TRACE CONTAMINANTS IN THE GREATER ST. GEORGE BASIN
A STATISTICAL REVIEW

by

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Final Report
Outer Continental Shelf Environmental Assessment Program
Research Unit 691

December 1988

ACKNOWLEDGMENTS

Thanks go to J. V. Gardner, D. M. Metzger, H. M. Ohlendorf, and E. J. Skoch for sharing unpublished data. The staff of the Alaska Resources Library, Department of the Interior, and the staff of the Publications Department of the Institute of Marine Science, University of Alaska, provided many other sources of data. I am grateful to Raymond Vaa of LSIS for writing the computer program for calculating expected normal distributions.

This study was funded by the Minerals Management Service, Department of the Interior, through an Interagency Agreement with the National Oceanic and Atmospheric Administration, Department of Commerce, as part of the Alaska Outer Continental Shelf Assessment Program.

ABSTRACT

Reported data on the concentrations of trace chemical contaminants in surface sediments and animal tissues are reviewed for the greater St. George Basin area of the southeastern Bering Sea. The tabular data from original reports are compiled in an appendix, summarized statistically, and compared among investigations.

Thirty reports from sixteen investigations were found for the area. These include hydrocarbon concentrations for sediment from one investigation and for animals from two other studies. Organochlorine residue data are examined from four investigations of fur seals and one report on seabird eggs. Concentrations of elements, including trace metals, are reviewed from three investigations of surface sediment. Seven other research efforts, including five investigations of seals, provide data on metals concentrations in animals.

The reports vary in their usefulness for monitoring contaminant levels. Many samples are constrained by low testing power and by frequency distributions which violate assumptions of parametric methods. However, other investigations report large samples, examine them for normality of distribution, and accompany them with measures of auxiliary variables. These latter data offer more robust estimates of trace contaminant levels for monitoring and further analyses.

Keywords: Bering Sea, hydrocarbons, marine contaminants, Pribilof Islands, seals, sediments, trace metals.

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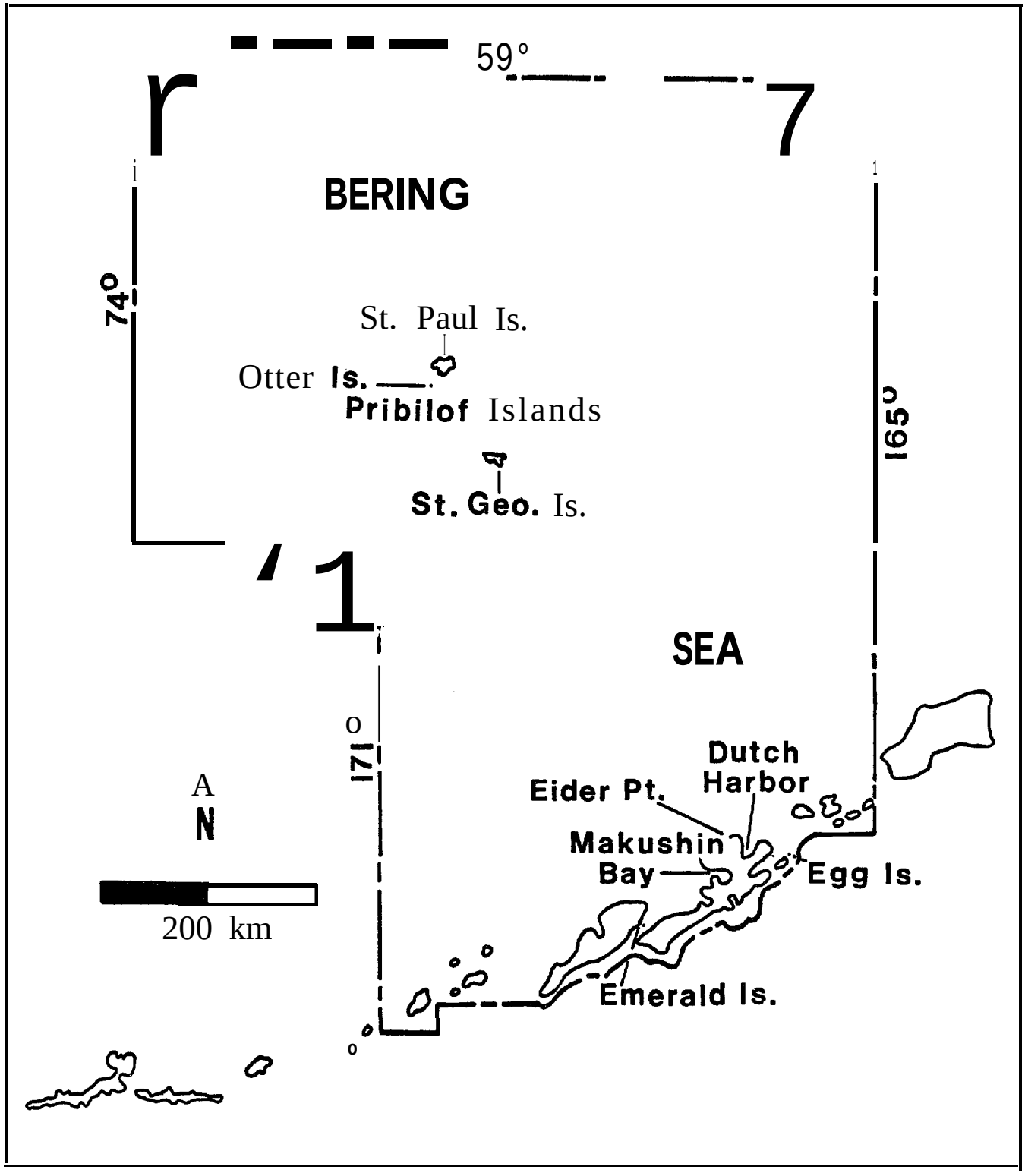

Frontispiece. Map of the location of the St. George Basin planning area in the southeastern Bering Sea, Alaska.

INTRODUCTION

The monitoring of marine pollutants in the southeastern Bering Sea will become increasingly important as the area is leased for oil and gas development. To evaluate pollution changes in the area, scientists and regulators are likely to rely on past reports of contaminants. However, some of these past research efforts may be more useful than others for detecting trace chemical trends and anomalies.

