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U.S. NAVY REPORT
OF ENVIRONMENTAL MONITORING IN
SASEBO, YOKOSUKA, AND NAKAGUSUKU WAN, JAPAN
FOR RADIOACTIVITY ASSOCIATED WITH
NAVAL NUCLEAR PROPULSION PLANTS
2007



NAVAL NUCLEAR PROPULSION PROGRAM
DEPARTMENT OF THE NAVY
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INTRODUCTION

The policy of the U.S. Navy is to reduce to the minimum practicable the amounts of radioactivity released from naval nuclear-powered ships, particularly within twelve miles from shore, including into harbors. Consistent with that policy, the total amount of gamma radioactivity released within all U.S. and foreign harbors visited by nuclear-powered ships in the U.S. Navy was less than 0.002 curie¹ in 2007. This amount of radioactivity is too small to have had any discernable effect on the radioactivity of any harbor environment. However, to provide additional assurance that procedures used by the U.S. Navy to control radioactivity are adequate to protect the environment, the Navy conducts periodic radiological environmental monitoring surveys. This report summarizes the results of environmental monitoring in the harbors of Sasebo and Yokosuka, and in Nakagusuku Wan on Okinawa Island.

The Navy environmental monitoring program consists of analyzing samples of harbor water, sediment, and marine life. Sampling harbor water and sediment each quarter year is emphasized since these materials would be the most likely affected by releases of radioactivity. The environmental samples are analyzed by a laboratory of the U.S. Department of Energy for cobalt-60 and other gamma emitting radionuclides. These environmental media are analyzed since they are the ones that would most likely reveal any changes in radioactivity concentrations due to nuclear-powered ship operations. Cobalt-60 is specifically analyzed because it is a sensitive tracer used to follow environmental distribution of radioactivity and it is the predominant long-lived radionuclide associated with liquid effluents from U.S. naval nuclear-powered ship operations. Results of this monitoring show that radioactivity in the harbor environment has not increased above natural background levels as a result of operations by U.S. naval nuclear-powered ships. These results also confirm that procedures used by the Navy to control radioactivity are effective in protecting the environment and the health and safety of the general public.

¹ One curie equals 3.7×10^{10} becquerels.

HARBOR WATER SAMPLES

Harbor water samples are taken once each quarter year in Sasebo, Yokosuka, and Nakagusuku Wan in areas where nuclear-powered ships berth and from upstream and downstream locations. A germanium detector with a multichannel analyzer is used to measure the gamma radioactivity of the samples and to detect the presence of cobalt-60. Procedures for analysis will detect cobalt-60 if its concentration exceeds the EPA drinking water limits ($3.7 \text{ becquerel per liter}^2$), which is more than a factor of 25 lower than the drinking water standard set by the World Health Organization ($100 \text{ becquerel per liter}$). No cobalt-60 was detected in any of the quarterly water samples collected. The harbor water sample locations are shown in Figures 1, 2, and 3.

On September 27, 2006, the Government of Japan reported the detection of radioactivity in a harbor water sample drawn by the Government of Japan in Yokosuka Harbor as USS HONOLULU (SSN 718) was departing. The U.S. Navy responded quickly to questions from the Government of Japan about this detection. Of five harbor water samples and five sediment samples, only one harbor water sample contained detectable cobalt-60 and cobalt-58 activity (1.2×10^{-3} and 2.1×10^{-3} becquerel per liter, respectively). For perspective, the reported concentration of radioactivity is about 5,000 times less than the naturally occurring radioactivity found in seawater and 30,000 times less than levels of cobalt-60 and cobalt-58 allowed by the World Health Organization for clean drinking water. HONOLULU's Commanding Officer reported that no accidental events occurred which could have caused such a discharge. An independent U.S. Navy expert, technically trained in U.S. nuclear-powered warship technology and outside of USS HONOLULU's chain of command inspected the submarine. This inspection included a detailed review of applicable ship's documents and confirmed the Commanding Officer's report.

Senior U.S. Navy experts traveled to Japan to meet with Government of Japan officials within four days of the reported detection. In these meetings, the U.S. Navy discussed the results of the U.S. Navy's assessment of the detection and provided full disclosure of all relevant facts and data necessary to understand the appropriate perspective on this detection. The Government of Japan determined that the reported detection had no discernable effect on the environment and that it will not effect continued U.S. nuclear-powered warship visits to Japan.

² One becquerel per liter equals 2.7×10^{-8} microcurie per milliliter.

