United States
Environmental Protection
Agency
Office of Radiation Programs

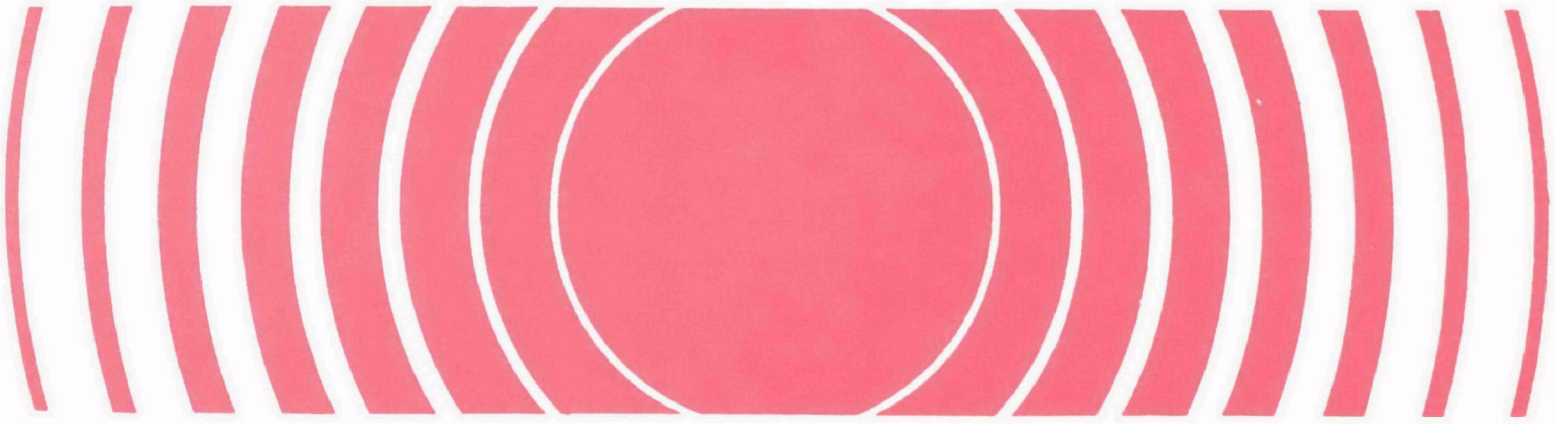
Eastern Environmental
Radiation Facility
1890 Federal Drive
Montgomery, AL 36109

EPA 520/5-88-019
June 1989

Radiation

EPA

Radiological Survey of San Diego Bay



EPA 520/5-88-019

Radiological Survey of San Diego Bay

Mark O. Semler

and

Richard L. Blanchard

Eastern Environmental Radiation Facility

1890 Federal Drive

Montgomery, Alabama 36109

March 1989

U.S. Environmental Protection Agency

Office of Radiation Programs

401 M Street SW

Washington, DC 20460

Table of Contents

List of Figures

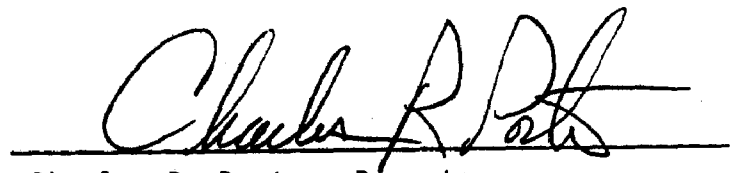
List of Tables

Preface

The Office of Radiation Programs identifies and evaluates environmental public health impacts of both natural and man-made radiation sources. The Eastern Environmental Radiation Facility (EERF) is a fully integrated participant with other components of the Office in these efforts. The Facility provides comprehensive capability for evaluating radiation sources through planning and conducting environmental studies, nationwide surveillance, and laboratory analysis. The EERF also 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 EERF personnel to assess levels of environmental radioactivity resulting from maintenance and operation of nuclear-powered warships in San Diego Bay, California. 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.



Charles R. Porter, Director
Eastern Environmental Radiation Facility

Introduction

Since 1963, the Eastern Environmental Radiation Facility (EERF), U.S. Environmental Protection Agency (USEPA), 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 operation of nuclear-powered warships, during construction, maintenance, overhaul, or refueling, 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 survey all active facilities serving nuclear-powered warships over the next three years. This report contains the results of the survey conducted in San Diego Bay on the southern coast of California in 1986. A map of the bay and the surrounding area of San Diego is shown in Figure 1.

