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MERCURY DISTRIBUTION IN ANCIENT AND MODERN SEDIMENT OF NORTHEASTERN BERING SEA

By

C. Hans Nelson, David E. Pierce, Kam W. Leong, and Frank F. H. Wang

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Contents

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Abstract

A reconnaissance of surface and subsurface sediments to a maximum depth of 244 feet below the sea floor shows that natural mercury anomalies from 0.2 to 1.3 ppm have been present in northeastern Bering Sea since early Pliocene. The anomalies and mean values are highest in modern beach (maximum 1.3 and mean 0.22 ppm Hg) and nearshore subsurface gravels (maximum 0.6 and mean .06 ppm Hg) along the highly mineralized Seward Peninsula and in organic rich silt (maximum 0.16 and mean 0.10 ppm Hg) throughout the region; the mean values are lowest in offshore sands (0.03 ppm Hg). Although gold mining may be partially responsible for high mercury levels in the beaches near Nome, Alaska, equally high or greater concentrations of mercury occur in ancient glacial sediments immediately offshore (0.6 ppm) and in modern unpolluted beach sediments at Bluff (0.45 - 1.3 ppm); this indicates that the contamination effects of mining may be no greater than natural concentration processes in the Seward Peninsula region. The background content of mercury (0.03) throughout the central area of northeastern Bering Sea is similar to that elsewhere in the world. The low mean values (0.04 ppm) even immediately offshore from mercury-rich beaches, suggests that in the surface sediments of northeastern Bering Sea, the highest concentrations are limited to the beaches near mercury sources; occasionally, however, low mercury anomalies occur offshore in glacial drift derived from mercury source regions of Chukotka and Seward Peninsula and reworked by Pleistocene

shoreline processes. The minimal values offshore may be attributable to beach entrapment of heavy minerals containing mercury and/or dilution effects of modern sedimentation.

Introduction

Recent recognition that inorganic mercury in aquatic environments may enter the food chain (Wood and others, 1968) and may eventually concentrate in human tissue (Ackefors, 1971) makes it important to evaluate the concentrations of mercury contained in the sediments of the continental shelves. The distribution of mercury in marine sediments is not well known (Klein and Goldberg, 1971; U.S. Geological Survey, 1970) nor are the processes or rates of removal from the sediment. A first step in evaluating this potential hazard to man is to establish the level of mercury deposited in sediment by natural processes as opposed to artificial. Defining these concentrations in an area of low population density and minimal industrial activity provides a reference point for studies in developed areas where mercury pollution already exists in rivers (de Groot and others, 1971), lakes (Kennedy and others, 1971), and estuaries (McCulloch and others, 1971).

This report presents data on mercury in surface and subsurface sediment of a large area of shelf (fig. 1). Natural mercury deposits occur locally in this region (Herreid, 1965; Cobb, 1970; Sainsbury, 1970) and mercury was also introduced by mining activities; therefore, the amount of mercury distributed by natural processes can be compared to that introduced by man. By analyzing ancient sediments as old as Pliocene that lie 244 feet below the sea floor off Nome, the mercury distribution can be established over a period of several million years and the relative effects of recent mining contamination can be evaluated.

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Methods of Investigation

Samples of varying sediments (fig. 2) were collected on the Bering shelf by Van Veen grab samplers, box corers, and placer drills; in selected locations modern beach sediments were channel sampled in the swash, foreshore, and backshore zones (Appendix I). The grab and box corer devices both sampled an area approximately 20 by 30 cm; the grab sampler usually penetrated about 10 cm and the box corer about 30 cm. Box cores were divided into surface 1 mm, surface 0-10 cm, and subsurface 10-45 cm samples. Some of the box cores penetrated older glacial or shoreline deposits. Certain drill holes extended through the Pleistocene deposits and into marine sediments that ranged to early Pliocene age at 244 feet below the sea floor (Nelson and Hopkins, 1972). Subsamples of consolidated cuttings from each six foot increment of the three inch diameter drill holes were analyzed.

The sediment was air dried and gently ground by a hand mortar and pestle in order to volatilize mercury as little as possible. Mercury content was then determined (Appendix I) by an atomic absorption technique, a method in which the precision is ± 5% or better (Vaughn and McCarthy, 1964). The limit of detection was 0.01 ppm using 0.2 gram samples. The average mercury concentrations are reported for samples with more than one analysis.

Two factors were found that affected the accuracy of measurement of the mercury content; these were particle sparsity effect and combustion of large fragments of organic matter during analysis. Smoke from the burning of a large quantity of organic debris generally deflects the meter off scale on the mercury detector and of course gives erroneously high readings; in three cases it appears that less conspicuous meter deflections from this cause were not detected. Particle sparsity effect results when the analysis for a component such as cinnabar, based on a small split of unprocessed sample, depends more upon the chance occurrence of particles in the analytical portion than upon the actual concentration within the sample (Clifton and others, 1969).

To test for the aforementioned inaccuracies, duplicate splits were run on 30 samples and five splits were analyzed for each of five sample stations where duplicate splits indicated a significant difference. All replicate splits of samples greater than 40 kilometers from the coast and eighty percent of those within 40 kilometers of the shoreline deviate no more than 0.02 ppm mercury from sample mean values ranging from 0.01 to

0.08 ppm. From samples taken less than 40 kilometers from the shore, the greatest variance in replicate splits is 0.27 ppm mercury for a sample with a mean of 0.09 ppm; this and two other stations with maximum deviations of 0.2 ppm Hg from means of 0.08 ppm (see 252HI in Table 1) are the only instances where split values deviated more than 0.10 ppm from the mean value of a sample. Sample 252HI in Table 1 is typical of the three samples with maximum deviations; all show inconsistent and markedly decreasing mercury values with increasing time between date of analysis. This differing and declining mercury content with time, in addition to smoke detected in later analyses, suggests that abnormally large contents of organic material affected the original analyses of the three samples. Sample 235T in Table 1 is representative of the maximum differences attributable to particle sparsity effects from particulate mineral grains of non-organic origin. This and the few other such samples with deviations as much as 0.10 ppm generally occur in nearshore ancient and modern beach sands and gravels, particularly near Nome.

It is concluded that no particle sparsity effects are indicated for samples greater than 40 kilometers from shore. Particle sparsity effects are progressively greater toward the shoreline of Seward Peninsula; however, because values generally range from 0.1 to 1.3 ppm mercury in these beaches (fig. 1) and deviation from particle sparsity is 0.10 ppm or less, the relative percent of inaccuracy of analyses is low. Consequently, the patterns of similar values (fig. 1) do appear to be representative even though particle sparsity is a minor sampling problem and large organic fragments apparently disrupted analyses of three sample splits.

Table 1.--Mercury values in replicate splits of different sample types. (Sample 252HI, a limnetic peaty clay, exemplifies organic disruption of the analytical instrument, sample 235T, a relict gravel shows particle sparsity of a nearshore sample; and sample 241B, a silty sand, shows variability of a typical sample.)

Split	Analysis Date	Number of Sample and Mercury Value in ppm 252HI	235T	241B
A	4/6/71	0.28	0.25	0.03
B	9/10/71	0.08		
C	4/29/72	0.01	0.16	0.01
D	4/29/72	0.03	0.11	0.01
E	4/29/72	0.01	0.12	0.02
F	4/29/72	0.03	0.13	0.02
Mean Value		0.07	0.15	0.02
Maximum Deviation From Mean		0.21	0.10	0.01
Average Deviation From Mean		0.10	0.05	0.006

Mercury Distribution

The median, mean, and mode values all equal 0.03 ppm mercury for the 237 samples from the northeastern Bering Sea (fig. 3, Table 2). These average values from Bering Sea are comparable to those for unconsolidated and presumably uncontaminated aquatic sediments in the few, but widely ranging locations elsewhere that have been investigated

(Table 3). Nearly 90 percent of the values are less than 0.10 ppm mercury and the range from less than 0.01 to 0.1 ppm mercury appears to represent normal values for this region.