HARBOR SEDIMENT SAMPLES

Sediment samples are obtained once each quarter year in Sasebo, Yokosuka, and Nakagusuku Wan from select locations including U.S. nuclear-powered ship berthing locations and areas away from these berthing locations. This frequency is adequate to monitor nuclear-powered ship operations since the predominant associated radionuclide, cobalt-60, has a half-life slightly in excess of five years, and will not appreciably decay between surveys. The harbor sediment sample locations are shown in Figures 1, 2, and 3. The samples are collected with a six inch square Birge-Ekman dredge (grapple type sampler) modified to collect only the top one-half to one inch of sediment. This layer was selected because it should be more mobile and more accessible to marine life than deeper layers. The dredge samples are analyzed for gamma radioactivity, including cobalt-60 and other non-naturally occurring radionuclides using a germanium detector with a multichannel analyzer. The dredge samples are not dried prior to analysis, but are drained of excess water. Results from the dredge samples are summarized in Table 1. A range is shown since samples from different locations show some variation.

Results of these analyses show that the most predominant gamma emitting radionuclides are naturally occurring potassium-40 and daughters of uranium and thorium. Cesium-137 was detected in some sediment samples from Sasebo, Yokosuka, and Nakagusuku Wan. The cesium-137 detected is not related to U.S. naval nuclear reactor operations because the high integrity naval fuel retains all related fission products. The cesium-137 concentrations measured in the sediment are due to worldwide dispersion from weapons testing and are similar to those found in many parts of the world. All Sasebo, Yokosuka, and Nakagusuku Wan samples analyzed contained no detectable cobalt-60.

TABLE 1
RESULTS OF HARBOR SEDIMENT SAMPLES

SASEBO HARBOR

Quarter	Number of Samples	Number of Samples with Detectable Co-60	Range of Co-60 Analytical Results (Bq/kg)	Range of Other Non-Naturally Occurring Radionuclides (Bq/kg)
1 st	7	0	<0.560 – <0.624	Cs-137: 0.744 – 1.418
2 nd	17	0	<0.992 – <1.411	Cs-137: 0.842 – 1.289
3 rd	17	0	<0.901 – <1.202	Cs-137: 0.571 – 1.507
4 th	17	0	<0.881 – <1.151	Cs-137: 0.666 – 1.405

NAKAGUSUKU WAN

Quarter	Number of Samples	Number of Samples with Detectable Co-60	Range of Co-60 Analytical Results (Bq/kg)	Range of Other Non-Naturally Occurring Radionuclides (Bq/kg)
1 st	5	0	<0.351 – <0.468	Cs-137: 0.243 – 0.388
2 nd	12	0	<0.545 – <0.810	None
3 rd	12	0	<0.475 – <0.877	None
4 th	12	0	<0.468 – <0.900	None

Notes:

- (1) Results with a "<" symbol contained less than the minimum detectable activity. The minimum detectable activity may differ from sample to sample or quarter to quarter due to differences in the amount of naturally occurring radioactivity in each sample, differences in detection equipment, statistical fluctuations and variations in sample size.
- (2) Values given as "<X - <Y" reflect the range of minimum detectable activities measured for individual samples.
- (3) One becquerel per kilogram (Bq/kg) equals 0.027 picocurie per gram.

TABLE 1
RESULTS OF HARBOR SEDIMENT SAMPLES - CONTINUED

YOKOSUKA HARBOR

Quarter	Number of Samples	Number of Samples with Detectable Co-60	Range of Co-60 Analytical Results (Bq/kg)	Range of Other Non-Naturally Occurring Radionuclides (Bq/kg)
1 st	6	0	<0.453 – <0.535	Cs-137: 0.392 – 0.775
2 nd	16	0	<0.656 – <0.986	Cs-137: 0.544 – 0.992
3 rd	16	0	<0.719 – <1.242	Cs-137: 0.791 – 0.796
4 th	16	0	<0.693 – <1.056	Cs-137: 0.468 – 0.983

Notes:

- (1) Results with a "<" symbol contained less than the minimum detectable activity. The minimum detectable activity may differ from sample to sample or quarter to quarter due to differences in the amount of naturally occurring radioactivity in each sample, differences in detection equipment, statistical fluctuations and variations in sample size.
- (2) Values given as "<X - <Y" reflect the range of minimum detectable activities measured for individual samples.
- (3) One becquerel per kilogram (Bq/kg) equals 0.027 picocurie per gram.

MARINE LIFE SAMPLES

An evaluation by the U.S. Environmental Protection Agency shows that the cobalt-60 from naval nuclear propulsion plants is in the form of metallic corrosion product particles which do not appear to be concentrated in the food chain. However, samples of marine life such as mollusks, crustaceans, and marine plants were collected from the harbors in 2007. Marine life samples were also analyzed using a germanium detector with a multichannel analyzer. The results of these analyses are shown in Table 2. No cobalt-60 has been detected in these samples of marine life.

