United States
Environmental Protection
Agency
Office of Radiation Programs

National Air and
Radiation Environmental Laboratory

EPA 520/5-91-003

EPA

Radiation

Radiological Survey of the Portsmouth Naval Shipyard

EPA 520/5-91-003

Radiological Survey of the Portsmouth Naval Shipyard

Mark O. Semler

National Air and Radiation Environmental Laboratory
1504 Avenue A
Montgomery, Alabama 36115-2601

October 1991

U.S. Environmental Protection Agency
Office of Radiation Programs
401 M Street, S.W.
Washington, DC 20460

TABLE OF CONTENTS

List of Figures v

List of Tables. v

Preface vi

Introduction. 1

Characteristics of the Harbor and Sampling Areas. 2

Survey and Analytical Methods 5

Results and Discussion. 11

Conclusions 17

References. 18

Appendix: Description of Samples Collected 21

LIST OF FIGURES

Figure

1. Piscataqua River Area Map, Sampling Sites Off Naval Facilities. 4

2. Portsmouth Naval Shipyard Sediment Sampling Sites. 9

3. Portsmouth Naval Shipyard Biota Sampling Sites. 10

LIST OF TABLES

Table

1. Summary of Samples Collected 8

2. Summary of Radionuclide Concentrations in Sediment Samples 14

3. Description of Biota Samples 14

4. Summary of Gamma-Ray Exposure Rates. 15

PREFACE

The Office of Radiation Programs identifies and evaluates environmental public health impacts of both natural and manmade radiation sources. The National Air and Radiation Environmental Laboratory (NAREL), formerly the Eastern Environmental Radiation Facility, is a fully integrated participant with other components of the Office in these efforts. NAREL provides comprehensive capability for evaluating radiation sources through planning and conducting environmental studies, nationwide surveillance, and laboratory analysis. In addition, NAREL provides special analytical support for Environmental Protection Agency Regional Offices and other federal government agencies, as requested, as well as technical assistance to the radiological health programs of state and local health departments.

This report presents results of the survey conducted by NAREL personnel to assess levels of environmental radioactivity resulting from maintenance and operation of nuclear-powered warships at Portsmouth Naval Shipyard, Kittery, Maine. The purpose of the survey was to determine if activities related to nuclear-powered warships resulted in release of radionuclides which may contribute

to significant population exposure or contamination of the environment.

Readers of our reports are encouraged to bring comments, omissions, or errors to our attention.

Sam T. Windham

Sam T. Windham, Director
National Air and Radiation
Environmental Laboratory

INTRODUCTION

Since 1963, the National Air and Radiation Environmental Laboratory (NAREL), U.S. Environmental Protection Agency (EPA), in cooperation with the U.S. Naval Sea Systems Command (NAVSEA), has surveyed facilities serving nuclear-powered warships on the Atlantic and Pacific coasts and the Gulf of Mexico. These surveys assess whether the construction, maintenance, overhaul, or refueling of nuclear-powered warships have created elevated levels of radioactivity. The surveys emphasize sampling those areas and pathways that could expose the public.

In 1984, NAVSEA requested that EPA again survey all active facilities servicing nuclear-powered warships. The Portsmouth Naval Shipyard was surveyed September 11 to 15, 1989. This facility was previously surveyed by EPA in July 1977. At that time, no Co-60 was found in any of the silt samples, but tritium (H-3) activities of 200 to 400 pCi/L were found in water samples from both background sites and shipyard sites. Cesium-137 and Zr-95/Nb-95, which are products of atmospheric nuclear weapons testing and are not due to the operations of the shipyard, were also detected in silts and biota.

CHARACTERISTICS OF THE HARBOR AND SAMPLING AREAS

Portsmouth Naval Shipyard is located in Portsmouth Harbor on Seavey Island. The shipyard is accessible via bridge from Kittery, Maine, and occupies all of the island (Figure 1). The facility is approximately 1981 meters (east-west) by 1158 meters (north-south), an area of 277.8 acres. The Piscataqua River empties into the harbor on the west-northwest side. The deepest part of the harbor is approximately 23 meters in the channel at low tide. The shipyard is a major repair facility for the Navy's nuclear submarine fleet.