With few exceptions, intermediate values between 0.11 and 0.2 ppm mercury occur in either fine-grained sediments with a relatively high organic content or in buried subaerial sediments that often contain peat from relict soils. These values lie well within the expected range of Hg content associated with fine grained sediments (de Groot, 1971), modern soils (Shacklette and others, 1971), and organic rich sediments (Kennedy and others, 1971).

Values greater than 0.2 ppm mercury from any sediment and greater than 0.1 ppm mercury from sediments low in organic content probably result from concentrations of particulate minerals containing mercury, such as cinnabar. An analysis by the U.S. Bureau of Mines (1967) of a heavy mineral concentrate from Bluff Beach shows 4 percent cinnabar and confirms the presence of such minerals.

All values greater than 0.2 ppm mercury occur within 40 kilometers of the shoreline and the highest contents (0.45 to 1.3 ppm) occur in the modern beach sediments along southern Seward Peninsula (Table 2). Although mean values (0.04 ppm) of nearshore sediments within 20 km of the shoreline of Seward Peninsula (fig. 4) are slightly higher than values (0.02 ppm) greater than 20 kilometers from the shoreline, all offshore values beyond the shoreline are nearly a factor of ten lower than the Seward Peninsula beaches. Generally high, but normal mean

Table 2.--Comparative values of mercury content in surface and subsurface sediments of different regions in northeastern Bering Sea.

Sample Group	Number of Samples	Value in ppm Mean	Median	Range of 70% Values	Total Range Max.	Min.
Beaches						
C. P. Wales (Seward Peninsula)	11	0.17	0.09	0.07-0.14	0.96	0.05
Nome (Seward Peninsula)	16	0.12	0.10	0.04-0.14	0.45	0.03
Bluff (Seward Peninsula)	4	0.61	0.45	0.25-0.45	1.30	0.25
Stuart Island	4	0.06	0.06	0.05-0.07	0.08	0.04
St. Matthew Island	2	0.06	0.06	0.06	0.06	0.06
St. Lawrence Island	7	0.08	0.06	0.06-0.08	0.04	0.18
Surface Sediment Offshore Beyond the Shoreline						
All areas surface 1 mm	20	0.06	0.04	0.02-0.14	0.23	0.01
Surface 0-10 cm						
<40 km from shoreline	83	0.04	0.03	0.01-0.08	0.23	<0.01
>40 km from shoreline	17	0.03	0.02	0.01-0.06	0.07	<0.01
<20 km Wales shoreline	3	0.04	0.03	0.03	0.06	0.03
<20 km Nome shoreline	10	0.04	0.03	0.01-0.06	0.15	<0.01
<20 km Bluff shoreline	8	0.03	0.03	0.02-0.04	0.09	0.01
<40 km from shoreline of St. Lawrence Island	29	0.04	0.03	0.01-0.07	0.23	<0.01
<20 km from shoreline of St. Matthew Island	19	0.03	0.02	0.01-0.05	0.07	<0.01
Subsurface Sediment Offshore Beyond the Shoreline						
Box Cores						
-10 to 30 cm <40 km shoreline	24	0.04	0.03	0.01-0.09	0.16	<0.01
-10 to 30 cm >40 km shoreline	4	0.03	0.03	0.03	0.04	0.01
-10 to 30 cm <20 km Nome "	4	0.04	0.02	0.01-0.03	0.09	0.01
Nome Drill Holes	29	0.06	0.04	0.02-0.06	0.60	0.01
Sediment Type (Surface Sediments)						
Beach sand and gravel	26	0.22	0.10	0.05-0.45	1.30	0.03
Relict offshore gravel	25	0.05	0.03	0.01-0.06	0.25	<0.01
Relict offshore pebbly sand	28	0.03	0.02	0.01-0.06	0.11	<0.01
Relict offshore fine sand	15	0.03	0.02	0.01-0.06	0.07	<0.01
Modern or Holocene silt	29	0.06	0.03	0.02-0.09	0.16	<0.01
Organic rich clayey silt	8	0.10	0.15	0.05-0.16	0.16	<0.01
Submerged Beaches off Seward Peninsula						
-11 to -13 m	5	0.03	0.03	<0.01-0.03	0.07	<0.01
-16 to -18 m	3	0.05	0.04	0.02-0.04	0.09	0.02
-20 to -22 m	11	0.03	0.02	0.01-0.03	0.15	<0.01
-36 to -40 m	3	0.06	0.08	0.03-0.08	0.08	0.03
Total NE Bering Sea Samples	237	0.03	0.03	0.01-0.08	1.30	<0.01

values of mercury (0.03 to 0.08, Table 2, fig. 4) are found in the beach and nearshore sediments of Stuart, St. Matthew, and St. Lawrence Islands which contain no known mercury deposits.

Like surface sediments, the mercury content in subsurface sediments suggests that average values (0.04 ppm) are slightly higher less than 40 kilometers from the shoreline than are average values (0.025 ppm) more than 40 kilometers from the shoreline (Table 2). The highest mean values occur in the nearshore subsurface sediments off Seward Peninsula, particularly in drill holes (fig. 4) off Nome (0.06 ppm). Drill holes within 3 miles of Nome penetrated Illinoian glacial drift (Nelson and Hopkins, 1972) that contained up to 0.6 ppm mercury and Pliocene marine silts more than 200 feet below the sea floor that contained up to 0.15 ppm mercury.

Discussion

Mercury is consistently abundant in altered zones of Seward Peninsula metamorphic rocks (Sainsbury and others, 1970). For example, rocks from the many fault zones of Seward Peninsula commonly contain up to several parts per million mercury (Table 3). One such fault zone occurs several miles east of the beach on Cape Prince of Wales (Sainsbury, oral commun., 1971) where a high level (0.96 ppm) of mercury was found. Elsewhere, local cinnabar deposits constitute potential sources (Cobb, 1970) for mercury (fig. 2). One of these is located in the present beach cliff several miles east of the location of high mercury levels (1.3 - 0.45 ppm Hg) on Bluff Beach. The high values

Table 3.--Mercury content (ppm) of source rocks and unconsolidated sediments in Bering Sea other areas.

Representative Areas	Reference Source	Range Max	Range Min	Average Background Level
Average Sedimentary Rock	Vinogradov, 1959			.04
U.S. Soils	Shacklette & others, 1971	1.5	.01	.071
Lake Michigan	Kennedy & others, 1971	0.4	.02	.03 - .06
Rhine River	De Groot & others, 1971	23.3		
Em River	De Groot & others, 1971	3.3	.25	.75
San Francisco Bay	McCulloch & others, 1971	6.0	<.01	.35
Gulf of California	Bischoff, oral comm., 1972	.35	.01	.01 - .1
Pacific Manganese Nodules	Mero, 1965, p. 181			2.0
Bering Sea Area				
Seward Peninsula	Sainsbury & others, 1970			
Unaltered Rocks		.04	.01	.03
Altered Rocks		10.0	<.01	.1
Streams		.18	<.01	.08
Southwest Alaska Streams	Clark & others, 1970a, 1970b, 1971	20.0	.01	.2 - .5
Goodnews Bay	Barnes, oral comm., 1972	.70	<.01	.03
Northern Bering Shelf	This report	1.3	<.01	.03
Central Bering Shelf	This report	.07	<.01	.03
Chukchi Sea	Barnes & Leong, 1971	.04	<.01	.02

(0.2 - 0.6 ppm) found in Illinoian glacial drift, buried offshore from Nome, apparently were derived from material that was eroded from mineralized zones (Sainsbury and others, 1970) inland from the Nome beaches. Similarly, the area of high mercury content (0.10 - 0.25 ppm) that is found about 40 km west from St. Lawrence Island (figs. 1 and 2) occurs in relict gravels of glacial drift derived from mineralized areas in Chukotka (USSR Metalliferous Zones Map, 1967).

