,000	26,000	37,000	33,000		
BH11A	37,000	35,000	A	38,000	39,000	17,500		
BH12	A	A	A	36,000	40,000	17,000		
BH12A	A	A	A	38,000	39,000	17,500		
BH13	A	A	A	38,000	38,000	17,000		
BH13A	A	A	A	38,000	38,000	17,000		
BH14	A	A	A	38,000	37,000	17,500		
BH18	A	A	A	36,000	38,000	36,000		
BH22	36,000	38,000	A	38,000	37,000	34,000		
CR01	C	C	C	C	31,000	29,000		
CR02	C	C	C	C	33,000	36,000		
CR03	C	C	C	C	34,000	35,000		

A - Bad weather

B - Broken in transit

C - No sample taken


CHARLESTOWN
EAST BOSTON
WINTHROP
LOGAN INTERNATIONAL AIRPORT
BOSTON
(see chart 13272)
Reserved Channel
SOUTH BOSTON
Pleasure Bay
PRESIDENT ROADS
OLD HARBOR
COLUMBIA PT
DORCHESTER BAY
QUINCY BAY
North Quincy
Yards



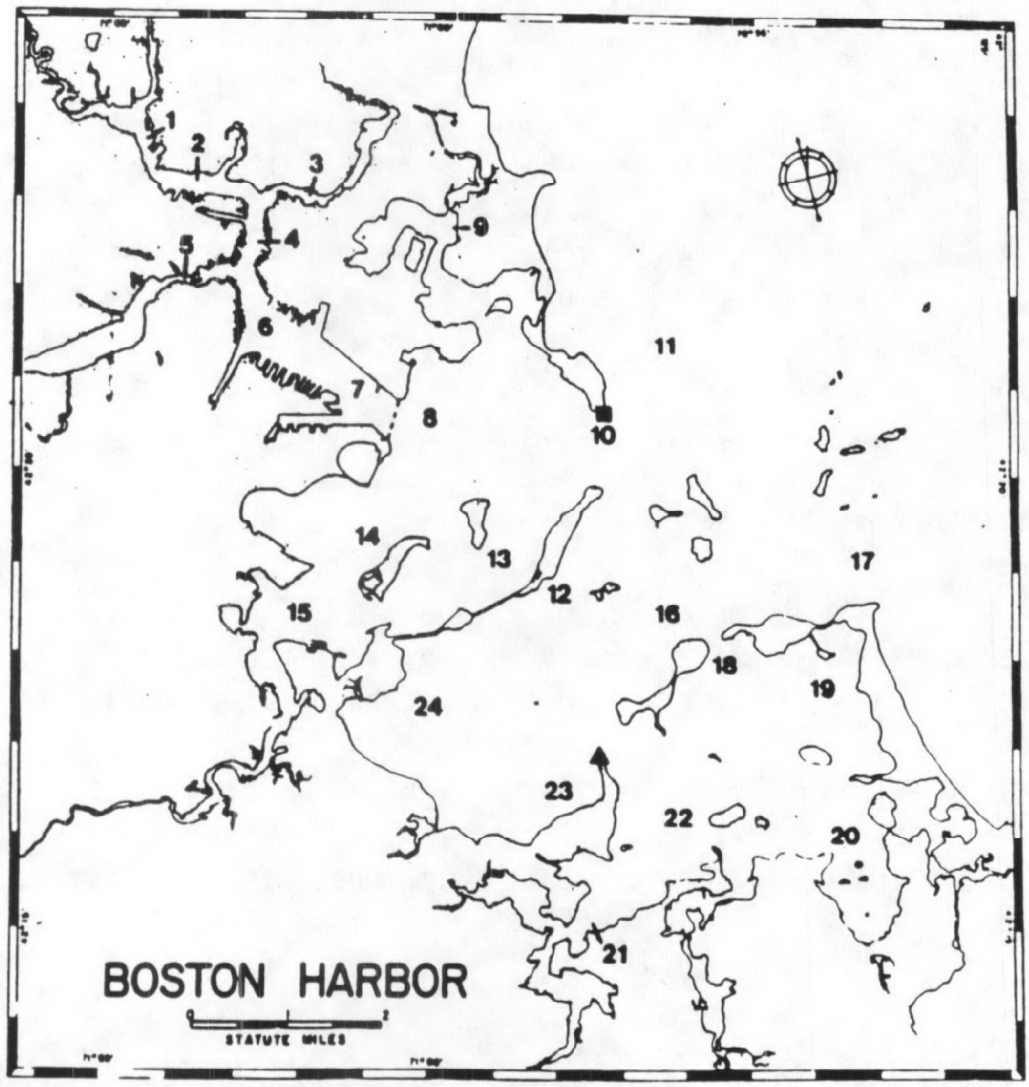
Appendix D

CONCENTRATIONS OF METALS IN BOSTON HARBOR WATERS

Results from:
Metal Distribution in a Major Urban Estuary (Boston Harbor)
Impacted by Ocean Disposal

By:
G.T.Wallace,Jr., W.H. Waugh and K.A. Garner

Paper Presented at the Proceedings of the
Fith International Ocean Disposal Symposium
September 10-14 1984, Oregon State University, Corvalis Oregon



SAMPLING LOCATIONS

BOSTON HARBOR DISSOLVED METAL CONCENTRATIONS - LOW TIDE

AUGUST 17 and 18, 1984 (Concentrations in ug/l*)

STATION	Zn	Pb	Cd	Cu	Ni	Fe	Mn