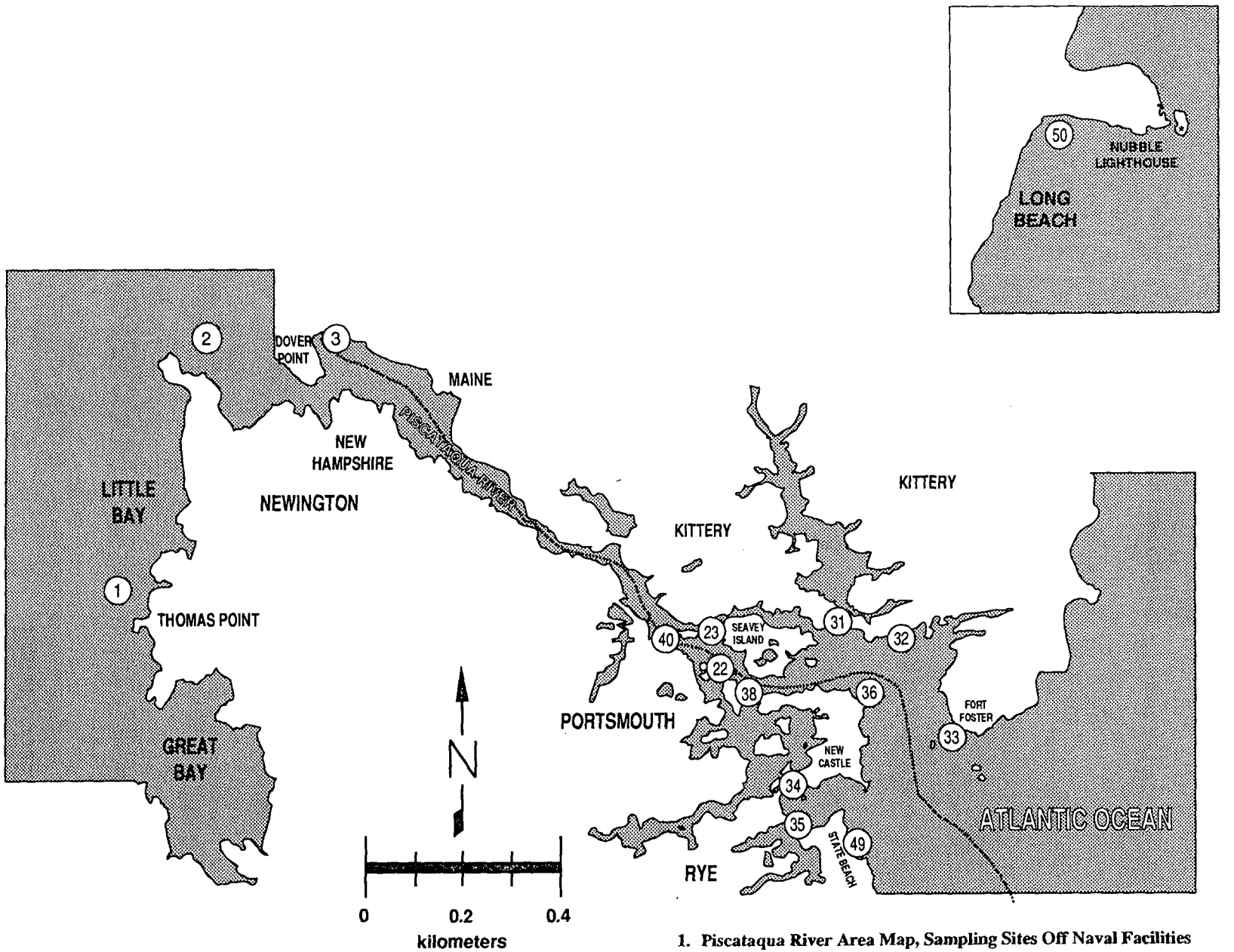
Observations made during the survey indicated that the harbor bottom surface is rock at several locations. The bottom at other areas is mud. Tidal action supplemented by the river flow results in a swift current around the shipyard. This current results in the lack of sediment on the bottom surface at several locations.

A major dredging project of the Portsmouth harbor by the Army Corps of Engineers was begun in 1989 and was in progress during this survey. This dredging was in the main channel areas of the harbor.