The high level of mercury (0.14 - 0.45 ppm) in the modern Nome beach sand may originate either from glacial drift sources or from the extensive gold mining in the early 1900's. Metallic mercury was used for amalgamating the gold from the beach placers and it can still be panned out of the present beach sediments. The content of mercury (0.6 ppm) in subsurface Neogene sediments off Nome (Table 2) indicates that the present beach anomalies cannot definitely be attributed to mining.

Several factors may contribute to the decrease in mercury values of offshore sediment adjacent to beaches. The most likely explanation, particularly along Seward Peninsula, is dilution by the great quantities of Yukon River silt and fine sand that are transported along this coastline (fig. 1; Nelson and others, 1972; McManus and Smyth, 1970). The modern Yukon sediment blankets the entire area off Bluff, covers the local depressions off Nome and Wales, and often is intermixed in the relict sands and gravels of the nearshore zone (Nelson and Hopkins, 1972).

Normal surf-zone processes tend to concentrate heavy minerals on beaches; light minerals are preferentially winnowed and transported into the nearshore belt of fine sand (Swift and others, 1971). This basic mechanism may increase beach content and dilute nearshore content of the particulate mercury bearing minerals like cinnabar which has a relatively high specific gravity. Entrapment of mercury on the beach may be enhanced because the cinnabar may be disseminated in coarser quartz particles (Allen Clark, personal commun., 1972, U.S. Geological Survey, Menlo Park CA) as it is elsewhere in Alaska (Clark and others, 1971). Such mineral grains containing mercury would be more resistant to breakdown into smaller particles and thus would tend to be concentrated on beaches.

Summary of Sedimentary Processes Affecting Mercury Distribution

Glacial transport may provide a means of carrying mercury-bearing minerals en masse from onshore sources to offshore areas. For example, the glacial debris sampled by drill holes off Nome (Table 2) and located off Northwest Cape of St. Lawrence Island both contain high mercury values (fig. 2). Similar concentrations of other particulate heavy metals are also found in glacial moraines off Nome (see gold, fig. 2) and St. Lawrence Island (see copper, Nelson and Hopkins, 1972). Although the glacial processes would tend to disperse these particulate minerals as they transport them from their bedrock sources, secondary enrichment processes occur. Processes of shoreline transgression and regression during the Pleistocene reworked the glacial debris through high energy of beach and stream action (Nelson and Hopkins, 1972). Consequently, placer concentrations can be expected in specific localities of these complex, older sediments in offshore areas; the most likely occurrence of such anomalous concentrations would be in buried ancient beaches derived from mercury-bearing glacial drift. The drill holes off Nome appear to have penetrated such deposits.

The distribution of mercury values in the Seward Peninsula region may serve as a preliminary model for dispersal of mercury from natural deposits through the present system of surficial sediments. The average values of mercury in the soils and offshore surface sediments of the southern Seward Peninsula area are comparable to normal values elsewhere in the world (Table 3). This distribution of mercury in surficial sediments suggests that particulate minerals bearing mercury have not been widely dispersed from Seward Peninsula in quantities sufficient to increase offshore mercury levels above normal. The major contamination of present surficial sediment from natural mercury deposits of Seward Peninsula takes place where high energy processes, such as on the beach, can concentrate particulate heavy minerals from sources of local lode or alteration zones in bedrock or from displaced glacial debris exposed in shorelines and stream valleys. The apparent shoreline entrapment and concentration of mercury source minerals and/or dilution from recent sediment deposition result in normal mercury values even immediately offshore from mercury rich beaches. Importance of the dilution factor offshore is emphasized by the observation that both mercury (Table 2) and gold (Nelson and Hopkins, 1972) values are nearly normal in the mixed modern and ancient surficial sediments of the submerged Quaternary beaches off Seward Peninsula.

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APPENDIX I

SAMPLE NUMBER	LATITUDE	LONGITUDE	WATER DEPTH	VALUE PPM HG	REMARKS
68 ANC 3B	65°32'53"	167°52'39"		0.96	Cape Prince of Wales Beach Area
68 ANC 8B	65°33'12"	167°54'19"		0.05	" " " "
68 ANC 6	65°32'54"	167°53'30"		0.14	" " " "
68 ANC 13	65°36'43"	168° 5'39"		0.07	" " " "
68 ANC 15	65°37' 6"	168° 6'30"		0.14	" " " "
68 ANC 17	65°37'42"	168° 7'		0.09	" " " "
68 ANC 23	65°42'54"	168° 1'		0.10	" " " "
68 PR 20	65°33'54"	167°57'20"		0.14	" " " "
68 PR 21	65°33'36"	167°58'48"		0.08	" " " "
68 PR 22	65°33'42"	167°58'		0.06	" " " "
68 PR 23	65°33'30"	167°57'30"		0.05	" " " "
G17-2b-c	64°32'12"	165°42'36"		0.10	Nome Beach Area
G25-4	64°31'12"	165°35' 4"		0.04	" "
G35	" "	" "		0.05	" "
G35-6b	" "	" "		0.19	" "
G35-1c	" "	" "		0.45	" "
G43-1b	64°30'19"	165°28'41"		0.13	" "
G43-3c	" "	" "		0.14	" "
G49-1c	64°29'54"	165°24'45"		0.11	" "
G49-3c	" "	" "		0.11	" "
69 ANC 127A	64°29'	165°18'10"		0.03	" "
69 ANC 127C	" "	" "		0.04	" "
69 ANC 130A	64°29'29"	165°21'43"		0.07	" "
69 ANC 130C	" "	" "		0.18	" "

SAMPLE NUMBER	LATITUDE	LONGITUDE	WATER DEPTH	VALUE PPM HG	REMARKS
69 ANC 145A	64°26' 8"	165° 30"		0.08	Nome Beach Area
69 ANC 145C	" "	" "		0.10	" "
69 ANC 147A	64°27'36"	165° 8'50"		0.09	" "
69 ANC 147C	" "	" "		0.08	" "
68 AWF 801A	64°34'40"	163°46' 7"		0.45	Bluff Beach Area
68 AWF 802	64°34'39"	163°45'30"		0.25	" "
68 AWF 807	64°34'51"	163°49'27"		0.45	" "
68 AWF 827	64°34'39"	163°46'52"		1.3	" "
69 ANC 85	64°37'26"	162°27'44"		0.08	Stuart Island Beach - North Side
69 ANC 86	64°37'26"	162°27'44"		0.05	" " " "
69 ANC 95	63°37'25"	162°31'10"		0.07	" " " "
69 ANC 97	63°37'48"	162°32'20"		0.04	" " " "
71ADE 3				0.06	St. Matthew Island Beach
71ADE 7				0.06	" " "
USBM 6-1	64°28'54"	165°25'26"	∿40'	0.04	Offshore Drill Hole 0'- 6' Depth
USBM 6-2	" "	" "	"	0.02	" " " 6'- 18' "
USBM 6-4	" "	" "	"	0.03	" " " 24'- 30' "
USBM 6-6	" "	" "	"	0.05	" " " 36'- 42' "
USBM 12-7	64°28'13"	165°33' 2"	∿58'	0.04	" " " 34'- 40' "
USBM 12-9	" "	" "	"	0.08	" " " 46'- 52' "
USBM 12-11	" "	" "	"	0.04	" " " 58'- 64' "
USBM 12-13	" "	" "	"	0.09	" " " 76'- 82' "
USBM 12-14	" "	" "	"	0.04	" " " 82'- 88' "
USBM 12-16	" "	" "	"	0.06	" " " 94'-100' "