San Diego Bay was previously surveyed by EERF personnel (at that time the U.S. Public Health Service) in April 1967 (Ca67). During the early survey, sampling was conducted primarily in the vicinity of the Submarine Pier on Point Loma. In addition to natural and fallout radionuclides, low concentrations of Co-60 that were attributed to nuclear-powered ships were observed in some sediment samples (Ca67). The Submarine Pier was resurveyed during the recent study conducted from September 15, 1986 to September 17, 1986. During the latter study, additional sampling was performed in the vicinity of the 32nd Street Naval Station and near the northeast corner of the North Island Naval Air Station. These sampling sites are located in Figure 1 as A, B, and C, respectively.

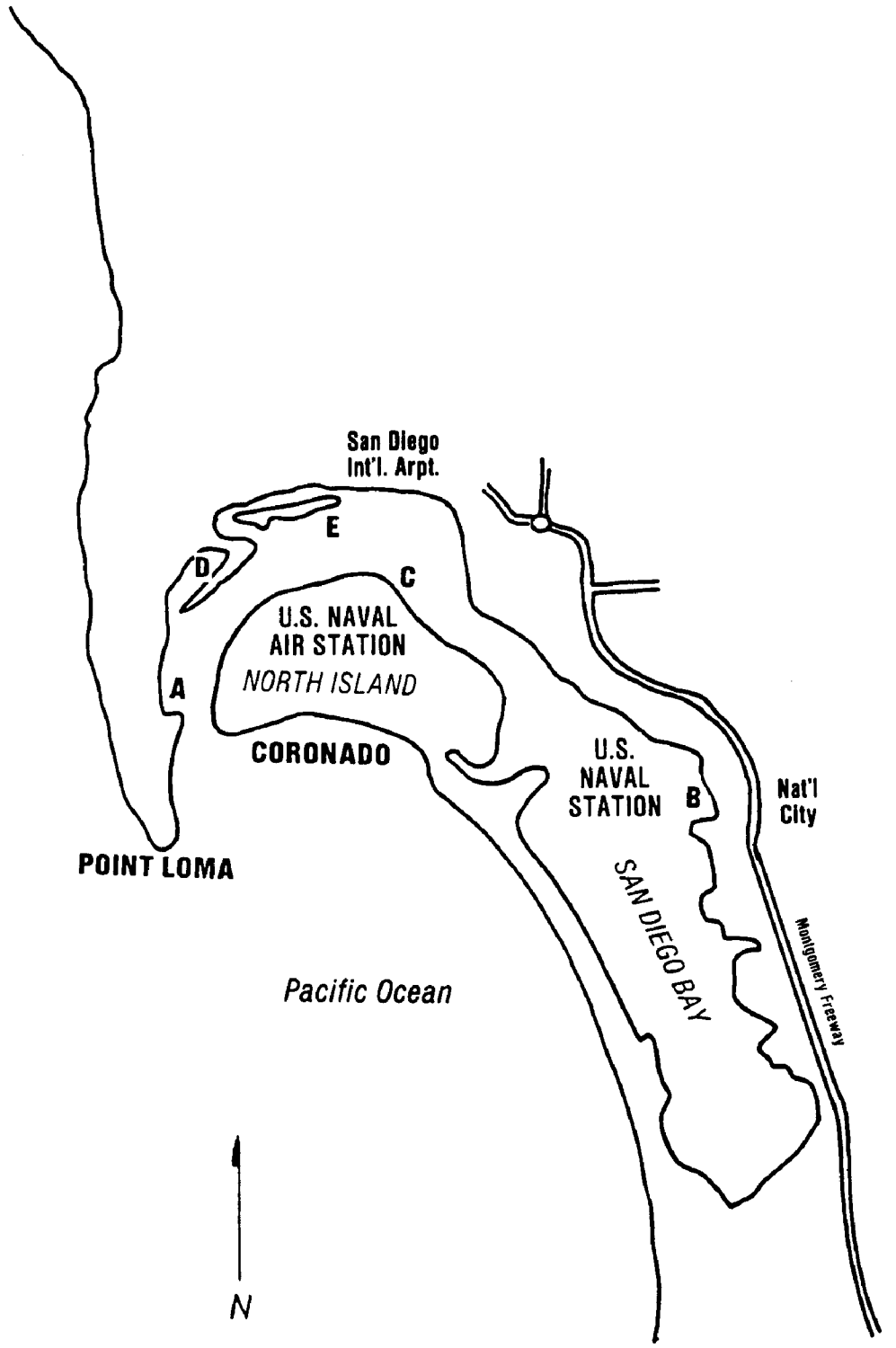


Figure 1. San Diego Bay and vicinity. Sampling sites are: (A) Submarine Pier; (B) 32nd Street Pier; (C) North Island Shipyard. Sites of gamma-ray surveys are Shelter Island (D) and Harbor Island (E).