This review indicates the availability of data on trace contaminant concentrations in surface sediment and organisms of the greater St. George Basin according to area, sampled material, and chemical analyte. The report also characterizes contaminant levels statistically, compares the results of various investigations, and indicates features of samples which affect their usefulness for statistical inferences.

METHODS

Tabular data were extracted from available reports of trace element and organic contaminant concentrations in surface sediment and animal tissue in the St. George Basin lease planning area.

These extracted data are presented in a series of tables in the appendix of this report. Although the data in the appendix are rearranged for clarity, they are otherwise unchanged and uncorrected from the original reports. The calculations and figures in this review are based solely on data in the appendix tables.

All the data reviewed here were taken at face value from original reports. No assumptions were made regarding the appropriateness of collecting, storage, or laboratory methods. Furthermore, the accuracy of the data was not evaluated and data were not selected on the basis of quality.

The appendix tables were written as Lotus electronic spreadsheets to include variables of interest from the original reports. The appendix tables reflect the information, labels, and conventions of expression as found in the original reports.

For statistical calculations and histograms, data matrices were imported to Complete Statistical System (CSS), produced by SoftStat, Inc., Tulsa, Oklahoma. Each sample was tested for departure from normal skewness and kurtosis. Samples significantly different from normal were transformed to log-normal values for parametric treatment. The 95% confidence intervals of the mean were calculated as plus or minus two standard errors of the mean, and they were determined only with samples indicating a normal distribution. Significance tests were at probability level alpha=.05.

Power of t-tests for the significance of the difference between two means was determined from Table E-1 in O. L. Davies (cd.) 1978. The design and analysis of industrial experiments. Longman Group Ltd., New York. 636pp.

Histograms of expected, normal frequency distributions are based on calculations of areas under the normal curve carried out with a C-language program written by Ray Vaa.

Lines of equal concentrations were interpolated by eye for the contour maps of trace chemical-concentrations in the St. George Basin lease planning area.

As illustrated in the frontispiece, the planning area includes the Pribilof Islands and Unalaska and Umnak Islands. It is bounded on the south by the southern shore of the Aleutian Island chain, on the east by 165 degrees west longitude, and on the north by 59 degrees north latitude. The western boundary is 174 degrees west longitude near the Pribilof Islands and 171 degrees west longitude southward of those islands.

RESULTS

Sediment hydrocarbons

Concentrations and ratio indices of hydrocarbons in surface sediment were reported for the greater St. George Basin by Kaplan, et al (1977) and Venkatesan, et al (1981). They analyzed sediment from fourteen locations within the St. George Basin lease planning area. Unsummarized tabular data from these specimens presented in the original reports are repeated in the appendix. Figure 1 shows the locations of the sampling stations.

Geographical variation in four measures of hydrocarbons within the lease planning area is depicted by lines of equal quantities in Figures 2 to 5. These isolines are interpolated for 12 to 14 sampling locations.

The regional trends suggested by the contour maps, however, are valid only if it is assumed that variation is actually small within localities. Because localities are represented by single grab specimens, local variation and regional variation cannot be distinguished.

In the statistical summaries of the data for this review, station 35 is omitted. As Venkatesan, et al (1981) pointed out, hydrocarbons were anomalously high in the grab specimen. Indeed, the concentrations of the aliphatic fraction, the aromatic fraction, and total hydrocarbons each exceeded their respective regional means by more than three standard deviations at this station.

Table 1 lists the means and confidence intervals for hydrocarbon indicators and a normalizing variable. None of the variables was found to be significantly different from an expected normal distribution, on the basis of two-tailed t-tests of skewness and kurtosis (P>.05).

Percentage organic carbon accounts for a significant part of the variation in the concentrations of total n-alkanes and total hydrocarbons. These two dependent variables show significant simple linear regressions on percentage of organic carbon (P<.0026, P<.0002, respectively) . The coefficients of determination, based on the adjusted R-squares, indicate that 72% of the variation in n-alkanes, and 90% of the variation in total hydrocarbons can be "explained" by variation in organic carbon. No other hydrocarbon measure shows a significant affect by organic carbon.

The samples of this investigation provide a moderate power to detect differences in means representing the region. The four estimates of hydrocarbon concentrations shown in Table 1 have samples of size 13 and coefficients of variation in the narrow range of .48 to .58, where coefficient of variation is the sample standard deviation divided by the mean. Samples with these means and dispersions will reject a null hypothesis of no difference between means about 65% of the time when the means differ by

Table 1. Summary of the concentrations (ppm, dry weight) of hydrocarbons in upper 10 cm of sediment in the greater St. George Basin. Based on data in Kaplan, et al (1977) and Venkatesan, et al (1981). N-alkanes are carbon chain lengths 15 to 34.

The 95% confidence interval of the mean is two standard errors about the mean. The 95% confidence interval of the sample is two standard deviations about the mean and measures "precision."

Variable	n	Arith. mean	95% confidence interval of mean	95% confidence interval of sample
N-alkanes, ppm	13	1.198	.7758-1.621	0-2.663
Aliphatics, ppm	13	6.523	4.464-8.582	0-13.66
Aromatics, ppm	13	5.992	4.082-7.903	0-12.61
Total hydrocarbons, ppm	13	12.52	9.079-15.95	.6120-24.42
Org. carbon, %	12	.5300	.4272-.6328	.1891-.8709

an amount equal to the standard deviation.

Sediment metals

The small surveys

Three OCSEAP regional reconnaissance surveys of trace metal concentrations in surface sediment provide small sample sizes for the St. George Basin planning area.

Concentrations of nine metals in surface sediment of the southeastern Bering Sea were determined by Burrell (1977, 1978) using a weak acid-extraction method. Figure 6 shows the locations of the fourteen specimen cores obtained within the St. George Basin planning area. In this area, Burrell shared eight locations with the investigation of Kaplan, et al (1977) and Venkatesan, et al (1981), and four locations with Robertson and Abel (1979). However, Burrell's "acid-extracts" determinations are not directly comparable to concentrations from the "whole-rock" fraction measured by other investigators.