SAMPLE NUMBER	LATITUDE	LONGITUDE	WATER DEPTH	VALUE PPM HG	REMARKS
USBM 17-1	64°30'47"	165°40'53"	~40'	0.04	Offshore Drill Hole 0'- 3' Depth
USBM 17-3	" "	" "	"	0.01	" " " 9'- 21' "
USBM 17-5	" "	" "	"	0.02	" " " 29'- 33' "
USBM 17-9	" "	" "	"	0.05	" " " 39'- 45' "
USBM 24-5A	64°24'58"	165°12'31"	~75'	0.01	" " " 42'- 53' "
USBM 24-5B	" "	" "	"	0.04	" " " 42'- 53' "
USBM 24-15	" "	" "	"	0.04	" " " 151'-162' "
USBM 24-20	" "	" "	"	0.15	" " " 206'-217' "
USBM 24-23	" "	" "	"	0.04	" " " 238'-244' "
USBM 28-11	64°26'	165° 6'58"	~47'	0.03	" " " 63'- 69' "
USBM 28-15	" "	" "	"	0.05	" " " 87'- 93' "
USBM 28-17	" "	" "	"	0.06	" " " 100'-107' "
USBM 47-2	64°29'39"	165°30'56"	~35'	0.60	" " " 7'- 13' "
USBM 47-4	" "	" "	"	0.02	" " " 19'- 25' "
USBM 47-6	" "	" "	"	0.04	" " " 31'- 37' "
USBM 47-8	" "	" "	"	0.03	" " " 43'- 49' "
USBM 47-10	64°29'39"	165°30'56"	~35'	0.02	" " " 55'- 61' "
USBM 47-12	" "	" "	"	0.05	" " " 67'- 73' "
USBM 47-14	" "	" "	"	0.04	" " " 79'- 85' "
67 ANC 30	64°27'35"	165°19'48"	45'	0.04	Offshore Surface
68 AWF 310	64°28' 8"	164°41'58"	31'	0.02	" "
68 AWF 327	64°32'12"	164°25'12"		0.02	" "
68 AWF 338	64°32'41"	163°59'50"	46'	0.03	" "
68 AWF 343	64°32'48"	163°54'18"	14'	0.03	" "

SAMPLE NUMBER	LATITUDE	LONGITUDE	WATER DEPTH	VALUE PPM HG	REMARKS
68 AWF 344	64°33'24"	163°50'42"	20'	0.03	Offshore Surface
68 AWF 345	64°33'24"	163°48'	22'	0.03	" "
68 AWF 346	64°33'24"	163°45'24"	18'	0.03	" "
68 AWF 350	64°32'	163°50'42"	47'	0.01	" "
68 AWF 354	64°33'	163°43'30"	24'	0.04	" "
68 AWF 355	63°33'	163°41' 6"	20'	0.03	" "
68 AWF 357	64°30'48"	163°41' 6"	50'	0.02	" "
68 AWF 410	64°30'10"	164°11'50"	64'	0.02	" "
68 AWF 430	64°28'26"	164°26'30"	71'	0.02	" "
68 AWF 440	64°23'40"	164°46'31"	84'	<0.01	" "
68 AWF 505	64°32'48"	166°15'	40'	0.03	" "
68 ANC 30B	65°42'16"	168° 7'37"	25'	0.03	" "
68 ANC 61B	65°25'	167°36'54"	49'	0.06	" "
68 ANC 70B	65°32' 6"	168° 2'18"	87'	0.03	" "
68 ANC 95B	63°49'	171°40'	121'	0.03	" "
68 ANC 105B	63°37'	171°10'48"	49'	0.01	" "
68 ANC 112B	63°42'	170°38'	117'	0.02	" "
68 ANC 115B	63°44'	170°25'12"	143'	0.08	" "
68 ANC 118A	63°41'	170°11'	142'	0.06	" "
68 ANC 118G	" "	" "	"	0.02	Offshore Subsurface
68 ANC 120B	63°39'48"	170° 1'30"	143'	0.01	Offshore Surface
68 ANC 126B	63°32'	169°44'36"	121'	0.02	" "
68 ANC 140B	63°22'30"	168°56'	87'	0.03	" "
68 ANC 154B	63°50'	169°47'	104'	0.01	" "

SAMPLE NUMBER	LATITUDE	LONGITUDE	WATER DEPTH	VALUE PPM HG	REMARKS
68 ANC 166B	64°57'	167°49'	136'	0.01	Offshore Surface
68 ANC 179T	65°16'12"	166°57'12"	50'	0.07	" "
68 ANC 179B	" "	" "	"	0.04	Offshore Subsurface
68 ANC 181B	65°13'	167°26'48"	69'	0.01	Offshore Surface
68 ANC 182B	65°10'36"	167°23'24"	63'	0.01	" "
68 ANC 187B	65° 2' 6"	167°21' 5"	76'	0.08	" "
68 ANC 190B	64°58'	167°10'30"	45'	0.03	" "
68 ANC 200B	64°39'42"	166°36'30"	72'	<0.01	" "
68 ANC 212T	64°37'32"	167°14'26"	96'	0.02	" "
68 ANC 212B	" "	" "	"	0.06	Offshore Subsurface
68 ANC 215B	64°26'	168° 4'36"	119'	0.06	Offshore Surface
68 ANC 216A	64°18'30"	168°20'48"	130'	0.02	" "
68 ANC 216B	" "	" "	"	0.03	Offshore Subsurface
68 ANC 231B	64°20'48"	166° 8'24"	135'	0.04	Offshore Surface
68 ANC 233B	64°26'30"	166° 4'30"	106'	0.03	" "
68 ANC 234B	64°29'54"	166° 2'18"	67'	0.02	" "
68 ANC 235T	64°29'30"	165°45'54"	66'	0.25	Offshore Surface, 1st Trial
68 ANC 235T	" "	" "	"	0.16	" " 2nd Trial
68 ANC 235T	" "	" "	"	0.11	" " 3rd Trial
68 ANC 235T	" "	" "	"	0.12	" " 4th Trial
68 ANC 235T	" "	" "	"	0.13	" " 5th Trial
68 ANC 235B	" "	" "	"	0.36	Offshore Subsurface, 1st Trial
68 ANC 235B	" "	" "	"	0.05	" " 2nd Trial
68 ANC 235B	" "	" "	"	0.03	" " 3rd Trial