Characteristics of the Harbor and Sampling Areas

San Diego Bay is a natural landlocked harbor on the coast of Southern California containing approximately 22 square miles of surface area. The entrance to the bay is formed by Point Loma on the west and North Island on the east. The bay has an axial length of 14.7 statute miles with the main portion of the bay extending in a northwest-southeast direction. The mean width is 1.26 miles varying from 0.31 miles near the entrance to 2.24 miles at the widest point near the end. The mean tidal range is 4.2 feet and the current at the entrance has an average velocity of 2.4 feet per second and an extreme velocity of 4.55 feet per second.

Freshwater inflow for the bay consists of storm runoff and four small rivers which are dry in the summer. This freshwater flow is so small there are no stream gauge records showing actual volumes. The average annual rainfall, 10.30 inches, falls predominantly from October through May. Due to the absence of extensive silting from freshwater streams, a minimum of maintenance dredging is required in the bay. The bottom of the bay is characterized by shells and small gravel. Naval facilities are located at a number of points around the harbor with the Submarine Base, fuel and ammunition piers and floating dry dock at Ballast Point on Point Loma.

Even though commercial fishing is prohibited in the bay, sport fishing is popular and is centered around the municipal fishing pier on Shelter Island. The bay is also a popular area for power boating and sailing. Agriculture is not present along the perimeter of the harbor.

The city of San Diego has an estimated population of 876,000 and the metropolitan area has a population approaching two million. San Diego's major industries are aircraft, shipbuilding and tuna fishing. Naval and marine installations provide employment for a large segment of the total work force. The water supply for the city of San Diego comes from a group of reservoirs in the mountainous area of the county and two aqueducts from the Colorado River.

Survey and Analytical Methods

Navy personnel helped the EERF survey team identify the most probable sampling locations, those where radioactivity associated with Naval nuclear propulsion plants, if it were present, would most likely be detected. Extensive sampling was conducted in the pier and dry dock areas of the Submarine Base and the U.S. Naval Station (32nd Street), while fewer samples were collected near the carrier and cruiser piers at North Island because of the smaller area and less frequent use of the site. These are areas where nuclear warships either had been serviced or were being serviced. Sampling locations are shown in Figures 2, 3, and 4. Samples of bottom sediment were collected at each location, while samples of water and aquatic life were taken at a few selected locations.

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

An underwater gamma scintillation probe with a 10-centimeter by 10-centimeter sodium iodide detector was used with a portable multichannel pulse height analyzer to help locate areas of radioactivity. All probe