TABLE 2
RESULTS OF MARINE LIFE SAMPLES

SASEBO HARBOR

Sample Type	Co-60 Analytical Results (Bq/kg)	Other Non-Naturally Occurring Radionuclides (Bq/kg)
Mollusk	<0.837	None
Crustacean	<0.571	None
Plant	<0.860	None

NAKAGUSUKU WAN

Sample Type	Co-60 Analytical Results (Bq/kg)	Other Non-Naturally Occurring Radionuclides (Bq/kg)
Mollusk	<0.658	None
Crustacean	N/A	N/A
Plant	<0.861	None

YOKOSUKA HARBOR

Sample Type	Co-60 Analytical Results (Bq/kg)	Other Non-Naturally Occurring Radionuclides (Bq/kg)
Mollusk	<0.397	None
Crustacean	N/A	N/A
Plant	N/A	N/A

Notes:

- (1) Results with a "<" symbol contained less than the minimum detectable activity. The minimum detectable activity may differ from sample to sample or quarter to quarter due to differences in the amount of naturally occurring radioactivity in each sample, differences in detection equipment, statistical fluctuations and variations in sample size.
- (2) N/A = Not Available. Marine life samples of the specified type were not available for collection.
- (3) One becquerel per kilogram (Bq/kg) equals 0.027 picocurie per gram.

CONCLUSION

The results of this environmental monitoring show that there has been no increase in radioactivity above natural background levels in the Sasebo, Yokosuka, and Nakagusuku Wan environment as a result of U.S. naval nuclear-powered ship operations. These results confirm that procedures used by the U.S. Navy to control radioactivity are effective in protecting the environment and the health and safety of the general public.