SAMPLE NUMBER	LATITUDE	LONGITUDE	WATER DEPTH	VALUE PPM HG	REMARKS
68 ANC 235B	64°29'30"	165°45'54"	66'	0.01	Offshore Subsurface, 4th Trial
68 ANC 235B	" "	" "	"	0.01	" " 5th Trial
68 ANC 240B	64°18'12"	165°40'12"	69'	0.03	Offshore Surface
68 ANC 241T	64°24'	165°35'	102'	0.11	Offshore Surface, 1st Trial
68 ANC 241T	" "	" "	"	0.08	" " 2nd Trial
68 ANC 241T	" "	" "	"	0.03	" " 3rd Trial
68 ANC 241T	" "	" "	"	0.02	" " 4th Trial
68 ANC 241T	" "	" "	"	0.02	" " 5th Trial
68 ANC 241B	" "	" "	"	0.03	Offshore Subsurface, 1st Trial
68 ANC 241B	" "	" "	"	0.01	" " 2nd Trial
68 ANC 241B	" "	" "	"	0.01	" " 3rd Trial
68 ANC 241B	" "	" "	"	0.02	" " 4th Trial
68 ANC 241B	" "	" "	"	0.02	" " 5th Trial
68 ANC 244T	64°27'24"	165°24'42"	69'	0.06	Offshore Surface
68 ANC 244B	" "	" "	"	0.01	Offshore Subsurface
68 ANC 248B	64°10'12"	165°24'	65'	0.02	Offshore Surface
68 ANC 251B	64°25'	165°14'24"	71'	<0.01	" "
69 ANC 100S	63°39'12"	162°29' 6"	53'	0.14	Offshore Surface, 1st Trial
69 ANC 100S	" "	" "	"	0.03	" " 2nd Trial
69 ANC 100S	" "	" "	"	0.02	" " 3rd Trial
69 ANC 100S	" "	" "	"	0.01	" " 4th Trial
69 ANC 100S	" "	" "	"	0.02	" " 5th Trial
69 ANC 100BUH	" "	" "	"	0.14	Offshore Upper Subsurface, 1st Trial
69 ANC 100BUH	" "	" "	"	0.01	" " " " 2nd Trial

SAMPLE NUMBER	LATITUDE	LONGITUDE	WATER DEPTH	VALUE PPM HG	REMARKS
69 ANC 100BUH	63°39'12"	162°29' 6"	53'	0.02	Offshore Upper Subsurface, 3rd Trial
69 ANC 100BUH	" "	" "	"	0.04	" " " " 4th Trial
69 ANC 100BUH	" "	" "	"	0.02	" " " " 5th Trial
69 ANC 100BLH	" "	" "	"	0.05	Offshore Lower Subsurface, 1st Trial
69 ANC 100BLH	" "	" "	"	0.02	" " " " 2nd Trial
69 ANC 100BLH	" "	" "	"	0.03	" " " " 3rd Trial
69 ANC 100BLH	" "	" "	"	0.02	" " " " 4th Trial
69 ANC 100BLH	" "	" "	"	0.06	" " " " 5th Trial
69 ANC 101B	64° 9'42"	164° 7'36"	74'	0.03	Offshore Surface
69 ANC 105B	64°10'36"	166°33'42"	95'	0.02	" "
69 ANC 107B	63°52'	167°18'48"	110'	0.01	" "
69 ANC 114	62°31'24"	165°57'30"	44'	0.03	" "
69 ANC 116	63°12'30"	165°19'42"	42'	0.06	" "
69 ANC 118	63°45'36"	166° 0'42"	88'	0.02	" "
69 ANC 120S	63°39'30"	164°37'	42'	0.02	" "
69 ANC 120B	" "	" "	"	0.01	Offshore Subsurface
69 ANC 121	63°35'30"	163°59'	47'	0.16	Offshore Surface
69 ANC 122S	64°22'30"	165°44'48"	88'	0.05	" "
69 ANC 122U	" "	" "	"	0.01	" "
69 ANC 122L	" "	" "	"	0.01	Offshore Subsurface
69 ANC 155B	63°52'	165°44'20"	110'	0.01	Offshore Surface
69 ANC 200B	64°25'48"	165°25'16"	39'	0.02	" "
69 ANC 204H III	63°46'36"	170° 1'30"	141'	0.04	" "
69 ANC 204H I	" "	" "	"	0.03	Offshore Subsurface

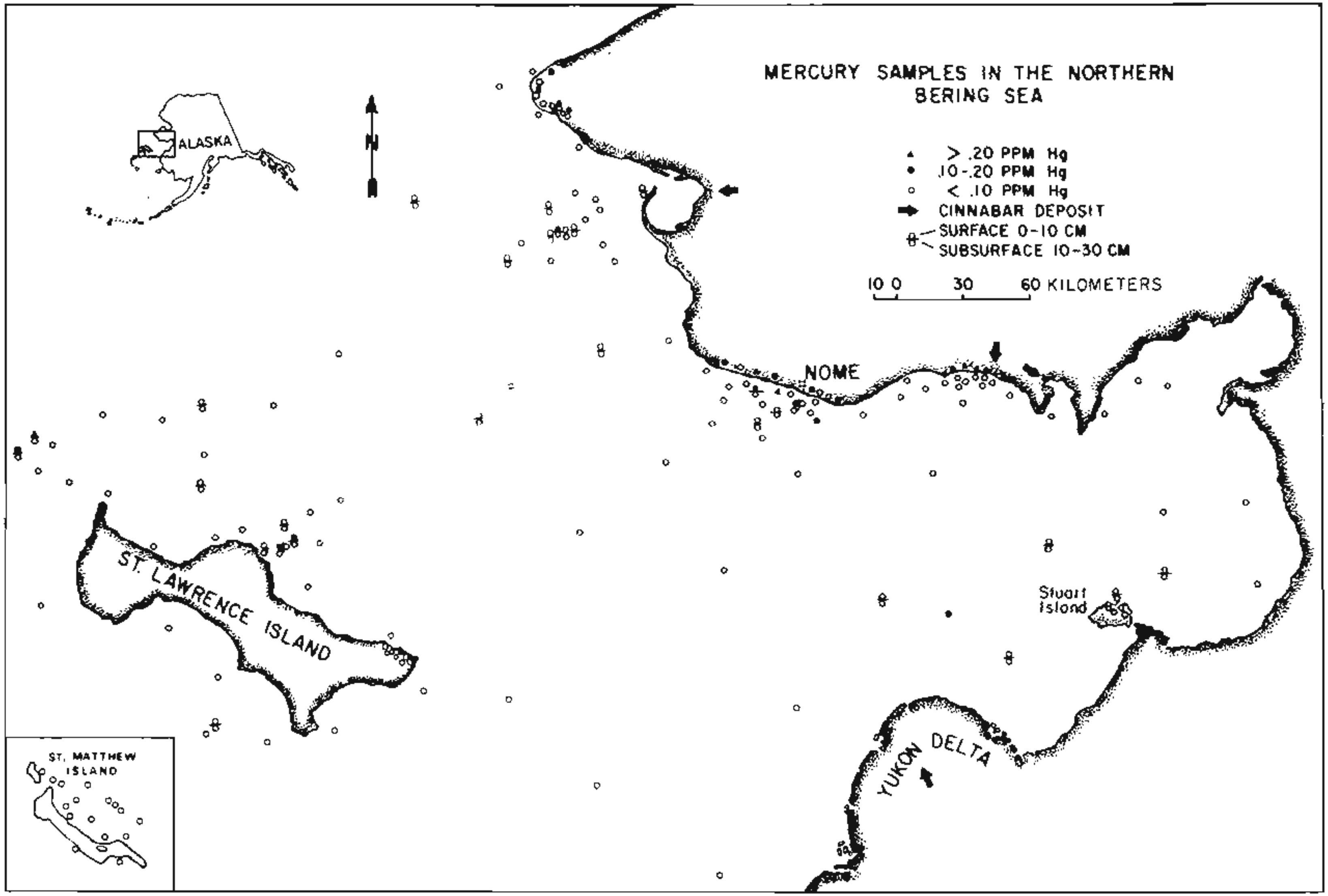
SAMPLE NUMBER	LATITUDE	LONGITUDE	WATER DEPTH	VALUE PPM HG	REMARKS
69 ANC 206S	63°41'	170° 0'	144'	0.03	Offshore Surface
69 ANC 206B	" "	" "	"	0.03	Offshore Subsurface
69 ANC 207	63°43'42"	169°54'12"	138'	0.14	Offshore Surface
69 ANC 207	" "	" "	"	<0.01	" "
69 ANC 207	" "	" "	"	0.01	Offshore Subsurface
69 ANC 208B	63°42'36"	169°36'36"	125'	0.05	Offshore Surface
69 ANC 209B	63°53'24"	169°29'48"	105'	<0.01	" "
69 ANC 215	63°54'	170°48'30"	93'	0.01	" "
69 ANC 215	" "	" "	"	<0.01	Offshore Subsurface
69 ANC 216	64° 0'54"	170°49'30"	89'	0.02	Offshore Surface
69 ANC 220B	63°51'18"	171°59'24"	125'	0.01	" "
69 ANC 221B	63°52'18"	172°18'	177'	<0.01	" "
69 ANC 222H II	63°56'48"	172°31'	180'	0.10	" "
69 ANC 222H I	" "	" "	"	0.06	Offshore Subsurface
69 ANC 223	64° 0'54"	172°25' 6"	184'	0.23	Offshore Surface
69 ANC 223	" "	" "	"	0.03	Offshore Subsurface
69 ANC 224A	63°58'18"	172°12'48"	177'	0.01	Offshore Surface
69 ANC 224B	" "	" "	"	0.03	" "
69 ANC 227B	64° 8'12"	171°47'18"	159'	0.06	" "
69 ANC 229	64° 8' 6"	171°13' 7"	118'	0.04	" "
69 ANC 230	64°13'	170°52' 7"	118'	0.02	" "
69 ANC 230	" "	" "	"	0.04	Offshore Subsurface
69 ANC 232	64°15'30"	170°18'	125'	0.04	Offshore Surface
69 ANC 235	64°29'54"	169°39'42"	121'	0.01	" "