1	12.486	.557	.105	9.277	21.605	84.877	39.282
2	5.883	.286	.081	6.862	1.667	15.077	13.735
3	7.256	.294	.083	9.277	1.744	12.452	15.273
4	7.321	.218	.081	5.147	1.62	12.173	15.603
5	1.896	.39	.063	6.418	2.936	10.889	2.198
6	9.413	.354	.062	4.13	1.562	15.3	15.273
7	6.602	.269	.076	4.257	1.573	9.772	11.867
8	5.687	.191	.075	4.956	1.92	8.432	11.537
9	4.053	.228	.076	5.02	1.256	18.539	11.208
10[1]	15.689	.327	.572	6.481	2.266	13.346	15.603
11	2.549	.191	.076	2.033	1.209	8.544	7.582
12	3.791	.369	.087	1.652	.916	7.259	7.637
12[2]	3.203	.431	.08	2.033	.822	5.64	7.417
13	4.314	.321	.086	2.986	.969	8.041	12.032
14	4.903	.267	.097	2.923	.963	6.589	15.438
15	4.968	.367	.094	3.304	1.086	7.65	16.097
16	3.072	.236	.074	3.939	.887	4.914	12.526
17	1.83	.182	.056	3.113	.634	5.137	5.934
18	2.026	.24	.057	3.368	.622	5.193	6.922
19	2.68	.193	.061	2.796	.587	3.741	6.922
20	2.223	.288	.057	12.39	1.292	7.65	7.252
21	4.576	.369	.065	18.49	.916	10.442	16.427
22	2.876	.3	.07	14.741	.881	5.361	7.911
23	2.549	.261	.054	12.009	.822	3.797	9.56
24	3.138	.39	.071	13.979	1.421	4.411	7.582

Notes: 1. Sample taken within Deer Island Outfall plume.

2. Station 12 reoccupied on second day of low tide sampling.

Data originally expressed in nM/L except Cd which appeared as pM/L.