Figure 1

Environmental Monitoring
Survey Chart

Sasebo Harbor, Japan

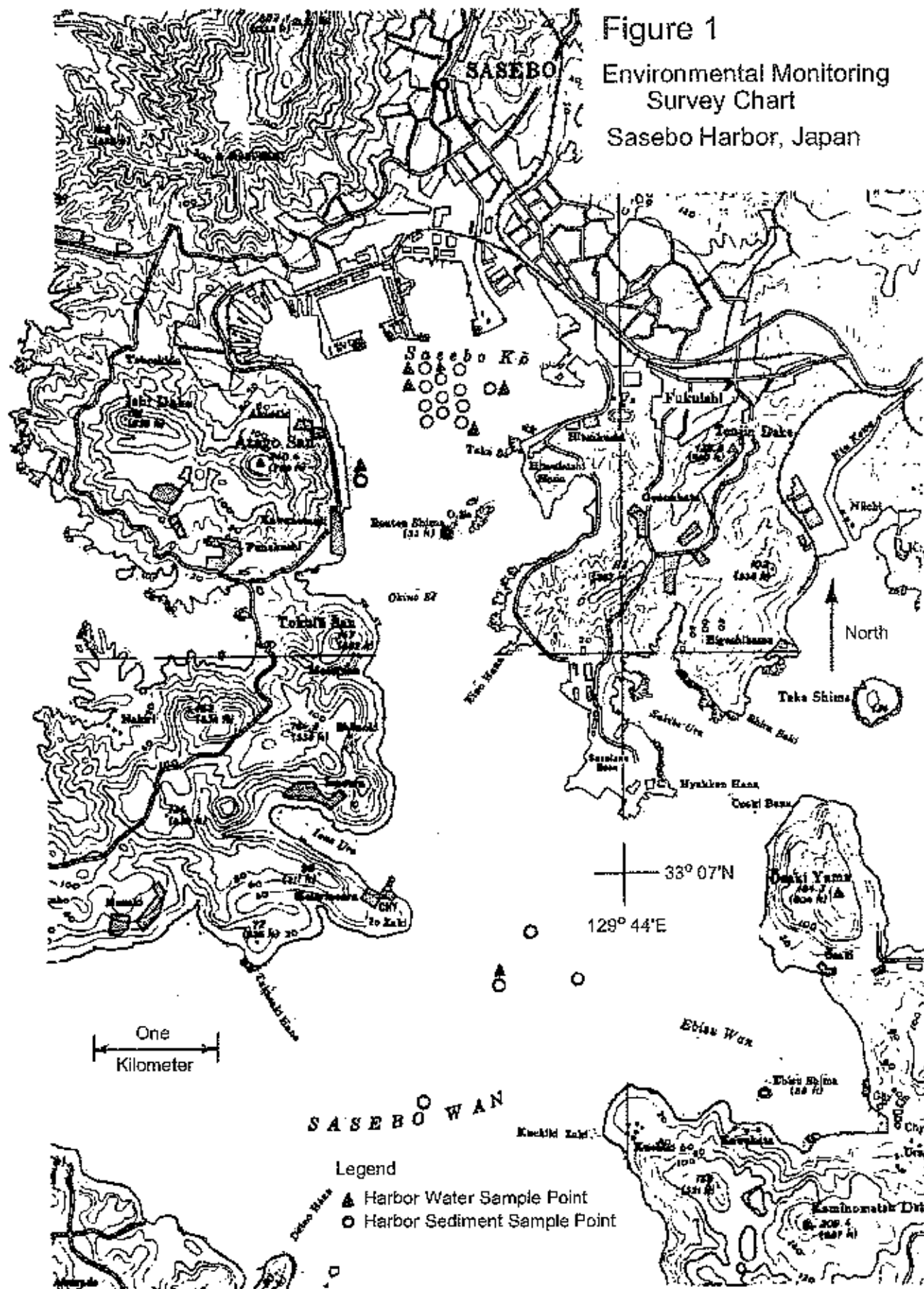
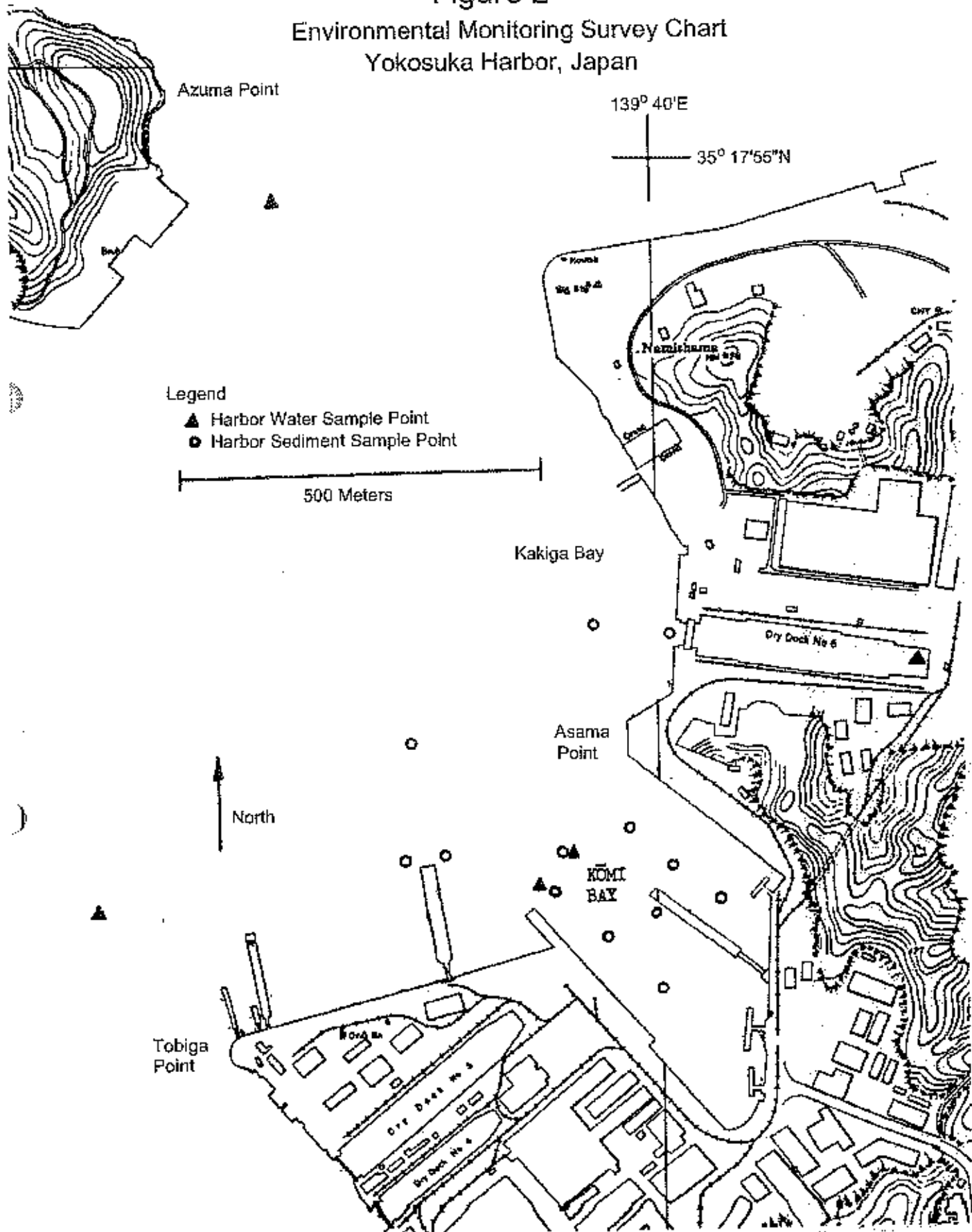


Figure 2

Environmental Monitoring Survey Chart
Yokosuka Harbor, Japan



Three additional sediment and one additional water sampling sites are not shown. These sites are located approximately two thousand yards northeast of the harbor where ships sometimes anchor off shore.

Figure 3
Environmental Monitoring Survey Chart
Nakagusuku Wan, Okinawa Island