Although some dredging was done near Seavey Island, it was not related to the shipyard operations and was not inside the restricted area. There has been no significant dredging of

sediments immediately adjacent to Seavey Island since the last survey.

Discussions with shipyard personnel indicated that most of the water is accessible to the public by boat with the exception of certain areas that are restricted for security reasons. There are extensive commercial fishing and recreational activities in the area, the most significant being lobstering. There are many commerical and private lobster traps in the immediate vicinity of the shipyard.



1. Piscataqua River Area Map, Sampling Sites Off Naval Facilities

SURVEY AND ANALYTICAL METHODS

Personnel from the radiological control office at Portsmouth Naval Shipyard accompanied the NAREL team during the survey. The Navy personnel provided information on those sampling sites where radioactivity associated with Naval nuclear propulsion plants, if it were present, would most likely be detected. Extensive sediment sampling was conducted in the pier and dry dock areas where nuclear warships were being or had been serviced. Public access or recreational areas and public drinking water supplies in the vicinity of the shipyard were also surveyed for radioactivity.

Cobalt-60 is the predominant radioisotope one would find in environmental media if radioactivity were present as a result of Naval nuclear propulsion plant operations (Ca77, Se88, Sen88); therefore, environmental sampling focused on detecting this radioisotope. The Co-60 content in all samples was determined by gamma-ray spectroscopy. Water samples were also analyzed for tritium since this radionuclide is known to be produced in the coolant of light-water nuclear reactors.

According to past surveys, if radioactivity were released as a result of Naval nuclear propulsion plant operations, it would be detected as Co-60 in the sediment (Ca77, Ca79). Radionuclides tend to accumulate in the sediment over time, which enables detection of

events that may have occurred in the past. A standard Peterson dredge was used to sample approximately the top 10 centimeters of sediment. Forty sediment samples were collected during the survey. At the laboratory, these samples were dried, ground to a fine powder, placed in 400 cubic centimeter (cm^3) sample counting containers, and counted on intrinsic germanium detectors for 1000 minutes. The minimum detectable activity for Co-60 in this geometry is approximately 0.01 picocuries per gram (pCi/g).

Sediment core samples are useful in determining the vertical distribution of radioactivity in harbor bottom sediment. If radioactive material were present from past operations and subsequently covered with sediment, the radioactivity might be detected in the core samples. Four core samples were taken using 3.8 centimeter diameter plastic tubes and a mechanical coring tool. The cores were frozen and sectioned into 2.5 centimeter lengths. The individual sections were freeze-dried and counted on intrinsic germanium detectors for 1000 minutes to analyze for gamma-ray emitting radioisotopes. The minimum detectable activity for Co-60 in this geometry is approximately 0.1 pCi/g.

Water samples were collected at six sites. The surface water samples were grab samples. The drinking water samples, collected from taps, represent the water supplied to Portsmouth, New Hampshire, Kittery, Maine, and the shipyard. One liter water samples were analyzed for gamma-ray emitting radionuclides, especially Co-60, on intrinsic germanium detectors. The minimum

detectable level for Co-60 in this geometry is 5 picocuries per liter (pCi/L). Water samples were also analyzed for tritium. The tritium found in reactor coolant systems is in the oxide form and chemically indistinguishable from water; therefore, it does not accumulate in marine life or on the harbor floor (Ma88). The minimum detectable level for tritium is 200 pCi/L with the analytical procedure used.

Aquatic biota samples were collected at three sites by the divers. These samples were divided for analysis as follows: (1) fish -- muscle; (2) crab -- samples included muscle, viscera, and exoskeleton; (3) barnacles and mussels; (4) lobster -- the tail and claw meat; and (5) vegetation. The biota samples were dried, ground to a fine powder, and counted on intrinsic germanium detectors for 1000 minutes. The counting geometry was determined by the amount of sample available: the minimum detectable level for Co-60 is 0.01 pCi/g for a 400 cm^3 sample or 0.1 pCi/g for a 40 cm^3 sample.

Gamma radiation exposure measurements were made with pressurized ionization chambers or portable scintillation survey instruments that were calibrated with the pressurized ionization chambers. Measurements were made at all sites in the pier and dry dock areas where the majority of the sediment samples were collected and along the restricted area line. Public access and recreation areas in the vicinity were surveyed with portable scintillation survey instruments.