BOSTON HARBOR DISSOLVED METAL CONCENTRATIONS - HIGH TIDE

AUGUST 23 and 24, 1984 (Concentrations in ug/l*)

STATION	Zn	Pb	Cd	Cu	Ni	Fe	Mn
1	4.118	.408	.053	13.089	2.284	31.326	27.58
2	5.622	.334	.079	12.644	1.198	14.686	11.647
2 (13)[a]	3.988	.408	.074	11.183	2.712	17.645	10.988
3	8.106	.361	.074	8.197	1.292	17.199	15.933
4	6.995	.255	.081	12.009	1.573	13.234	13.295
4 (13)	2.549	.244	.061	5.973	.84	9.995	7.032
6	4.249	.228	.072	6.227	1.069	8.32	11.098
6 (13)	2.484	.288	.065	6.418	.851	10.721	6.428
7	5.23	.186	.07	3.241	1.045	8.153	10.219
7 (13)	2.353	.22	.056	3.939	.71	12.843	7.197
8	1.961	.137	.07	3.113	.687	4.3	5.549
8[b]	1.896	.157	.064	3.749	.569	4.579	6.263
9	3.922	.203	.07	3.812	.951	11.838	9.779
10	1.961	.174	.069	2.796	.716	4.244	5.604
10 (15)	1.569	.16	.056	4.067	.517	4.356	4.23
10[c]	3.857	.255	.047	6.227	1.802	13.792	11.318
11	2.026	.133	.07	4.257	1.397	3.127	3.187
11 (15)	.784	.091	.04	.381	.628	6.254	3.626
12	4.903	.271	.088	1.97	.81	7.036	6.593
13	3.661	.267	.09	1.652	.845	7.873	8.516
13[b]	3.399	.356	.086	1.207	.816	5.919	8.626
14	3.399	.249	.081	1.97	1.051	6.533	7.582
14 (8)	3.922	.334	.082	1.461	.81	24.681	7.582
15	3.269	.332	.082	1.271	.658	15.133	9.834
16	1.438	.139	.06	.89	1.632	1.787	4.175
16[b]	2.092	.182	.058	1.017	.587	3.797	4.945
17	1.438	.112	.052	3.685	.616	1.899	3.901
17(15)	.85	.095	.038	2.415	.546	4.244	1.758
18	2.811	.286	.06	3.558	.622	6.757	9.56
18 (20)	1.438	.133	.051	2.669	.546	4.523	4.945
19	2.876	.344	.064	3.05	.787	6.701	8.461
20	2.353	.247	.058	4.067	.675	8.488	7.747
21	4.576	.344	.063	2.224	.787	8.432	16.976
22	3.269	.57	.067	2.351	.787	6.422	8.461
23	2.484	.313	.056	2.605	.734	9.94	6.373
24	3.922	1.032	.083	2.605	.734	7.538	5.659

Footnotes appear at end of Appendix.

BOSTON HARBOR PARTICULATE METAL CONCENTRATIONS - HIGH TIDE

AUGUST 23 and 24, 1984 (Concentrations in ug/l*)

STATION	Zn	Pb	Cd	Cu	Ni	Fe	Mn
1	1.059	.636	9E-03	.941	.133	127.874	1.066
2	.732	.47	1E-03	.471	.065	84.318	.769
2 (13)[a]	.549	.41	3E-03	.405	.073	111.68	.928
3	.523	.516	3E-03	.445	.043	79.851	.637
4	.346	.325	1E-03	.301	.038	53.048	.637
4 (13)	.758	.456	3E-03	.588	.087	112.797	1.698
6	.373	.286	1E-03	.451	.042	52.49	1.769
6 (13)	.66	.311	3E-03	.543	.085	106.096	1.703
7	.418	.249	1E-03	.386	.045	49.139	1.395
7 (13)	.981	.39	7E-03	1.013	.059	145.742	1.824
8	.275	.126	3E-03	.379	.042	34.621	.747
8[b]	.399	.267	2E-03	.608	.048	54.165	1.066
9	.621	.286	1E-03	.288	.105	104.421	1.324
10	.464	.24	2E-03	.445	.016	51.931	1.187
10 (15)	.412	.174	4E-03	.438	.016	43.555	1.165
10[c]	8.563	.806	.069	3.197	.255	107.771	1.61
11	.451	.182	3E-03	.281	.042	28.478	1.143
11 (15)	.412	.176	2E-03	.595	.08	73.709	1.253
12	.412	.336	2E-03	.268	.055	49.698	.736
13	.869	.572	4E-03	.392	.077	67.566	.978
13[b]	.66	.503	4E-03	.346	.059	59.19	.841
14	.837	.361	3E-03	.333	.21	61.982	1.148
14 (8)	.824	.45	4E-03	.608	.099	99.395	1.319
15	1.222	.661	6E-03	1.039	.146	157.469	1.604
16	.601	.122	1E-03	.163	.031	29.595	.967
16[b]	.856	.153	1E-03	.183	.032	28.478	1.099
17	.431	.091	1E-03	.098	.022	13.402	1.17
17 (15)	.32	.087	0	.105	.026	22.336	1.016
18	.497	.3	1E-03	.34	.055	49.698	1.368
18 (20)	.34	.131	1E-03	.118	.034	26.803	.989
19	.379	.207	1E-03	.209	.047	42.997	1.258
20	.431	.211	1E-03	.242	.044	46.906	1
21	.686	.479	1E-03	.307	.058	67.008	1
22	.608	.332	3E-03	.438	.072	58.632	1.555
23	.798	.497	4E-03	.34	.066	59.19	2.181
24	1.314	.646	5E-03	.876	.141	124.523	2.264