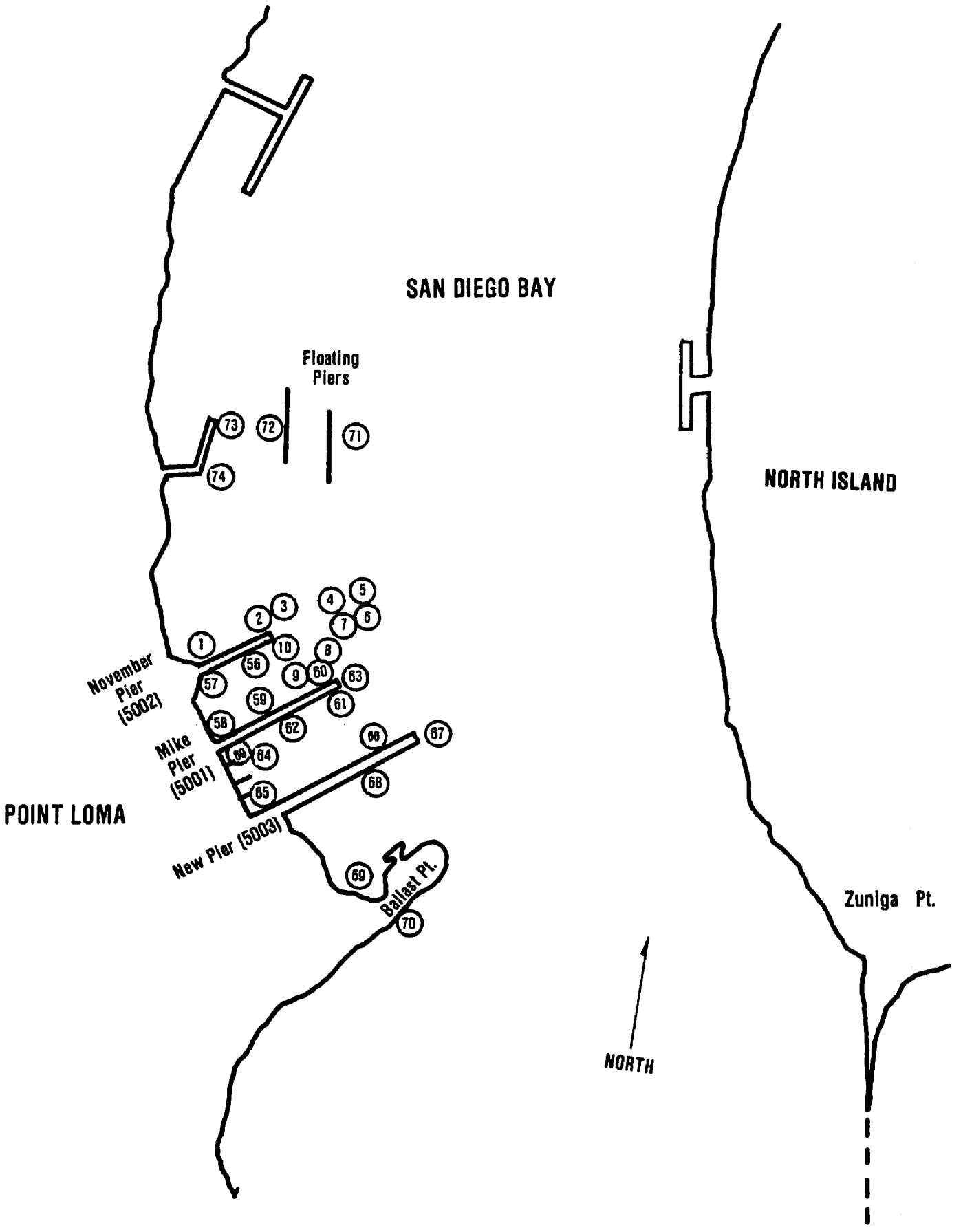


Figure 2. Sampling locations at the Submarine Base, Point Loma.