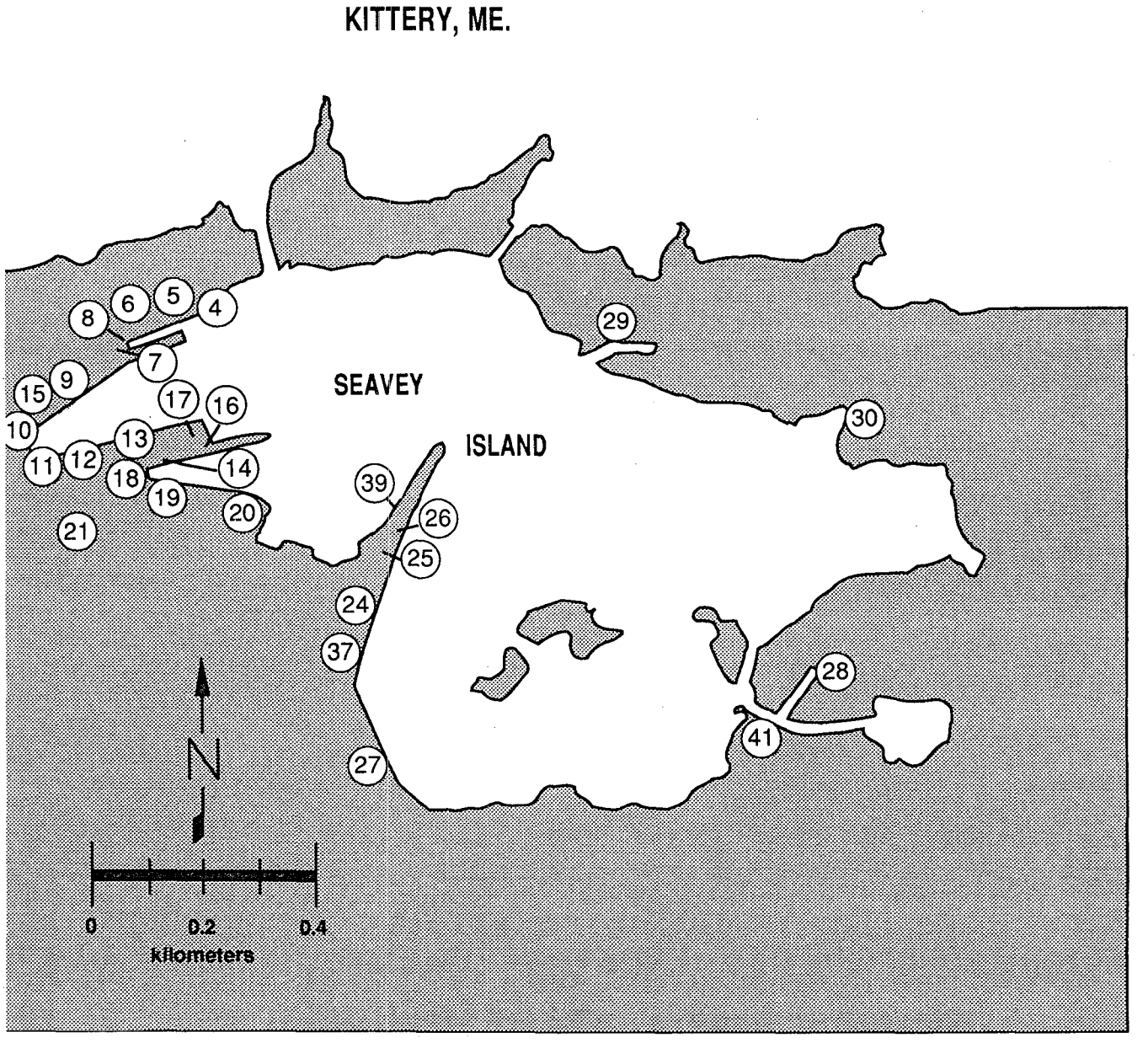
Sampling sites are shown on maps of Portsmouth Naval Shipyard in Figures 2 and 3. Sites that are located outside the boundaries of the Naval facilities are shown on the area map in Figure 1. A summary of the samples collected during the survey is presented in Table 1. Sample types collected at each site are detailed in the Appendix.