SAMPLE NUMBER	LATITUDE	LONGITUDE	WATER DEPTH	VALUE PPM HG	REMARKS
69 ANC 237	65° 4'30"	169°14'42"	164'	0.03	Offshore Surface
69 ANC 237	" "	" "	"	0.03	Offshore Subsurface
69 ANC 245H II	65°11'12"	167°53'12"	102'	0.03	Offshore Surface
69 ANC 245H I	" "	" "	"	0.04	Offshore Subsurface
69 ANC 247H VII	65°13'54"	167°39'30"	118'	0.03	Offshore Surface
69 ANC 250B	65° 7'24"	167°30'	56'	0.02	Offshore Subsurface
69 ANC 251S	65° 6'18"	167°37'12"	69'	0.03	Offshore Surface
69 ANC 251T	" "	" "	"	0.02	" "
69 ANC 251B	" "	" "	"	0.01	Offshore Subsurface
69 ANC 252H IV	65° 5' 6"	167°43'24"	120'	0.28	Offshore Surface, 1st Trial
69 ANC 252H IV	" "	" "	"	0.08	" " 2nd Trial
69 ANC 252H IV	" "	" "	"	0.05	" " 3rd Trial
69 ANC 252H IV	" "	" "	"	0.03	" " 4th Trial
69 ANC 252H IV	" "	" "	"	0.02	" " 5th Trial
69 ANC 252H IV	" "	" "	"	0.03	" " 6th Trial
69 ANC 252H II	" "	" "	"	0.12	Offshore Upper Subsurface, 1st Trial
69 ANC 252H II	" "	" "	"	0.04	" " " " 2nd Trial
69 ANC 252H II	" "	" "	"	0.05	" " " " 3rd Trial
69 ANC 252H II	" "	" "	"	0.02	" " " " 4th Trial
69 ANC 252H II	" "	" "	"	0.04	" " " " 5th Trial
69 ANC 252H I	" "	" "	"	0.28	Offshore Lower Subsurface, 1st Trial
69 ANC 252H I	" "	" "	"	0.08	" " " " 2nd Trial
69 ANC 252H I	" "	" "	"	0.01	" " " " 3rd Trial
69 ANC 252H I	" "	" "	"	0.03	" " " " 4th Trial

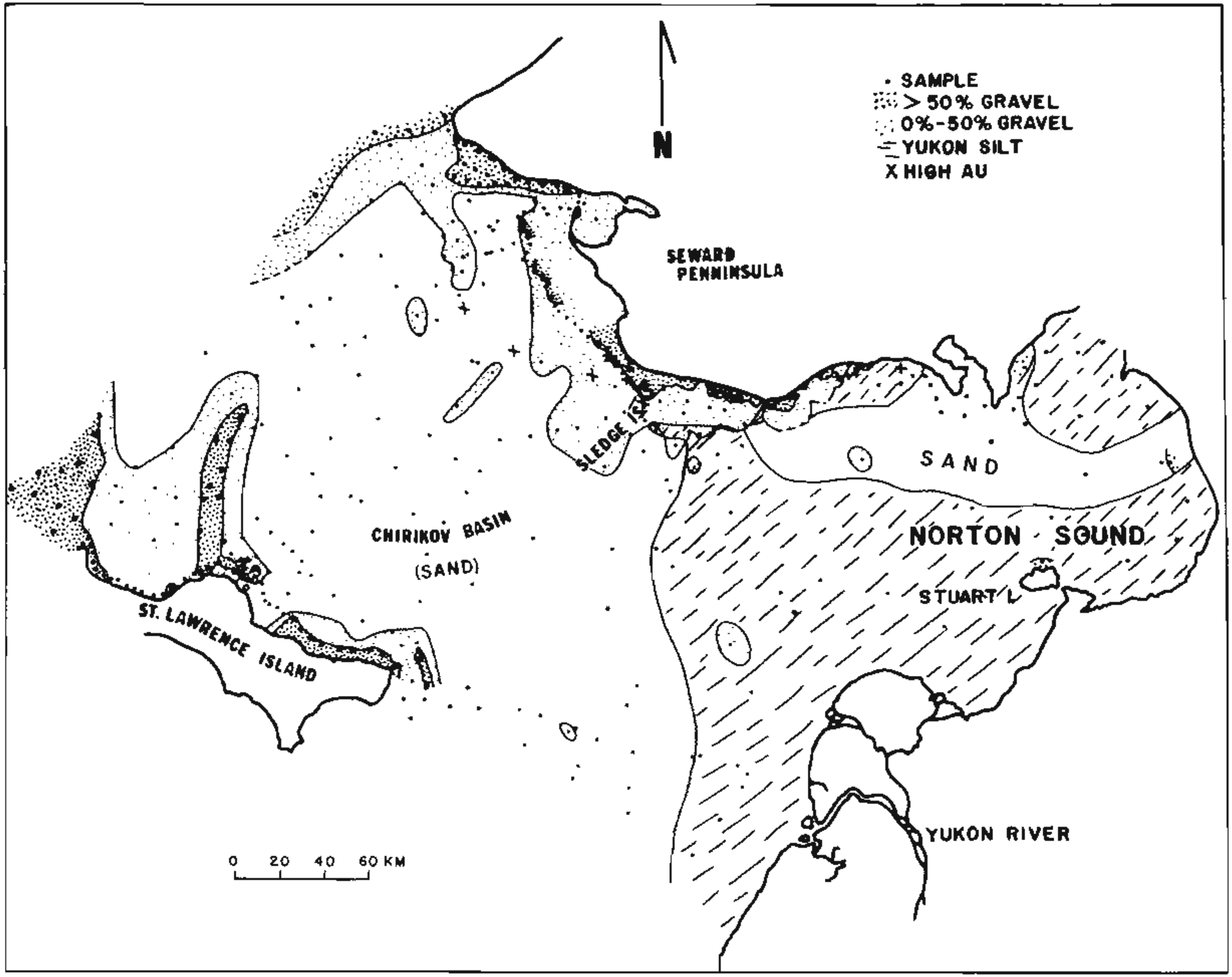
SAMPLE NUMBER	LATITUDE	LONGITUDE	WATER DEPTH	VALUE PPM HG	REMARKS
69 ANC 252H I	65° 5' 6"	167°43'24"	120'	0.01	Offshore Lower Subsurface, 5th Trial
69 ANC 252H I	" "	" "	"	0.03	" " " " 6th Trial
69 ANC 253S	65° 5'24"	167°47'	102'	0.01	Offshore Surface
69 ANC 253B	" "	" "	"	0.02	Offshore Subsurface
69 ANC 253BC	" "	" "	"	0.01	Offshore
69 ANC 253BB	" "	" "	"	0.01	Offshore
69 ANC 254B	65° 1'36"	168° 5'30"	112'	0.01	Offshore Surface
69 ANC 255UH	64°57'	168°15'	134'	0.03	" "
69 ANC 255LH	" "	" "	"	0.05	Offshore Subsurface
70 ANC 7B	63°17'30"	172°18'	202'	0.16	Offshore Surface, 1st Trial
70 ANC 7B	" "	" "	"	0.04	" " 2nd Trial
70 ANC 7B	" "	" "	"	0.01	" " 3rd Trial
70 ANC 7B	" "	" "	"	0.01	" " 4th Trial
70 ANC 7B	" "	" "	"	0.03	" " 5th Trial
70 ANC 11B	63°18'30"	170°55'54"	88'	0.06	Offshore Surface
70 ANC 13B	63° 8'12"	170°28'	124'	<0.01	" "
70 ANC 14B	62°54'48"	170°36'48"	139'	0.06	" "
70 ANC 15S	62°57'42"	170°27'24"	147'	0.06	" "
70 ANC 15B	" "	" "	"	0.09	Offshore Subsurface
70 ANC 16S	62°54'	169°58'	137'	0.01	Offshore Surface
70 ANC 20S	62°37'18"	169°24'	115'	<0.01	" "
70 ANC 24S	63°10'	168°38'	88'	0.04	" "
70 ANC 27B	63° 9'36"	167°56'54"	77'	<0.01	" "
70 ANC 29S	62°52'	167° 4'	91'	0.07	" "