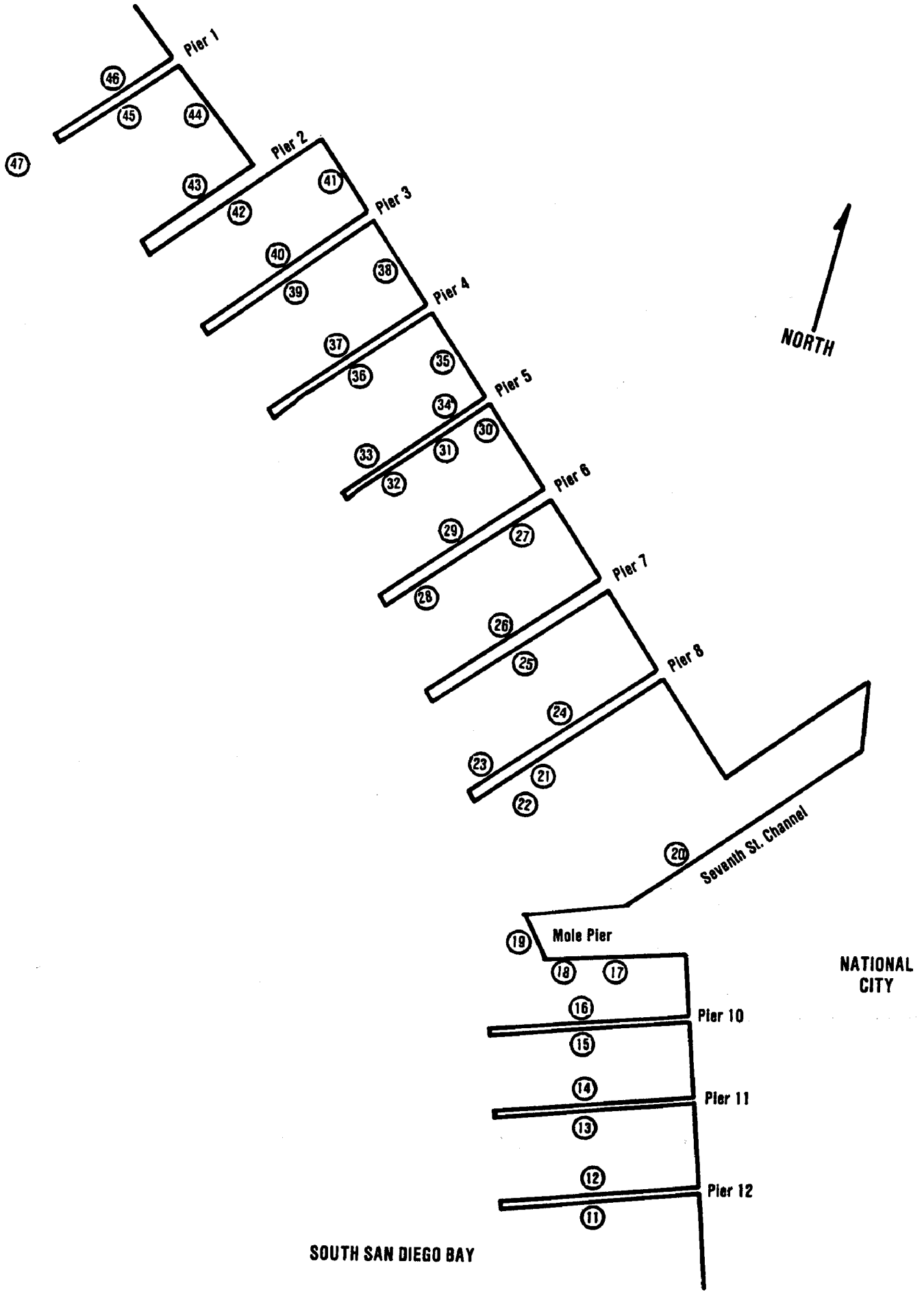


Figure 3. Sampling locations at the U.S. Naval Station - 32nd Street Pier.