Robertson and Abel (1979) report "whole-rock" mean concentrations of elements in the surface sediment at eight locations in the St. George Basin planning area (Figure 7). Table 2 lists summary statistics of the mean concentrations for 10 elements. None of the samples of means is significantly different from a normal distribution. Excluded from the summary statistics is one mean each for the aluminum, vanadium, and arsenic samples which exceeded three standard deviations. Robertson and Abel (1979) did not provide original, unsummarized concentrations of elements in their sediment specimens nor indicate sample size.

The Gardner survey

Statistical summaries

Gardner, et al (1978a, 1978b) reported the largest collection of sediment samples of elemental concentrations in the southeastern Bering Sea. The authors measured 31 elements, grain size, total carbon, and mineral composition at 65 stations, but did not measure organic carbon. Their reports provide summary statistics and analysis of variance for log-transformed data. They also illustrate "contour" distributions of metals, grain size, mineral, and carbon normalizing variables.

Gardner, et al (1978a, 1978b) estimated the variation in analyte concentrations within stations, as well as regional variation among stations. After measuring local variation, they concluded that differences between stations showed real regional trends and were not simply a result of sampling error within collecting locations.

Figure 8 shows a chart of the collecting locations. The

Table 2. Summary of the concentrations (dry weight) of elements in the whole-rock fraction of surface sediment in the greater St. George Basin. Based on data in Robertson and Abel (1979: Tables C.1 and C.2).

Variable	No. of means	Mean of means	95% confidence interval of mean	95% confidence interval of sample
Aluminum, %	a	4.851	3.726-5.976	1.875-7.828
Calcium, %	8	2.366	2.182-2.847	1.391-3.638
Manganese, ppm	8	441.1	371.9-510.3	258-624.3
Vanadium, ppm	8	87.50	79.53-95.47	66.41-108.6
Arsenic, ppm	7	3.000	2.138-3.862	.8888-3.056
Barium, ppm	5	644.0	298.4-989.6	0-1,335
Cobalt, ppm	7	8.871	8.189-9.554	7.195-10.54
Chromium, ppm	7	71.57	53.11-90.04	26.34-116.4
Iron, ppm	7	2.657	2.320-2.794	1.831-3.483
Antimony, ppm	7	.5900	.5310-.6490	.4454-.7346

latitude and longitude points for Figure 8 are based on unpublished data received from Gardner (pers. comm., 1988) .

Gardner, et al (1978a, 1978b) transformed their original values to log values and then summarized the data (Gardner, et al, 1978b: Tables 6 and 7). Using their summary statistics for eight selected elements, I calculated the confidence intervals shown in Table 3.

Effect of collection methods

Gardner, et al (1978a, 1978b) collected samples by different methods according to the coarseness of the sediment. Coarse sediment was collected with a van Veen grab and yielded the undisturbed top 3 cm for analysis. Finer sediments were collected with core devices and the analyzed material was representative of the homogenized top 30 cm. The variation among specimens in percentage silt and clay (dry weight) is graphed in Figure 9. The horizontal axis is labelled with the upper limits of the frequency intervals.

I tested the possibility that the use of various collection instruments led to differences in estimates of element concentrations which are not solely the result of grain size variation. The calculations below show that, with one exception? estimates were not biased by sampling device differences.

Initial Kolmogorov-Smirnov tests show that the frequency distributions of some of the element concentrations are

significantly different between collection techniques. Such differences between techniques, however, are expected if grain size affects the concentrations. Indeed, levels of mercury, zinc, chromium, copper, nickel, vanadium, silt-clay, and total carbon differ significantly between the gravity core sample and the van Veen grab sample (P<.05). Barium and arsenic, however, do not differ between the two methods.

The van Veen and piston core techniques differ significantly for mercury, zinc, copper, and vanadium, but do not result in significant differences for barium, chromium, and nickel. .

Differences are not significant between the gravity core and the piston core samples for any variable.

To further determine the affect of collection method without the affect of area, 1 compared gravity cores and van Veen grabs obtained within the same area. Table 4 shows the results of t-tests of normalizers over that area near St. George Island. Without area affects, collection methods are seen to yield significant differences in the means and variances of percentage silt and clay and percentage total carbon, as expected.

Table 3. Summary statistics for concentrations (dry weight) of elements in surficial sediments of greater St. George Basin. Pooled sample calculations are based on the sample sizes, logarithm variances and geometric means reported for 103 grab specimens at 65 stations by Gardner, et al (1978b: Tables 6 and 7). The confidence intervals shown with geometric means are the antilogs of the confidence limits of the log values and are calculated for this review. The underlying lognormal frequency distributions may not be norms 1.

Arithmetic means and intervals are calculated from samples, pooled for 1976 and 1977, having skewness and kurtosis not significantly different from normal. The original data were presented in appendices of Gardner, et al (1978a, 1978b) and are in the appendix of this review.

Method & analyte	n	Geom. mean	95% confidence interval of mean	of sample
All methods pooled				
Barium, ppm	103	570	547-594	371-875
Chromium, ppm	103	50	45.92-54.45	20-123
Copper, ppm	103	30	26.49-33.96	8.6-105
Mercury, ppm	103	.041	.0387-.0435	.022-.076
Nickel, ppm	103	20	18.49-21.63	8.8-46
Vanadium, ppm	103	130	121.6-139.0	64-262
Zinc, ppm	103	80	75.68-84.53	47-135

Table 3. con't

		Arith. mean		
Gravity core				
Silt-clay, %	41	58.31	49.52-67.09	2.749-113.9
Tot. carbon, %	41	.5493	.4626-.6360	.0013-1.097
Zinc, ppm	81	85.22	80.58-89.86	43.71-126.7
Copper, ppm	98	36.73	32.81-42.66	0-75.38
Vanadium, ppm	98	138.2	129.1-147.2	49.39-226.9
van Veen grab				
Silt-clay, %	15	7.805	6.219-9.392	1.870-13.74
*Tot. carbon, %	15	.2640	.2160-.3120	.0842-.4438
Mercury, ppm	15	.0333	.0301-.0365	.0213-.0453
Arsenic, ppm	9	5.616	4.92-6.311	3.648-7.584
Barium, ppm	27	651.9	591.1-712.6	342.2-961.5
Vanadium, ppm	27	99.63	85.86-113.4	29.4-169.9
Piston core				
Mercury, ppm	6	.0517	.0351-.0683	.0145-.0889
Zinc, ppm	6	103.2	90.05-115.7	75.18-131.2
Barium, ppm	8	700.0	553.6-846.4	312.7-1,087
Chromium, ppm	8	58.75	45.97-71.53	24.93-92.57
Copper, ppm	8	58.75	43.9-73.60	19.46-98.04
Nickel, ppm	8	23.75	18.84-28.66	10.76-36.74
Vanadium, ppm	8	156.3	134.2-178.3	96.30-216.2

		Geom. mean		
van Veen grab				
Chromium, ppm	27	78.52	67.77-90.97	37.07-166.3
Nickel, ppm	27	29.8	24.32-36.51	10.57-83.99

*Estimated kurtosis=2.69 > critical value=2.35 at .05 level.