SAMPLE NUMBER	LATITUDE	LONGITUDE	WATER DEPTH	VALUE PPM HG	REMARKS
70 ANC 32B	64°26'42"	163°51'18"	58'	0.04	Offshore Surface
70 ANC 35S	64°28'36"	163°25'30"	53'	0.09	" "
70 ANC 40B	64°23'18"	163° 2'30"	39'	0.03	" "
70 ANC 45S	64°23'48"	162°32'48"	61'	0.07	" "
70 ANC 47B	64°31'42"	162°14'	42'	<0.01	" "
70 ANC 48B	64°30'18"	161°56'36"	43'	0.07	" "
70 ANC 53S	64°	162° 1'30"	60'	0.03	" "
70 ANC 54S	64° 1'30"	161°16'36"	51'	0.06	" "
70 ANC 56B	63°41'24"	161°11'36"	42'	0.07	" "
70 ANC 58S	63°45'30"	162° 2'30"	52'	0.07	" "
70 ANC 58H III	" "	" "	"	0.03	Offshore Subsurface
70 ANC 59T	63°53' 6"	163° 5'36"	61'	0.08	Offshore Surface
70 ANC 59C	" "	" "	"	0.09	Offshore Subsurface
70 ANC 61S	63°26' 6"	163°27'12"	36'	0.09	Offshore Surface
70 ANC 61T	" "	" "	"	0.05	" "
70 ANC 61B	" "	" "	"	0.04	Offshore Subsurface
71 ADE 3	60°32'24"	172°53'12"	95'	0.01	Offshore Surface
71 ADE 6	60°30' 6"	172°50'42"	76'	0.01	" "
71 ADE 10	60°25'18"	172°26'48"	135'	0.01	" "
71 ADE 13	60°28'36"	172°22'	192'	0.01	" "
71 ADE 15	60°30'36"	172°29'30"	175'	0.02	" "
71 ADE 16T	60°32'18"	172°32'42"	168'	0.03	" "
71 ADE 16B	" "	" "	"	0.04	Offshore Subsurface
71 ADE 17	60°33' 6"	172°34'54"	163'	0.07	Offshore Surface

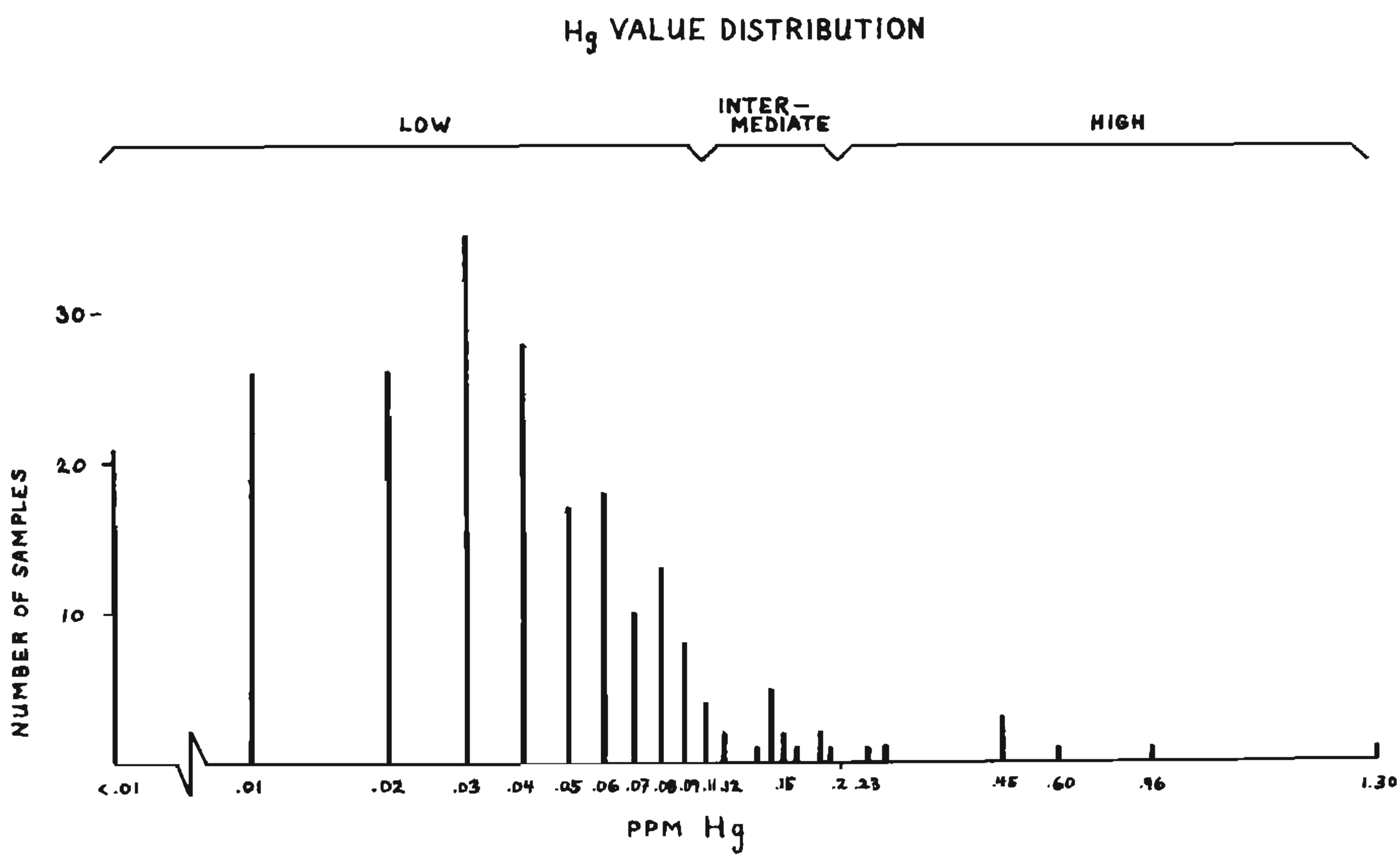
SAMPLE NUMBER	LATITUDE	LONGITUDE	WATER DEPTH	VALUE PPM HG	REMARKS
71 ADE 19	60°35'54"	172°42'42"	146'	0.05	Offshore Surface
71 ADE 20	60°32'30"	172°47'36"	132'	0.04	" "
71 ADE 22	60°29'24"	172°41'24"	92'	0.02	" "
71 ADE 26	60°24'42"	172°34'12"	93'	0.03	" "
71 ADE 30	60°20'12"	172°25'30"	42'	0.05	" "
71 ADE 32	60°23'30"	172°48'	42'	0.01	" "
71 ADE 35	60°36'12"	172°53'54"	117'	0.01	" "
71 ADE 36	60°37'48"	172°58' 6"	120'	<0.01	" "
71 ADE 38	60°38'54"	173° 3'42"	50'	0.01	" "