Footnotes appear at end of Appendix.

Note Data originally expressed in nM/L except Cd (pM/L), and Fe (uM/L).

BOSTON HARBOR TOTAL METAL CONCENTRATIONS - HIGH TIDE

AUGUST 23 and 24, 1984 (Concentrations in ug/l*)

1	5.177	1.044	.062	14.031	2.417	159.2	28.646
2	6.354	.804	.081	13.115	1.262	99.004	12.416
2 (13)[a]	4.537	.818	.078	11.588	2.785	129.325	11.916
3	8.629	.876	.078	8.641	1.334	97.05	16.57
4	7.341	.58	.082	12.31	1.612	66.282	13.933
4 (13)	3.308	.7	.065	6.561	.927	122.792	8.73
6	4.622	.514	.073	6.678	1.111	60.81	12.867
6 (13)	3.144	.599	.068	6.96	.936	116.817	8.131
7	5.648	.435	.071	3.626	1.09	57.292	11.614
7 (13)	3.334	.609	.063	4.953	.77	158.586	9.021
8	2.236	.263	.072	3.493	.729	38.92	6.296
8[b]	2.294	.425	.066	4.357	.618	58.744	7.329
9	4.543	.489	.071	4.1	1.056	116.259	11.103
10	2.425	.414	.071	3.24	.733	56.175	6.791
10 (15)	1.981	.334	.06	4.505	.532	47.911	5.395
10[c]	12.42	1.061	.116	9.424	2.057	121.564	12.927
11	2.478	.315	.072	4.538	1.44	31.605	4.329
11 (15)	1.196	.267	.042	.976	.709	79.963	4.879
12	5.315	.607	.09	2.238	.865	56.733	7.329
13	4.53	.839	.094	2.044	.923	75.44	9.494
13[b]	4.059	.86	.09	1.554	.875	65.109	9.466
14	4.236	.609	.085	2.303	1.261	68.516	8.73
14 (8)	4.746	.783	.086	2.069	.909	124.076	8.9
15	4.491	.992	.088	2.31	.803	172.601	11.439
16	2.04	.261	.061	1.053	1.663	31.382	5.142
16[b]	2.948	.336	.059	1.2	.619	32.276	6.043
17	1.87	.203	.052	3.783	.639	15.3	5.071
17 (15)	1.17	.182	.038	2.519	.572	26.58	2.774
18	3.308	.586	.061	3.898	.678	56.454	10.928
18 (20)	1.778	.263	.052	2.786	.58	31.326	5.934
19	3.255	.551	.065	3.259	.834	49.698	9.719
20	2.785	.458	.059	4.308	.719	55.393	8.746
21	5.262	.823	.064	2.531	.845	75.44	17.976
22	3.876	.901	.07	2.789	.858	65.054	10.016
23	3.282	.81	.059	2.945	.8	69.13	8.554
24	5.236	1.678	.088	3.481	.875	132.062	7.922

Footnotes appear at end of Appendix.