Table 4. Tests of differences between gravity cores and van Veen grabs for two normalizing variables in surface sediment collected by Gardner, et al (1978a, 1978b) between 168 and 170 degrees longitude in 1976 and 1977. The variables percentage silt and clay and percentage total carbon are normally distributed. Dry weight.

	% Silt & clay		% Total carbon	
	gravity core	van Veen	gravity core	van Veen
mean	51.63	7.805	.8375	.2640
n	12	15	12	15
SD	31.6	2.97	.5153	.0899
2-tail t value	5.2		4.1	
test probability	<.001		<.001	
HO:F value	33.8		33.5	
test probability	<.001		<.001	

Although total carbon differs significantly between collection methods by t-test (Table 4), this difference becomes insignificant when adjusted for silt and clay. Gardner, et al (1978b:28) noted that concentrations of total carbon generally show a negative correlation with grain size in fine-grain marine environments. Analysis of covariance (ANCOVA) in this review indicates a significant covariance between these two normalizing variables (F=14.2; df=1, 24; P=.001) near St. George Island. The adjusted means of percentage total carbon are .589 and .463 for gravity cores and van Veen grabs, respectively, and the affect of collecting method on percentage total carbon becomes insignificant after this adjustment (F=.592; df=1, 24;P=.455).

Of the elements examined, only arsenic remains significantly different between collection methods after adjustment by the covariate of percentage silt and clay (F=20.23; df=1, 8; P=.0024). None of the other seven elements listed in Table 3 demonstrate a significant difference in means after adjustment using percentage silt and clay as the covariate. Hence, except for arsenic, collection methods cannot be said to introduce differences unaccounted for by grain size.

Effect of year

Six variables examined in this review are significantly affected by differences between sampling years (Table 5). Kolmogorov-Smirnov tests using data in the appendix

indicate significant differences between 1976 and 1977 for percentage total carbon and for the concentrations of arsenic, chromium, copper, nickel, and zinc. Consequently, these samples cannot be combined between years.

In contrast, year differences are not significant for percentage silt and clay, or for concentrations of barium, mercury, and vanadium. Thus, the year samples for these four variables may be combined for stronger estimates.

Table 5. Kolmogorov-Smirnov tests of differences between 1976 and 1977 for selected elements and normalizers sampled by Gardner, et al (1978a, 1978b). Dry weight.

Variable	1976 n	1976 mean	1977 n	1977 mean	Max. absol. difference	Signif.
Silt & clay, %	56	39.9	12	45.5	.40	NS
Tot. carbon, %	52	.52	13	1.21	.85	s
Arsenic, ppm	42	5.9	8	16.5	.33	s
Barium, ppm	132	614	18	744	.17	NS
Chromium, ppm	132	60.0	18	41,4	.38	s
Copper, ppm	132	34.2	18	81.4	.75	s
Mercury, ppm	102	.044	18	.046	.28	NS
Nickel, ppm	132	24.6	18	35.3	.52	s
Vanadium, ppm	132	132	18	182	.33	NS
Zinc, ppm	103	82.8	16	101	.46	s

Normality of the distributions

Half of the variables examined in this review have frequency distributions for 1976 which exhibit significant skewness or kurtosis (Table 6). The majority of the specimens of Gardner, et al (1978a, 1978b) was collected in 1976. The sample for 1977 was small, offers poor testing power, and is omitted from tests for normality. Testing for skewness and kurtosis in the 1976 data shows that arsenic, barium, chromium, mercury, and nickel are not from normally distributed statistical populations. Furthermore, log normal transformation of the original values for these five elements does not make their distributions normal. Consequently, these five elements in 1976 do not meet the assumption of normality necessary for parametric statistical methods. Because parametric methods of statistical analyses are sensitive to departures from zero skewness, and somewhat

affected by departures from zero kurtosis, they should not be applied to the five samples.

The frequency distributions of the five elements found to be different from normal in 1976 are graphed in Figures 10 to 14. Each histogram compares the observed number of specimens to the number expected if concentrations were normally distributed in the sediment.

Table 6. Skewness and kurtosis of selected elements and normalizers sampled in surface sediment of greater St. George Basin in 1976 by Gardner, et al (1978a, 1978b). Dry weight.

Variable	n	Skewness	Signif.	Kurtosis	Signif.
Silt and clay, %	56	.27	NS	-1.49	NS
Tot. carbon, %	52	.509	NS	-1.23	NS
Arsenic, ppm	42	3.24	s	12.8	s
Barium, ppm	132	1.74	s	7.01	s
Chromium, ppm	132	1.60	s	3.88	s
Copper, ppm	132	.765	NS	-.27	NS
Mercury, ppm	102	2.06	s	5.22	s
Nickel, ppm	132	4.01	S	22.7	s
Vanadium, ppm	132	.404	NS	-.069	NS
Zinc, ppm	103	.272	NS	-.905	NS

Effects on variances

Collection method affects variances for four variables measured in 1976 (Table 7). F-tests, on samples between 168 and 170 degrees longitude indicating no significant departure from zero skewness and kurtosis, show significantly larger variances for the cores than for van Veen grabs with regard to silt and clay, log normal total carbon, arsenic, and log normal mercury. Refer to Table 4 for F-test results on the two normalizers pooled between years. Such differences among grain-size categories probably reflect a correlation between grain size, mean concentrations and variance of the concentrations.

Such differences violate the assumption of equal variances which underlies parametric methods, and thus preclude multivariate analyses for percentage silt-clay, percentage carbon, arsenic, and mercury.

However, the variances of the log-normal values of

barium, chromium, and vanadium are not significantly affected by collection method and thus may be used in multivariate analyses.