TABLE 1

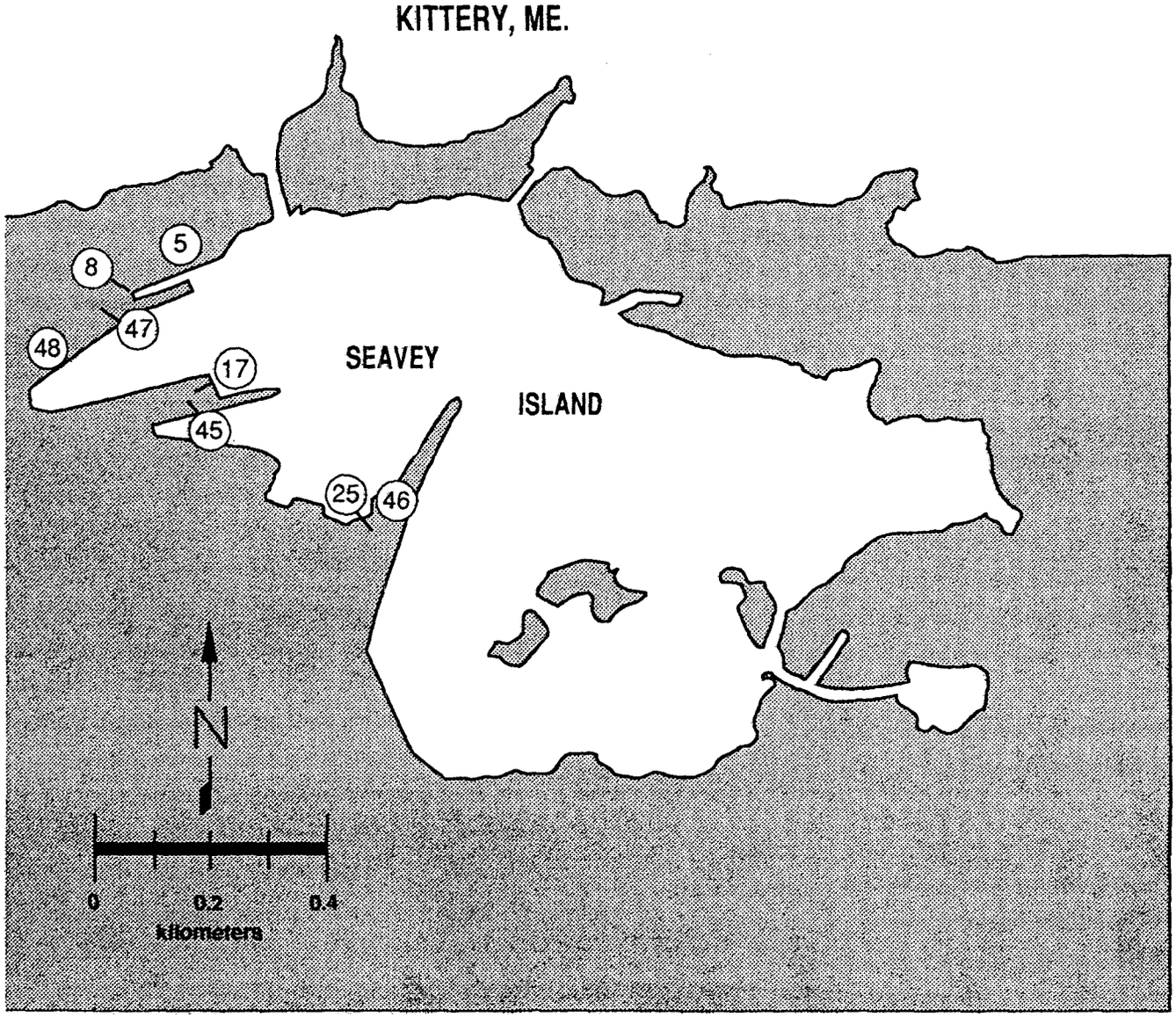
Summary of Samples Collected

Facility	Sampling Sites	Number of Samples			
		Water	Sediment	Cores	Biota
Portsmouth Naval Shipyard	50	6	40	4	11

NOTE: See Appendix for a list of all samples collected at each sampling location.