FOOTNOTES TO HIGH TIDE SAMPLING TABLES

[a]Number in parenthesis following station number is depth of sample in meters. Otherwise samples were collected at a depth of ~10 cm.

[b]A second surface sample was taken nearby but in a visually more turbid zone.

[c]This sample was collected near station 10 but directly in the plume from the Deer Island Outfall.

Data originally expressed in nM/L except Cd which appeared as pM/L.

1984 BOSTON HARBOR SURVEY
DEER ISLAND WWTP DISCHARGE DATA*.

PARAMETER**	JULY 16	JULY 16/17		JULY 17/18	
		INFLUENT	EFFLUENT	INFLUENT	EFFLUENT
Chloride			450		1450
COD		396	498	583	518
BOD_5		120	90	120	99
pH (Standard Units)		7.0	7.1	7.1	7.1
Alkalinity (as $CaCO_3$)		114	105	113	99
Suspended Solids		166	94	183	94
Settleable Solids (ml/l)			3.0		
Total Solids		3930	2590	3,390	3350
Total Kjeldahl-Nitrogen		162	132	26	25
Ammonia-Nitrogen		10	13	16	15
Nitrate-Nitrogen		***	***	***	***
Total Phosphorus (as P)		5.8	3.8	3.8	3.6
Aluminum		0.46	****		
Cadmium		0.00	****		
Chromium, Total		0.10	****		
Tin		<0.5	****		
Iron		1.6	****		
Mercury		0.0000	****		
Manganese		0.14	****		
Nickel		0.04	****		
Lead		0.09	****		
Silver		0.01	****		
Arsenic		0.004	****		
Zinc		0.20	****		
Copper		0.40	****		
Total Coliform (#/100 ml)	240,000	—	240,000	—	11×10^6
Fecal Coliform (#/100 ml)	240,000	—	300	—	430,000
Flow (MGD)	—		246		255
Residual Chlorine	0.0		1.7		0.1
Total Chlorine	1.4		3.0		1.2

* Sludge not tested
** in mg/l unless stated otherwise
*** Interference

1984 BOSTON HARBOR SURVEY
DEER ISLAND WWTP DISCHARGE DATA*

PARAMETER**	AUGUST 27	AUGUST 27/28		AUGUST 28/29	
		INFLUENT	EFFLUENT	INFLUENT	EFFLUENT
Chloride			1520		
COD		637	642	650	640
BOD_5		153	108	60	48
pH (Standard Units)		6.8	6.9	6.8	6.8
Alkalinity (as $CaCO_3$)					
Suspended Solids		216	141	436	106
Settleable Solids (ml/l)			4.8		
Total Solids		3754	3650	3660	3464
Total Kjeldahl-Nitrogen		40	21	44	33
Ammonia-Nitrogen		14	14	16	15
Nitrate-Nitrogen		0.0	0.0	0.0	0.0
Total Phosphorus (as P)		8.5	4.5	5.8	5.0
Aluminum		0.4	0.5		
Cadmium		0.00	0.00		
Chromium, Total		0.09	0.08		
Copper		0.14	0.15		
Iron		1.5	1.5		
Mercury		0.0000	0.0000		
Manganese		0.06	0.02		
Nickel		0.05	0.05		
Lead		0.02	0.01		
Silver		<0.5	<0.5		
Tin		0.15	0.16		
Zinc		0.022	0.024		
Arsenic					
Total Coliform (#/100 ml)	30×10^6		2.4×10^6		46,000
Fecal Coliform (#/100 ml)	2.2×10^6		2.4×10^6		7500
Flow (MGD)	--		231		227
Residual Chlorine	0.0		--		--
Total Chlorine	0.0		--		1.0