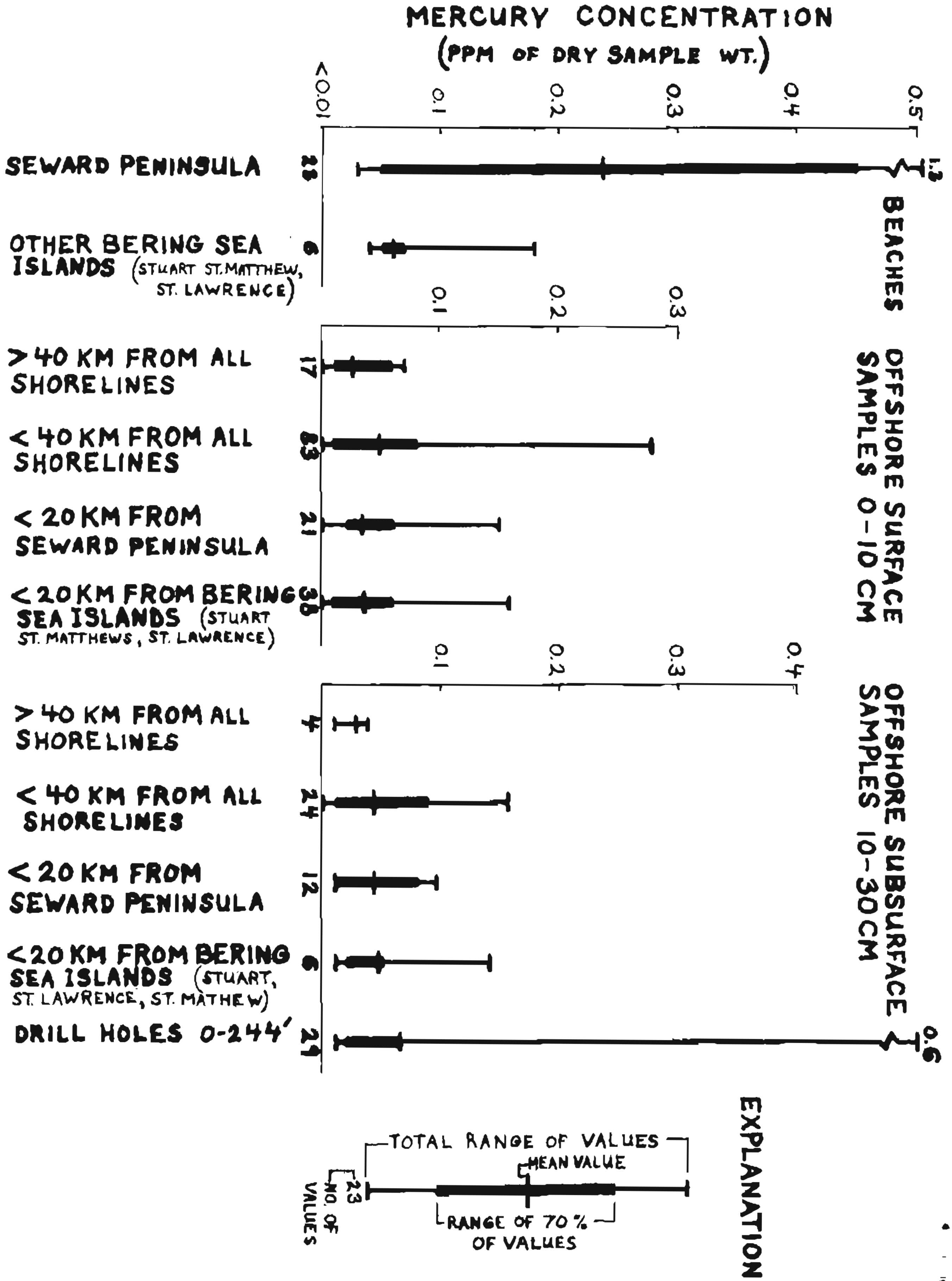


MERCURY SAMPLES IN THE NORTHERN BERING SEA
> .20 PPM Hg
.10-.20 PPM Hg
< .10 PPM Hg
CINNABAR DEPOSIT
SURFACE 0-10 CM
SUBSURFACE 10-30 CM
10 0 30 60 KILOMETERS
ALASKA
N
NOME
ST. LAWRENCE ISLAND
Stuart Island
YUKON DELTA
ST. MATTHEW ISLAND



N
SAMPLE
> 50% GRAVEL
0%-50% GRAVEL
YUKON SILT
X HIGH AU
SEWARD PENNINSULA
SLEDGE IS.
SAND
CHIRIKOV BASIN
(SAND)
NORTON SOUND
STUART I.
ST. LAWRENCE ISLAND
YUKON RIVER
0 20 40 60 KM


Hg VALUE DISTRIBUTION
LOW
INTER-
MEDIATE
HIGH
30
20
10
NUMBER OF SAMPLES
<.01
.01
.02
.03
.04
.05
.06
.07
.08
.09
.11
.12
.15
.2
.23
.45
.60
.96
1.30
PPM Hg


MERCURY CONCENTRATION
(PPM OF DRY SAMPLE WT.)
<0.01
0.1
0.2
0.3
0.4
0.5
1.3
0.6
BEACHES
OFFSHORE SURFACE SAMPLES 0-10 CM
OFFSHORE SUBSURFACE SAMPLES 10-30CM
SEWARD PENINSULA
28
OTHER BERING SEA ISLANDS (STUART ST. MATTHEW, ST. LAWRENCE)
6
> 40 KM FROM ALL SHORELINES
17
< 40 KM FROM ALL SHORELINES
83
< 20 KM FROM SEWARD PENINSULA
21
< 20 KM FROM BERING SEA ISLANDS (STUART ST. MATTHEWS, ST. LAWRENCE)
38
> 40 KM FROM ALL SHORELINES
4
< 40 KM FROM ALL SHORELINES
24
< 20 KM FROM SEWARD PENINSULA
12
< 20 KM FROM BERING SEA ISLANDS (STUART, ST. LAWRENCE, ST. MATHEW)
6
DRILL HOLES 0-244'
29
EXPLANATION
TOTAL RANGE OF VALUES
MEAN VALUE
23
NO. OF VALUES
RANGE OF 70% OF VALUES