Table 7. Tests for differences in variances between cores and van Veen grabs for the area between 168 and 170 degrees longitude, 1976, based on data in Gardner, et al (1978a, 1978b). F-tests are conducted only on pairs of samples showing no significant departures from normal distribution. Dry weight.

Variable	Core SD	Grab SD	F	Test prob.	Signif.
silt and clay, %	17.1	2.97	33.8	<.001	s
in tot. carbon, %	.42	.19	4.93	.013	s
Arsenic, ppm	5.2	.98	29.5	<.001	s
in Mercury, ppm	.40	.19	4.3	.009	s
in Barium, ppm	.25	.19	1.64	.229	NS
in Chromium, ppm	.34	.37	1.16	.709	NS
in Vanadium, ppm	.33	.31	1.06	.889	NS

Effect of the normalizing variables

Copper, mercury, zinc, and vanadium concentrations increase significantly with percentage silt and clay and with percentage total carbon. Chromium and nickel concentrations, however, decrease significantly with increases in either normalizer. Arsenic and barium are not significantly correlated to either normalizer. Table 8 shows the results of Spearman's rank order non-parametric tests of correlation from which these trends are inferred. The correlations indicate that the two normalizers can reduce the variance of five of the elements, thereby increasing the power of tests and the precision of estimated means.

In Table 8, coefficients of determination (R-square) indicate the part of the variation in the concentrations of elements which is "explained" by normalizing variables.

Tissue hydrocarbons

Hydrocarbon concentrations in animals in the greater St. George Basin are not well documented. Two research projects, sponsored by the Outer Continental Shelf Environmental Assessment Program, examined levels of hydrocarbons in small samples of animals.

Table 8. Spearman rank order correlations for element concentrations (ppm, dry weight) with normalizing variables measured in 1976. Calculations for this review are based on data from surface sediment specimens collected in greater St. George Basin (Gardner, et al 1978a, 1978b), and repeated in the appendix of this review.

Variables	Spearman R	R-square	Z	Test prob.	Signif.	n
% Silt and clay with:						
Arsenic	-.073		.309	.75	NS	19
Barium	-.20		1.48	.13	NS	56
Chromium	-.42	.18	3.09	.0025	s	56
Copper	.75	.81	5.57	.00001	s	56
Mercury	.52	.27	3.27	.003	s	56
Nickel	-.28	.078	2.08	.035	s	56
Vanadium	.57	.33	4.25	.0001	s	56
Zinc	.74	.55	5.50	.00001	s	56
% Total carbon:						
Arsenic	.050		.201	.821	NS	17
Barium	-.149		1.065	.287	NS	52
Chromium	-.358	.128	2.560	.0102	s	52
Copper	.715	.511	5.11	.0002	s	52
Mercury	.564	.318	3.99	.00022	s	51
Nickel	-.226		1.61	.103	NS	52
Vanadium	.496	.246	3.54	.0007	s	52
Zinc	.713	.508	5.09	.00002	s	52

For one of these projects, Boersma (1984) reported n-alkanes in the regurgitate of pelagic birds at rookeries including two Aleutian Islands. The geometric mean of the quantity of n-alkane peaks in 32 specimens collected in 1981 is 207 rig/ml (Boersma, 1984: Table 24). "Dirty" specimens are considered those regurgitates which contained n-alkane peaks matching a Prudhoe Bay crude oil standard. Frequency of occurrence of dirty specimens is shown in Table 9.

Shaw (1977, 1978) surveyed fish and invertebrates in the Bering Sea for tissue concentrations of hydrocarbons. He concludes that, "None of the plankton analyses show evidence of petrogenic hydrocarbons," and that, ". . .None of the [fish] materials analysed shows evidence of petrogenic hydrocarbons," (Shaw, 1977: 43, 44). He further states that, "All the hydrocarbons. . . identified in the biota of the Bering Sea are biogenic and probably algal in origin," (Shaw, 1978:65). Table 10 shows the hydrocarbon concentrations reported by Shaw (1977, 1978) for the St. George Basin planning area.

Tissue metals

Invertebrates

Robertson and Abel (1979) reported estimates of metals in small samples of invertebrate animals collected in 1976. Their data are repeated in the appendix for eight metals and four animal taxa. Table 11 summarizes the authors' data pertaining to king crab mercury levels.

Table 11. Mean level (ppm, wet weight) of mercury in king crab tissue in St. George Basin, based on three means presented in Robertson and Abel (1979). Sample sizes of the original means were not reported.

Arith. mean	95% conf. int.	Geom. mean	95% conf. int.
.30	.19-.41	.29	.20-.43

Burrell (1978: Tables 52 and 53) reported heavy metal concentrations in soft body tissues of blue mussels and seaweed in the intertidal zone of three islands in the southern part of the St. George Basin area. Table 12 presents the original data, in addition to summaries calculated for this review.

Table 9. The number of Aleutian Island seabird regurgitate samples having n-alkane peaks which match the peaks of a Prudhoe Bay crude oil standard and thus scored as "dirty," (Boersma, 1984:Table 7). Specimens were collected from 24 fork-tailed storm-petrels and 8 Leach's storm-petrels at Egg Island and Emerald Island near Unalaska Island in the St. George Basin planning area in 1981.

	No.	% total samples
Samples with 9 matched peaks between C-20 and C-28	7	22
Samples with 21 matched peaks between C-n and C-32	1	3

Table 10. Hydrocarbon concentrations (ppm, wet weight) in animal tissues in the St. George Basin planning area reported by Shaw (1977, 1978). Fraction 1 represents hydrocarbons eluted by hexane and consists of saturates and some olefinic hydrocarbons. Fraction 2 has larger unsaturates, aromatics, and some non-hydrocarbon organic compounds.

The data are taken from Shaw (1977: Table 2, p. 21) and Shaw (1978: Table 8-3, p. 66), except geometric means which are calculated for this review.