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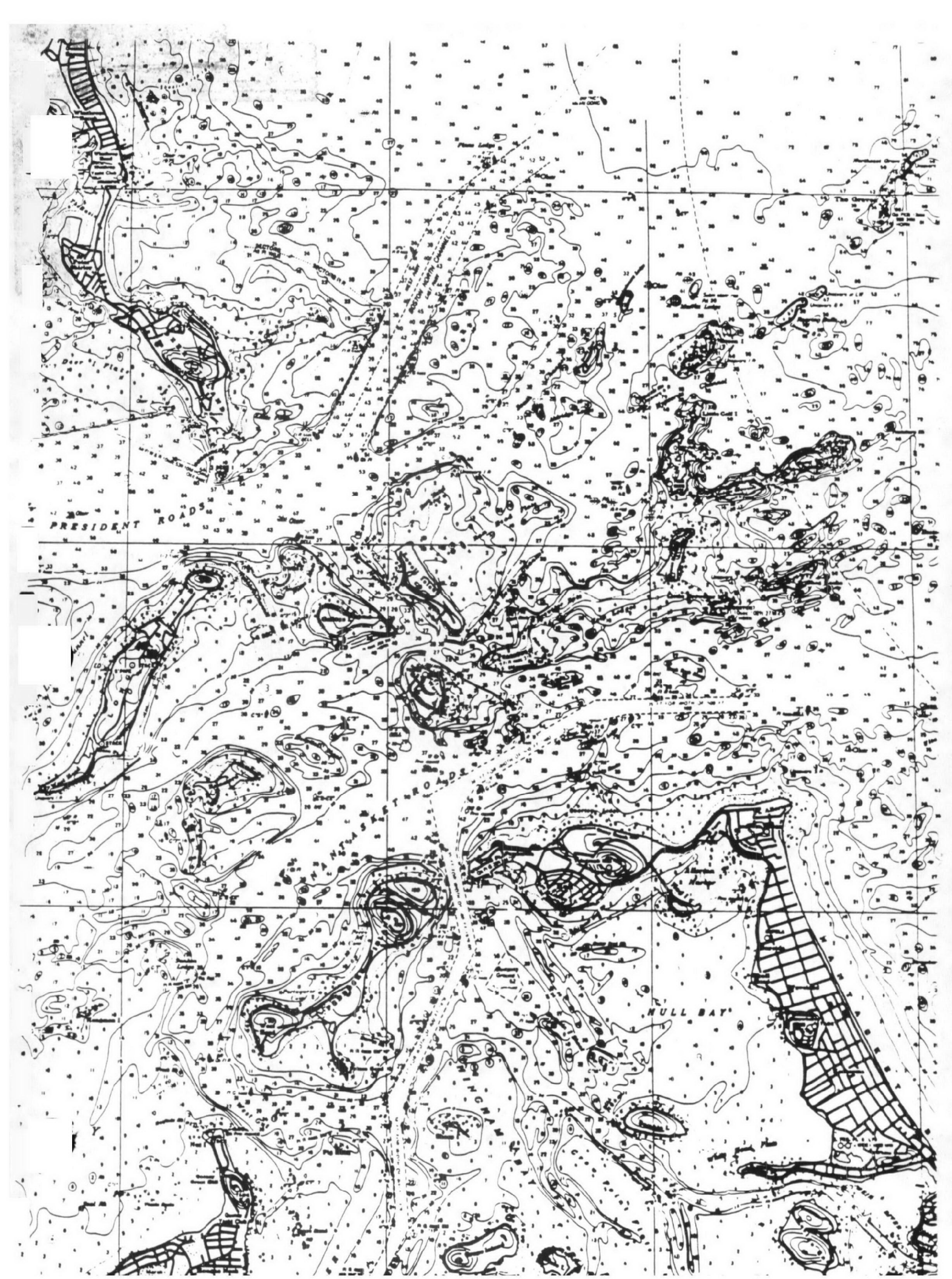
* Sludge not tested
** in mg/l unless stated otherwise


PRESIDENT ROADS
HULL BAY