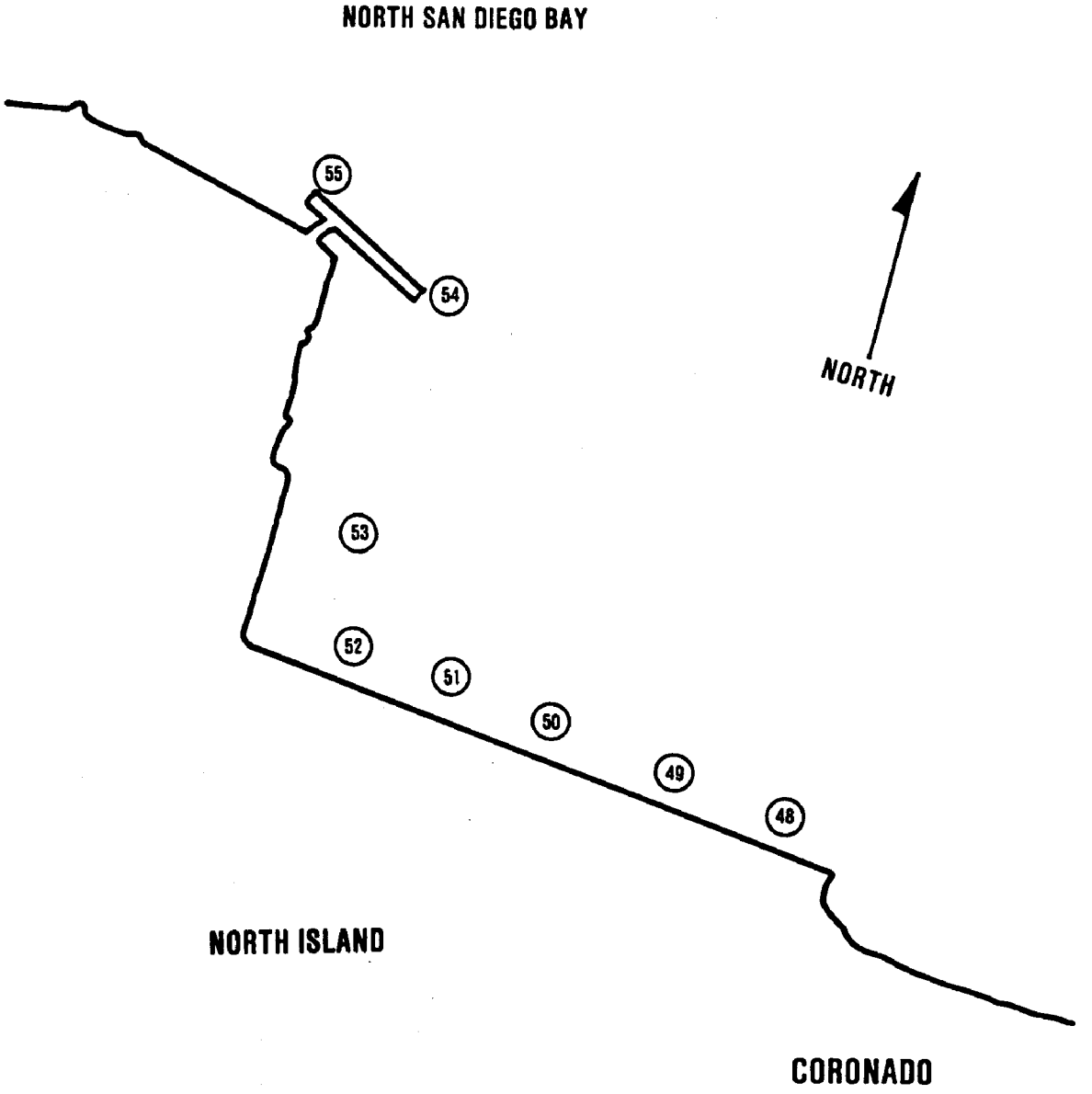


Figure 4. Sampling locations at the piers on North Island.

measurements were made for 10 minutes. The underwater probe has been useful in past surveys of other facilities to select areas for dredge sampling of bottom sediment and to delineate areas of radioactivity. However, due to the relatively low sensitivity (as compared to laboratory measurements) of the probe, sediment samples were collected for laboratory analysis at all locations of probe measurements. Duplicate samples were collected for quality assurance purposes at approximately 5 percent of the sites.

A standard Peterson dredge was used to sample approximately the top 10 centimeters of sediment. These sediment samples were collected at all locations shown in Figures 2, 3, and 4. At the laboratory these samples were dried, ground to a fine powder, placed in a 400 cm^3 sample counting container and counted on an intrinsic germanium detector for 1000 minutes. The minimum detectable activity for cobalt-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 materials were present from past operations which were subsequently covered with sediment, it might be observed in the core samples. Core samples were taken with a 3.8 centimeter diameter by 61 centimeter long plastic tube. A mechanical driver pushed the tube into the sediment and capped the ends. Core samples were collected at locations 10 and 62 at the Submarine Base (Fig. 2) and 51 at North Island (Fig. 4). At the laboratory the cores were frozen and cut into 2.5 cm sections. The

individual sections were freeze-dried and counted on an intrinsic germanium detector to determine the gamma-ray emitting radioisotopes. The minimum detectable activity for cobalt-60 in this geometry is approximately 0.1 pCi/g.

Surface water samples were collected from two locations, 1 and 10, at the Submarine Base and one sample each from the San Diego Naval Station and North Island sites, locations 36 and 53, respectively. In addition, two drinking water supplies were sampled. One sample was taken from the USS MCKEE at the Submarine Base and another at the Holiday Inn near the bay. The water samples were analyzed for gamma-ray emitters, especially cobalt-60, and for tritium. The minimum detectable activities for tritium and cobalt-60 in water are 200 pCi/L and 5 pCi/L, respectively, with the analysis procedures used.

Aquatic biota were collected only at the submarine base. One sample each of kelp, fish and algae were collected at locations 2, 10 and 70, respectively (see Fig. 2). At the laboratory the samples were cut into small pieces, dried in an oven at 110°C, and counted on an intrinsic germanium detector for 1000 minutes.

Gamma radiation measurements were made at each sampling location at the Submarine Base and the US Naval Station (32nd Street) using a high-pressure ionization chamber (PIC). Shoreline gamma radiation surveys were also conducted on Harbor Island, Shelter Island, on the sandy beach

opposite Shelter Island and on the beach near the Coast Guard Station at the north end of the Submarine Base. The shoreline surveys were made one meter above the ground using portable scintillation survey instruments that were periodically calibrated with a PIC. A summary of all samples collected from the three sites in San Diego Bay is presented in Table 1.

Table 1. A summary of samples collected from the three sites in San Diego Bay[a]

Facility	Sampling Sites	Number of Samples			
		Water	Sediment	Cores	Aquatic Life
Submarine Base	29	2	29	2	Kelp (1), algae (1), fish (1)
S.D. Naval Station	37	1	37	0	0
North Island	8	1	8	1	0

[a]Samples collected September 15-17, 1987. See Appendix 1 for a listing of all samples collected at each sampling site.