1975, 1976:		Fr. 1	Geom. mean	Fr. 2	Geom. mean
Chionocetes opilio, entire		0.2	.499	2.1	80.1
		3.1		3300.	
		1.0		330.	
		0.1		18.	
Hippoglossus stenolepis,	gills	6.6		130.	
	liver	6.9		1.9	
Pleuronectes quadrituberculatus		<.01		3.4	
Theragra chalcogramma,	gills	1.0		9.1	
	liver	1800.	59.1	300.	329.2
		19.		170.	
		17.		300.	
				470.	
		21.		590.	
	skin	7.3		30.	
	skin/flesh	.12	.0952	2.3	10.4
		.12		47.	
		.06			

1977:	Total satur.	GM	Total unsatur.	GM	Pristane	GM
Medusae	2.3		7.5		2.3	
Parathemisto pacifica	70		20		70	
Chaetognathae	60.2	24.56	10.3	1.05	60.2	24.56
	53.1		2.3		53.1	
	33.6		8.9		33.6	
	7.5		0.6		7.5	
	11.1		< .01		11.1	
Euphausiacea	52	14.83	31	44.47	52.5	11.22
	66		150		57.5	
	58		100		49	
	3.6		34		1.2	
	1.0		11		1.0	

Table 12. Concentrations (ppm, dry weight) of heavy metal contents in intertidal benthic tissues in St. George Basin planning area, collected in summer of 1976, reported as means of duplicate determinations by Burrell (1978: Tables 52 and 53). The geometric means with confidence intervals are added for this review.

Location	Lat/long	Cadmium	Copper	Nickel	Zinc
Mytilus, blue mussel:					
Eider Pt.	53d 58m, 166d 35m	4.0	9.8	1.3	122
Otter Is.	57d 3m, 170d 24m	4.6	6.0	1.8	156
Makushin Bay	53d 44m, 166d 46m	6.0	6.0	1.4	81
Geometric mean		4.8	7.1	1.5	116
95% confidence interval		3.8-6.1	5.1-9.8	1.2-1.8	79-169
Fucus, seaweed:					
Eider Pt.		5.5	1.5	4.9	17
Otter Is.		3.1	5.0	5.1	8
Makushin Bay		3.8	0.8	7.1	10
Geometric mean		4.0	1.8	5.6	11
95% confidence interval		2.8-5.6	1.0-3.4	4.4-7.1	7-17

Seals

Burrell (1979) reported the concentrations of heavy metals in tissues of three seal species collected in the St. George Basin planning area in 1977. The original data from that report are repeated in the appendix of this review.

Kruskal-Wallis non-parametric tests show there is no significant affect of species on levels of the metals, with one exception. Cadmium in liver is affected by differences associated with species (P=.0445). Nearly significantly different among species is cadmium in muscle (P=.0671). Frequency distributions of concentrations pooled among all three species do not depart significantly from normal, therefore the data are combined as single samples. Table 13 shows the means and confidence intervals for the four metals reported in spotted, ribbon, and bearded seals.

Four other investigations have reported metal concentrations in northern fur seals on the Pribilof Islands. None of these research projects was sponsored by the Outer Continental Shelf Environmental Assessment Program. Results of the four investigations are compared in Table 14 for those elements sampled by more than one investigation.

Although E. J. Skoch and his associates have produced a series of reports on metals concentrations in northern fur seals, only the most recent data, summarized in Skoch and Metzger (1988), are reviewed here. Earlier reports contain data which are "off by a certain factor" (Skoch, pers. comm., 1987). These earlier reports, available at the Alaska office of NOAA, are comprised of Skoch, Hoste, and Bral (no date), Hoste, Skoch, and Grills (1984), and Richard and Skoch (1986).

Statistics in Table 15 summarize the raw data in unpublished laboratory records accompanying the report by Skoch and Metzger (1988). For calculation purposes, I first substituted the data labelled "re-do's" in the laboratory records for several initial determinations. The concentrations of each analyte in each of the three tissues were then tested for skewness and kurtosis. Only those samples or their log-normal transformed values which were not found significantly different from normal are summarized as means and confidence intervals in Table 15.

Table 16 compares the arithmetic mean levels of those elements which have normal distributions and which were measured by more than one investigation.

The high mean concentration of mercury in liver is among the salient features of the four studies. Smithfs (1986) sample provides an estimate that the mean level of mercury in livers of the young male fur seals on St. George Island in 1986 has a 95% chance of lying between 50 and 84 ppm, dry weight (Table 15). Goldblatt and Anthony (1983) report a similar level. Their dry weight estimates, re-calculated by dividing wet weight by their factor of .21 g dry/g wet,

Table 13. Mean concentrations (ppm, dry wt.) of heavy metals in seal tissues in St. George Basin planning area, calculated from data in Burrell (1979: Tables 3 and 5). Data are pooled for spotted, ribbon, and bearded seals.

	n	Arith. mean	95% conf. interval
Kidney:			
Cadmium	9	29.84	21.97-37.72
Nickel	6	.2000	.0845-.3155
Copper	9	22.41	14.02-30.80
Zinc	9	110.2	88.48-131.96
Liver:			
*Cadmium	10	12.54	5.057-20.02
Nickel	7	1.543	.8817-2.33
Copper	10	22.09	15.57-28.52
Zinc	10	121.6	90.85-152.35
Muscle:			
Cadmium	10	.4090	.1803-.6377
Nickel	8	3.175	1.317-5.034
Copper	9	5.533	4.293-6.773
Zinc	10	67.20	40.91-93.49

*Includes significant species difference

Table 14. Statistical summaries of metal concentrations in northern fur seals collected on Pribilof Islands by four investigations. Calculations are based on data in appendix Tables Al, A7, A12, and A14. The summaries do not include Skoch's lab determinations marked "no detectable amount." Except zinc in kidney and liver, the samples of Skoch show significant skewness and kurtosis. Other investigations' samples do not indicate non-normal distributions. n = no. seals.

DRY WEIGHT BASIS: .