2. Portsmouth Naval Shipyard Sediment Sampling Sites



3. Portsmouth Naval Shipyard Biota Sampling Sites

RESULTS AND DISCUSSION

Results of the sampling of the Portsmouth Naval Shipyard and surrounding areas are summarized in Tables 2, 3, and 4. The sites sampled outside the shipyard were selected either as background sites, areas of public access and/or recreation, or public drinking water supplies.

Bottom sediment samples from 40 sites were analyzed for gamma-emitting radionuclides, with particular emphasis given to the detection of Co-60. Several additional sites around the shipyard were selected for sampling; however, no sediments were present at these sites because of the scouring action of the Piscataqua River tides. No Co-60 was detected in any of these sediments. Other radionuclides identified are either naturally occurring (K-40, Ra-226, Th-232, U-238) or are the result of fallout from atmospheric weapons testing (Cs-137).

Four sites, 5, 8, 17, and 25, were sampled with a mechanical coring tool to evaluate the deposition of radionuclides with time. Cores of 13 inches, 5 inches, 10 inches, and 22 inches in depth were taken, respectively, from these sites. Results of the analyses of 2.5 cm sections of each core are comparable to those of the sediments also taken at the sites. No Co-60 or other

radionuclide which could be attributed to the operations at the shipyard was found. Only Cesium-137 and naturally occurring radionuclides were detected.

Surface water samples at three sites, 1, 7, and 39, were collected and analyzed for both gamma-emitting radionuclides and tritium (H-3). No radioactivity was detected in any of these samples. Three additional water samples of the Portsmouth, New Hampshire, Kittery, Maine, and Seavey Island drinking water were also analyzed. No gamma emitting radionuclides or tritium were detected in these drinking water samples. These results are consistent with routinely analyzed water samples from New Hampshire and Maine (EPA89, EPA90a, EPA90b).

There is considerable sport and commercial fishing and lobstering in the area. Significant concentrations of lobster traps are placed in close proximity to Seavey Island. Lobster and crab were collected at three sites around the Island, 45, 46, and 47, by shipyard divers. The edible portions were analyzed for gamma-emitting radionuclides. The only radionuclides detected in these samples were K-40 and a trace of Cs-137. One fish sample from site 46 and samples of clams, barnacles, and mussels from sites 38, 45, and 48 were analyzed: only K-40 and Cs-137 were detected. No Co-60 or other radionuclide associated with shipyard operations was detected in any of these samples.

Vegetation was collected at four locations, sites 23, 37, 46, and 47. Potassium-40 and Th-232 were present in all samples, and

Cs-137 was detected in samples from sites 23 and 47. No Co-60 or other radionuclide associated with shipyard operations was detected in any of these samples.

External gamma radiation measurements were taken at all sampling sites and along the restricted area boundary of the shipyard. Measurements were also made at public access areas near the facility, including public parks and marinas in both Maine and New Hampshire, and the shoreline of Kittery, Maine, and Portsmouth, New Hampshire, opposite Seavey Island. Recreational areas on the eastern end of Seavey Island were also monitored. A summary of the locations and results is presented in Table 4.

Terrestrial gamma exposure rates ranged from 4 to 24 μR/hr; these exposure rates are comparable to those measured during other surveys of Naval facilities and background sites (Se88, Sm87, Wi87), and indicate that shipyard operations have no significant radiological impact on the public. One measurement taken on a granite sea wall at Fort McClary State Park was 24 μR/hr. This elevated reading is due entirely to the presence of naturally occurring radionuclides in the granite and has been observed during other surveys (Sen88, Sm87).

Gamma exposure rates taken over water at the background sites ranged from 3.5 to 4.8 μR/hr. Gamma exposure rates taken over water at the sampling sites adjacent to Seavey Island ranged from 3.8 to 5.9 μR/hr. The gamma exposure rates at the restricted area boundary ranged from 3.0 to 5.7 μR/hr.