Results and Discussion

Harbor bottom sediment sampling was the most extensive since past surveys have shown that if radioactivity has been released it usually would be detected as cobalt-60 in the sediment (Ca77, Se88). Radionuclides tend to accumulate in the sediment over time which enables detection of events that may have occurred in the past. Samples were collected from 73 locations at the three sites. Small amounts of Co-60 were detected in eight sediment samples, seven from the Submarine Base and one from near the sea wall at North Island. All other radionuclides detected in the 73 sediment samples were either of natural origin or fallout from past nuclear weapons testing (see Table 2). The underwater gamma scintillation probe, operated on the harbor floor during sediment sample collection, did not reflect any areas of radioactivity above background.

The concentrations of Co-60 measured in the 8 sediment samples are listed in Table 3. These concentrations, ranging from about 0.02 to 0.05 pCi/g, are less than one percent of the total background radioactivity concentration of harbor sediment samples. These concentrations are also very small compared to the Co-60 concentrations measured in sediment samples from the Submarine Base during the 1967 survey. During the early survey, detectable concentrations of Co-60 in sediment ranged from about 17 pCi/g at the Sub Pier to 0.2 pCi/g off the tip of Ballast Point (Ca67). These concentrations were nearly three orders of magnitude greater than those measured during the current survey.

Table 2. Summary of natural and fallout radionuclide concentrations in sediment samples

Radionuclide	Submarine Base	Naval Station (32nd Street)	North Island
K-40	12 (9-15)	13 (11-15)	13 (11-15)
Cs-137	0.083 (0.02-0.15)	0.15 (0.02-0.41)	0.10 (0.04-0.17)
Pb-214	0.35 (0.17-0.49)	0.42 (0.28-0.58)	0.39 (0.29-0.50)
Bi-214	0.76 (0.31-1.28)	1.0 (0.57-1.29)	0.85 (0.55-1.14)
Th-232	0.30 (0.14-0.45)	0.45 (0.26-0.65)	0.35 (0.22-0.45)

Notes:

1) Concentrations are pCi/g dry weight.
2) Mean concentrations are given with the range shown in parentheses.
3) Approximate 2 sigma counting errors are: K-40 (3 percent); Cs-137 (13 percent); Pb-214 (6 percent); Bi-214 (7 percent); Th-232 (11 percent).

Table 3. Concentrations of Co-60 in harbor sediment samples

Site	Concentration, pCi/g dry	Site	Concentration, pCi/g dry
	Submarine Base		
3	0.022 ± 0.008	65	0.021 ± 0.009
58	0.047 ± 0.014	69	0.035 ± 0.009
59	0.027 ± 0.014	71	0.029 ± 0.010
64	0.015 ± 0.007		
	North Island		
53	0.030 ± 0.011		

These data indicate that little, if any, additional Co-60 has been recently deposited in the sediments. Radioactive decay during the period since the initial survey (19.4 years or 3.7 half-lives of Co-60) has accounted for much of the reduction in the Co-60 activity. Further reduction of the Co-60 was probably the result of additional sedimentation. Core samples, taken at locations 10 and 62 at the Submarine Base and 51 at North Island, did not coincide with any of the locations where Co-60 was detected in this current survey. Only naturally occurring radioactivity and traces of Cs-137 from nuclear weapons fallout were observed in the core samples.

Surface water samples collected from the three sites, two at the Submarine Base (location Nos. 1 and 10) and one each at the San Diego Naval Station (location No. 36) and North Island (location No. 53), had tritium levels below the minimum detectable level of 200 pCi/L. Only naturally occurring radionuclides were measured in these samples, primarily K-40 with an average concentration of 330 ± 20 pCi/L. Also, no detectable radioactivity was found in either of the drinking water samples collected near the bay.

Only trace quantities of naturally occurring radionuclides were detected in the three samples of aquatic life that were collected from the harbor at the Submarine Base. The Cs-137 concentrations were less than 0.05 pCi/g dry weight in all samples. Naturally occurring potassium-40, the primary radionuclide measured, ranged from 82 pCi/g dry weight in the kelp to 15 and 11 pCi/g dry weight in the fish and algae samples, respectively.

Gamma-ray exposure rate measurements were made at the sampling locations at the Submarine Base and the San Diego Naval Station (32nd Street). No measurements were made at the North Island Naval Air Station because of the low utilization of this facility, making it unlikely that levels above background would be detected. A summary of the gamma-ray exposure rate measurements is given in Table 4. Exposure rates ranged between 3.5 and 5.2 μR/hr, averaging 4.1 μR/hr at both sites. Also, gamma-ray exposure rates were continuously measured while moving south at 3-4 knots from Pier 1 to Pier 12 at the San Diego Naval Station. The measurements during the traversal survey varied from 3.3 to 4.8 μR/hr. All exposure rate measurements resemble background levels.