	Goldblatt		Skoch		Smith	
KIDNEY :	n=36-37		n=72		n= 4	
	mean	SD	mean	SD	mean	SD
Mercury					5.458	0.903
Cadmium	266.9	97.7	235.1	178.5	249.3	128.9
Zinc	277.9	60.5	77.39	27.9	237	55.23
Lead	0.27	0.22	40.03	46.76	-	-
Copper			32.37	15.71	22.50	4.12
Nickel	0.556	0.57	7.559	4.887	-	-
LIVER :	n=36-37		n=58-59		n=4	
Mercury					61.09	23.08
Cadmium	55.63	27.8	88.20	90	67.25	48.7
Zinc	233.7	38.8	69	24.35	209.8	53.02
Lead	1.13	2.42	41.3	49.49	-	-
Copper			104.1	77.28	32.50	13.38
Nickel	0.411	0.32	7.227	7.818	-	-
MUSCLE :	n=38-39		n=56-57		n=4	
Mercury					1.387	0.742
Cadmium	0.9	0.641	27.55	64.55	0.633	0.666
Zinc	139.15	38.4	67	29.3	89.67	11.85
Lead	0.26	0.48	54.6	71.92	-	
Copper			15.48	26.94	-	
Nickel			9.383	7.504	-	

Table 14. **con't**

WET WEIGHT BASIS:	Goldblatt n=37			Anas n=29		
	mean	SD	range	mean	SD	range
KIDNEY :						
Mercury						
Cadmium	56.05					
Zinc	58.36 ,					
Lead	0.057					
Copper						
Nickel	0.117					
LIVER :						
Mercury	10.74	6.53	4.09-42.94	10.8	-	3.0-19.0
Cadmium	16.13					
Zinc	67.76					
Lead	0.328					
Copper						
Nickel	0.119					
MUSCLE :						
Mercury						0.1-0.4
Cadmium	0.271					
Zinc	42.16					

Table 15. Means and confidence intervals for elements in tissues of male northern fur seals, aged 2 to 4 years, at five rookeries in the Pribilof Islands. Original data are single determinations per tissue per animal, except 6 kidneys, 1 liver, and 1 muscle for which 2 determinations were recorded. Geometric means and confidence intervals are back-transformed from the log normal values. Based on data from Skoch and Metzger (1988) repeated in appendix of this review.

Tissue & sample size		Element	Arith. mean	Geom. mean	95% conf. int.
Kidney	23	Titanium		64.3	37.6-110.1
	60	Iron		461	378-562
	72	Zinc	77.4		70.8-84.0
	72	Zinc		72.1	65.7-79.1
	66	Chromium		1.34	1.13-1.59
	72	Lead		26.8	22.1-32.5
Liver	19	Titanium		70.6	36.2-137.6
	56	Iron	1567		1306-1828
	59	Cadmium		58.3	46.2-73.4
	56	Selenium	167		146-189
	58	Nickel		4.58	3.52-5.96
	58	Copper		85.8	73.3-1oo
	58	Zinc	69.7		63.2-76.1
	52	Chromium		1.33	1.07-1.64
Muscle	16	Titanium		95.5	55.8-163
	54	Selenium	224		192-256
	56	Nickel		6.77	5.37-8.52
	56	Zinc		62.1	55.6-69.5
	56	Aluminum	1.22		1.16-1.29
	56	Aluminum		1.20	1.14-1.26

Table 16. Selected arithmetic means and confidence intervals for elements in tissues of northern fur seals, Pribilof Islands. Based on the data of the four investigations represented in Table 14. Samples which depart from normal in tests of skewness and kurtosis are omitted. Values are rounded for ease of comparison. Ppm, dry weight.

Tissue	Element	Author	Arith. mean	95% confid. interval
Kidney	Cadmium	Goldblatt	267	234-300
		Smith	249	120-378
	Copper	Smith	22.5	18.4-26.6
	Lead	Goldblatt	0.27	.203-.349
	Mercury	Smith	5.46	3.65-7.26
	Nickel	Goldblatt	0.556	.366-.746
	Zinc	Goldblatt	278	258-298
		Skoch	77.4	71-84
		Smith	237	182-292
Liver	Cadmium	Goldblatt	55.6	46.3-64.9
		Smith	67.3	18.6-116
	Copper	Smith	32.5	19.1-45.9
	Lead	Goldblatt	1.13	.32%1.94
	Mercury	Smith	61.1	38.0-84.2
	Nickel	Goldblatt	.411	.304-.518
	Zinc	Goldblatt	234	221-247
		Skoch	69.7	64-75
		Smith	210	157-262
Muscle	Cadmium	Goldblatt	0.9	.69-1.1
		Smith	0.6	0-1.3
	Lead	Goldblatt	0.26	.10-.42
	Mercury	Smith	1.4	.53-2.2
	Zinc	Goldblatt	139	126-152
		Smith	90	78-102

yield a mean of 51 ppm, with a 95% confidence interval of 41 to 61 ppm. The wet weight mean of Goldblatt and Anthony (1983) is almost identical to that of Anas (1973, 1974). However, Anas reported no sample dispersion and thus the two means cannot be tested for significant difference.

Assuming that the statistics of Goldblatt and Anthony (1983) are from a normally distributed statistical population, samples of mercury in liver with the size and standard deviation of theirs can detect a significant difference in means of 5 ppm wet weight (less than the standard deviation of 6.53 ppm) about 90% of the time.

Cadmium levels (dry weight) in kidney are similar and high among the three investigations reporting the element. Cadmium in kidney has among the highest concentrations of the trace elements reported in fur seals and is similar to the levels of zinc in kidney and liver (Table 14). Goldblatt and Anthony (1983} compared cadmium levels among pinniped species and also tested for the affect of animal age on cadmium levels in fur seals.

Unlike cadmium, lead concentrations (dry weight) vary widely among the studies (Table 14). The unpublished laboratory records of Skoch and Metzger (1988) indicate mean levels from 40 to 55 ppm among three tissues, which are values far greater than those of other investigators. Goldblatt and Anthony (1983) found lead levels of approximately 1 ppm and lower. Smith (1983) did not detect lead at all above the lower detection limit .034 ppm dry weight. He suggests that the higher concentrations reported by the older investigations are either representative of different animal populations or "inaccurate due to sample and analytical contamination."

Zinc in kidney and liver was measured at lower concentrations by Skoch and Metzger (1988) than measured by Goldblatt and Anthony (1983) and by Smith (1986), as shown in Table 16.

These four investigations offer little opportunity for obtaining more robust estimates of analyte concentrations by combining sample data. Significant differences in the mean levels for several analytes, as well as the absence of the original laboratory determinations in two reports preclude calculations of means and confidence intervals from pooled samples.