TABLE 2

Summary of Radionuclide Concentrations in Sediment Samples[a,b,c]

Radionuclide	Samples Collected On-Site (N=26)	Samples Collected Off-Site (N=14)
K-40	17.1 (8.7 - 23.9)	16.3 (12.0 - 20.6)
Co-60	< 0.01	< 0.01
Cs-137	0.11 (0.01 - 0.49)	0.06 (0.02 - 0.18)
Ra-226	1.4 (0.52 - 2.1)	1.2 (0.50 - 1.9)
Th-232	0.69 (0.29 - 1.1)	0.58 (0.26 - 0.87)
U-238	2.9 (1.2 - 6.2)	2.4 (2.0 - 2.8)

[a] Concentrations are in pCi/gram dry weight.
[b] Mean concentrations are given, with the range shown in parentheses.
[c] Approximate 2-sigma counting errors are: K-40 (2 %); Cs-137 (28%); Ra-226 (21 %); Th-232 (9 %); and U-238 (69 %).

TABLE 3

Description of Biota Samples

Site No.	Samples Analyzed	Site No.	Samples Analyzed
23	Kelp and Algae	46	Sea Cucumber Crabs Lobster Fish Kelp
37	Seaweed		
38	Kelp Clams		
45	Barnacles/Mussels Lobster	47	Lobster Kelp
		48	Barnacles/ Mussels

TABLE 4

Summary of Gamma-Ray Exposure Rates

Location of Survey	Average Gamma-Ray Exposure Rates μR/hr)
Harbor Sediment Sampling Sites	
Off-Site	4.3 (3.5 - 4.8)[a]
On-Site	4.8 (3.8 - 6.0)[a]
Restricted Area Boundary around Seavey Island	4.3 (3.0 - 5.7)[a]
Terrestrial Surveys	
On Seavey Island	
Northeast tip at Jamaica Island park	12
Jamaica Island, Eastern tip	12
Jamaica Island, picnic table area	16
Jamaica Island, children's playground	12
Main road to Jamaica Park	15
North end of Seavey Island	15
Kittery, Maine, and surroundings	
Pepperell Road causeway	4
Pepperell Road, east of causeway	12
Fort McClary State Park, on granite sea wall	24
Frisbee Wharf	10
Chauncey Creek Road	11
Fort Foster State Park	14
West of Security Gate 1 to Seavey Island	14
Badgers Island, east end	13
U.S. 1 at bridge over Piscataqua River	10
U.S. 1, midspan of bridge	5
Portsmouth, New Hampshire	
Prescott Park, south end	13
Fourtree Island	13
Pierce Island	10
Pierce Island, at waste treatment plant	14
Pierce Island, Northernmost point	8
Market Street shoreline	17
Ceres Road, on a pier	7
Goat Island bridge	5
Shaws Hill bridge	11
Fort Dearborn	15

[a] Mean concentration given, with the range shown in parentheses.

TABLE 4 -- Continued

Summary of Gamma-Ray Exposure Rates

Location of Survey	Average Gamma-Ray Exposure Rates (μR/hr)
New Castle Island	
Shoreline at Cape and River Roads	12
Shoreline at Cape and Oliver Roads	15
Portsmouth Yacht Club	14
U.S. Coast Guard Station	13
Fort Constitution	13
Fort Point	7
Fort Stark State Park	12

CONCLUSIONS

The radiological survey of the Portsmouth Naval Shipyard provides the basis for the following conclusions:

1. No trace of Co-60 was detected in any samples at Portsmouth Naval Shipyard. All radioactivity detected in the forty sediment samples is attributed to naturally occurring radionuclides or fallout from past nuclear weapons testing.
2. Results of core sampling did not indicate any previous deposit of Co-60 in the sediment.
3. Water samples contained no detectable levels of radioactivity.
4. All radioactivity detected in the biota samples is attributed to naturally occurring radionuclides or fallout.
5. External gamma-ray measurements did not detect any increased radiation exposure to the public above natural background levels.
6. Based on this survey, we conclude that current practices regarding nuclear-powered warship operations have resulted in no increases in radioactivity that would result in significant population exposure or contamination of the environment.

REFERENCES

Bl76 Blanchard, R.L., et. al. 1976. *Radiological Surveillance Studies at the Oyster Creek BWR Nuclear Generating Station*. EPA-520/5-76-003. Washington, D.C.: U.S. Environmental Protection Agency, Office of Radiation Programs.

Ca77 Callis, R.S., Windham, S.T., and Phillips, C.R. 1977. *Radiological Survey of Puget Sound Naval Shipyard, Bremerton, Washington and Environs*. EPA 520/5-77-001. Washington, D.C.: U.S. Environmental Protection Agency, Office of Radiation Programs.