Table 4. A summary of the gamma-ray exposure rate measurements

Location of Survey[b]	No. of Measurements	Gamma-Ray Exposure Rates, μR/hr	
		Average[a]	Range
Submarine Base	26	4.1 ± 0.3	3.6 - 4.8
San Diego Naval Station			
Sampling locations	37	4.1 ± 0.5	3.5 - 5.2
Mobile survey	--	~ 3.8	3.3 - 4.8
North Island	0	--	--

[a] ± values are the standard deviation of the means.
[b] These results do not include shoreline survey results.

Shoreline gamma-ray exposure surveys were conducted on Harbor Island, Shelter Island and along the sandy shoreline of the mainland opposite Shelter Island (see Fig. 1). The shoreline gamma-ray exposure rates varied between 5 and 7 μR/hr. Four to 6 μR/hr exposure rates were observed along the beach near the Coast Guard Station at the north end of the Submarine Base. These exposure rates show no evidence that contamination exists along shorelines near the sites.

Conclusions

A radiological survey of three sites in San Diego Bay provided the basis for the following conclusions:

1. Small quantities of Co-60 (0.02-0.05 pCi/g) are present in the bottom sediments in some areas of the harbor at the Submarine Base. Most, if not all, of the Co-60 contamination present probably originated prior to the earlier 1967 survey that reported Co-60 levels as much as 300 times larger than those observed in this study. The highest Co-60 concentration measured is now less than one percent of the normal background radioactivity in harbor sediment samples.

2. No tritium or gamma-ray emitters, other than trace amounts of those occurring naturally, were detected in surface water from the dock areas or in nearby drinking water supplies.

3. Only radionuclides of natural origin and trace amounts of Cs-137 from fallout of previous nuclear weapons tests were detected in samples of kelp, algae, and fish taken from the harbor at the Submarine Base.

4. Gamma-ray surveys of the harbors near the docking areas and along shorelines and beaches near the shipyards failed to detect any exposure rates above background.

5. Based on this survey, operations related to nuclear-powered warship activities have contributed no increases in radioactivity to the harbors in San Diego Bay that would result in significant population exposure or contamination of the environment. Thus, under present conditions Naval operations within San Diego Bay pose no radiological health problems to the public.

References

Ca67 Cahill, D.F., McCurry, D.C., and Breakfield, W.D., 1967, "Radiological Survey of Major California Nuclear Ports-April 1967", U.S. Public Health Service, Southeastern Environmental Radiological Health Laboratory Report, PB-178-728.

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

Se88 Sensintaffar, E.L. and Blanchard, R.L., 1988, "Radiological Survey of the Norfolk Naval Station, the Norfolk Naval Shipyard, and Newport News Shipbuilding", U.S. Environmental Protection Agency Report, EPA 520/5-88-017.

APPENDIX 1

Description of Samples Collected

Sampling Site No.	Samples Collected	Sampling Site No.	Samples Collected
	Submarine Base, Point Loma		
1	Sediment, surface water	60	Sediment
2	Sediment, kelp	61	Sediment
3	Sediment	62	Sediment, core
4	Sediment	63	Sediment
5	Sediment	64	Sediment
6	Sediment	65	Sediment
7	Sediment	66	Sediment
8	Sediment	67	Sediment
9	Sediment	68	Sediment
10	Sediment, core, surface water, fish	69	Sediment
		70	Sediment, algae
56	Sediment	71	Sediment
57	Sediment	72	Sediment
58	Sediment	73	Sediment
59	Sediment	74	Sediment
	North Island		
48	Sediment	52	Sediment
49	Sediment	53	Sediment, surface water
50	Sediment	54	Sediment
51	Sediment, core	55	Sediment
	South San Diego Bay		
11	Sediment	30	Sediment
12	Sediment	31	Sediment
13	Sediment	32	Sediment
14	Sediment	33	Sediment
15	Sediment	34	Sediment
16	Sediment	35	Sediment
17	Sediment	36	Sediment, surface water
18	Sediment	37	Sediment
19	Sediment	38	Sediment
20	Sediment	39	Sediment
21	Sediment	40	Sediment
22	Sediment	41	Sediment
23	Sediment	42	Sediment
24	Sediment	43	Sediment
25	Sediment	44	Sediment
26	Sediment	45	Sediment
27	Sediment	46	Sediment
28	Sediment	47	Sediment
29	Sediment		