Ca79 Callis, R.S., Windham, S.T., and Phillips, C.R. 1979. *Radiological Survey of Portsmouth Naval Shipyard, Kittery, Maine, and Environs*. EPA 520/5-79-003. Washington, D.C.: U.S. Environmental Protection Agency, Office of Radiation Programs.

Ca87 Callis, R.S. 1987. *Radiological Survey of the Pearl Harbor Naval Shipyard and Environs, Honolulu, Hawaii*. EPA 520/5-87-010. Washington, D.C.: U.S. Environmental Protection Agency, Office of Radiation Programs.

REFERENCES - Continued

EPA89 Environmental Protection Agency. 1989. *Environmental Radiation Data: Report 58* (April - June 1989). EPA 520/5-89-034. Washington, D.C.: U.S. Environmental Protection Agency, Office of Radiation Programs.

EPA90a Environmental Protection Agency. 1990. *Environmental Radiation Data: Report 59* (July - September 1989). EPA 520/5-90-003. Washington, D.C.: U.S. Environmental Protection Agency, Office of Radiation Programs.

PA90b Environmental Protection Agency. 1990. *Environmental Radiation Data: Report 60* (October - December 1989). EPA 520/5-90-018. Washington, D.C.: U.S. Environmental Protection Agency, Office of Radiation Programs.

Ka74 Kahn, B., et. al. 1974. *Radiological Surveillance Study of the Haddam Neck PWR Nuclear Power Station.* EPA 520/3-74-007. Washington, D.C.: U.S. Environmental Protection Agency, Office of Radiation Programs.

Ma88 Mangeno, J.J., Steele, J.M., and Poletti, L.F. 1988. *Environmental Monitoring and Disposal of Radioactive Wastes from U.S. Naval Nuclear Powered Ships and Their Support Facilities.* Naval Sea Systems Command Report,

REFERENCES - Continued

Se88 Semler, M.O. and Blanchard, R.L. 1988. *Radiological Survey of San Diego Bay*. EPA 520/5-88-019. Washington, D.C.: U.S. Environmental Protection Agency, Office of Radiation Programs.

Sen88 Sensintaffar, E.L. and Blanchard, R.L. 1988. *Radiological Survey of the Norfolk Naval Station, the Norfolk Naval Shipyard, and Newport News Shipbuilding*. EPA 520/5-88-019. Washington, D.C.: U.S. Environmental Protection Agency, Office of Radiation Programs.

Sm87 Smith, J.M. 1987. *Radiological Survey of Charleston Naval Base and Shipyard and the Charleston Naval Weapons Station*. EPA 520/5-87-009. Washington, D.C.: U.S. Environmental Protection Agency, Office of Radiation Programs.

Wi87 Windham, S.T., 1987. *Radiological Survey of Kings Bay Submarine Support Facility*. EPA 520/5-87-008. Washington, D.C.: U.S. Environmental Protection Agency, Office of Radiation Programs.

APPENDIX

Description of Samples Collected
at Portsmouth Naval Shipyard

Site No.	Samples Collected
1	Sediment, Surface Water
2	Sediment
3	Sediment
4	Sediment
5	Sediment, Core
6	Sediment
7	Sediment, Surface Water
8	Sediment, Core
9	Sediment
10	Sediment
11	Sediment
12	Sediment
13	Sediment
14	Sediment
15	Sediment
16	Sediment
17	Sediment, Core
18	Sediment
19	Sediment
20	Sediment
21	Sediment
22	Sediment
23	Sediment, Vegetation
24	Sediment
25	Sediment, Core
26	Sediment
27	No Sediment*
28	Sediment
29	Sediment
30	Sediment
31	Sediment
32	Sediment
33	Sediment
34	Sediment

APPENDIX -- Continued

Description of Samples Collected
at Portsmouth Naval Shipyard

Site No.	Samples Collected
35	Sediment
36	Sediment
37	No Sediment*, Vegetation
38	No Sediment*, Vegetation
39	Sediment, Surface Water
40	Sediment
41	Sediment
42	Drinking Water
43	Drinking Water
44	Drinking Water
45	Biota
46	Biota
47	Biota
48	Sediment
49	Sediment
50	Sediment

* Area was scoured of sediment by the swift currents. No sediment sample could be obtained.