Nevertheless, these four studies indicate that fur seals carry greater burdens of cadmium and zinc than the three Phocidae species sampled by Burrell (1979). A comparison of the mean concentrations of the metals listed in Tables 13 and 16 shows this difference. Zinc mean concentrations appear twice as great in the fur seals of Goldblatt and Anthony (1983) as in the earless seals of Burrell (1979) for three tissues. Differences in cadmium levels are even more pronounced between the two sets of species. However, the confidence intervals of copper concentrations in kidney and liver overlap, suggesting that mean levels are not significantly greater in fur seals than in the phocids.

Table 17. The quantity of non-proprietary data on organochlorine concentrations in animal tissue in the greater St. George Basin. Analytes are the chemical species analyzed. Specimens are the northern fur seals and seabird eggs sampled. Tissues are the types sampled within specimens. The number of concentrations in the table includes those attempts which measured no quantities of the analyte.

	NUMBER OF LAB DETERMINATIONS:			
Citation	Analytes	Specimens	Tissues	Concentrations
Anas 1970	4	8	2	64
Calambokidis 1987	5	1	4	20
Calambokidis 1985	2	4	2	16
Kurtz 1976	8	7	2	112
Kurtz no date	7	18	4	504
Ohlendorf 1982,88	12	47	1	564
Wise 1988	35	2	4	280

censoring of data below lower detection limit precludes testing of assumptions about frequency distributions. These constraints and the small sample size of two may limit comparisons among such important factors as year, age, place, and species. Nevertheless, comparisons with other investigations reviewed here indicate that some means, such as for DDE congeners and dieldrin in liver and blubber, are so much lower that statistical tests of differences with other reports are unnecessary.

For northern fur seals, the only tissue-chemical combination with testable sample sizes in more than one investigation shows significant variation in concentrations among investigations. DDE concentrations in liver of subadult males, uncorrected for percentage recovery, are significantly different according to a Kruskal-Wallis rank test using samples of Anas and Wilson (1970), Calambokidis and Peard (1985), and Kurtz (no date) (test statistic H=11.4; df=2; P=.0037). Figure 15 illustrates the variation in mean levels of DDE in livers among the four studies.

Because the data on DDE in liver of Calambokidis and Peard (1985) and Kurtz (no date) are similar, they may be combined to "increase sample size. Their log-transformed values have means and variances which are not significantly different between studies, according to t-test and F-test. The resulting pooled sample of 22 has a geometric mean equal to .201 ppm wet weight, with a 95% confidence interval of .162 to .249 ppm. Figure 16 shows the frequency distribution of the untransformed concentration values for the pooled sample.

Seabird eggs

Ohlendorf, et al (1982) surveyed organochlorine residue concentrations in the eggs of Alaskan seabirds from 1973 to 1976. All of the data from that report regarding the four species and three islands studied in the greater St. George Basin are repeated in the appendix. The appendix also includes a table containing unpublished, unsummarized data received from Ohlendorf (pers. comm. ,1988) .

The values are not corrected for percentage recovery, which ranges from 83% to 104%. The lower limit of detection was .02 ppm for toxaphene and PCB's, and .005 ppm for the other pesticides (Ohlendorf, et al, 1982:4).

Table 18 shows the arithmetic means of DDE and PCB's in eggs collected in the St. George Basin area, based on the unpublished data of Ohlendorf (pers. comm., 1988) . These two chemicals are represented by the largest sample sizes and the highest concentrations in the data set. Their sample distributions do not differ significantly from normal according to tests for skewness and kurtosis. Figure 17 illustrates the variation in the mean levels of DDE and PCB's among bird species shown in Table 18.

The eggs of glaucous-winged gulls on Bogoslof Island exhibit the highest organochlorine residue quantities measured for St. George Basin area eggs. This sample includes an egg with 11.0 ppm DDE, wet weight, and another with 6.3 ppm PCB's, wet weight. See the appendix.

Table 18. Mean concentrations (ppm, wet wt.) of selected organochlorines in eggs of seabirds on Pribilof Islands and Bogoslof Island. Based on data from Ohlendorf (pers. comm. ,1988) .

	DDE:			PCB's:	
Species	n	Mean	95% conf. int.	Mean	95% conf. int.
Northern fulmar	6	.312	.216-.408	.400	.223-.577
Glaucous-winged gull	3	6.37	.938-11.8	3.90	1.28-6.52
Black-legged kittiwake	10	.033	.023-.043	.481	.375-.587
Common murre	7	.119	.111-.127	.126	.098-.155

National Status and Trends

The National Status and Trends Program of NOAA has developed several hundred data on trace contaminants in bottom fish and surface sediments at Dutch Harbor in 1986 and 1988 (Varanasi, et al, in prep.) . A preliminary view of the 1986 data indicated that the data include concentrations of 38 organochlorines, 16 metals, several

classes of polynuclear aromatic hydrocarbons, in addition to auxiliary variables from the sampled material and quality assurance documentation. The sampled material and the analytes of 1988 are similar to those of 1986.

The NS&T Program makes its data available to other users two years after the collection. Hence, the first set of data in this series will become available after October, 1988.

DISCUSSION

Availability of data

Data on trace contaminants in sediment of the St. George Basin area are available from several OCSEAP reconnaissance surveys. For three surveys, a small number of collecting stations fall in the area of the St. George Basin. Of these surveys, one measures hydrocarbons and percentage organic carbon, an important normalizing variable. The other two studies sample metals concentrations, unaccompanied by other specimen measurements. In contrast, the survey of Gardner, et al (1978a, 1978b) provides a large collection of metals determinations as well as measurements of grain size and carbon normalizers.

Tissue data for the St. George Basin were found in a wider variety of sources, including both reconnaissance and monitoring research. Concentrations of hydrocarbon fractions are provided for small samples of a large array of taxa in surveys by Shaw (1977, 1978). In addition, small samples of metals concentrations in several species of invertebrates at a few locations were determined by Burrell (1978) and Robertson and Abel (1979). Ohlendorf (1982) surveyed organochlorine residues in bird eggs. In contrast to these studies, designed to characterize contaminant levels within taxa, Boersma (1984) used hydrocarbon peaks as a tool for monitoring changes in oil pollution over time.

Seals have received more attention than any other taxon in the St. George Basin area. Seal organochlorines and metals have been sampled in five species and eight tissues by nine sets of investigators over a period of twenty years. Nevertheless, the small samples do not necessarily offer a basis for detecting increases and decreases in trace contaminant levels.

Adequacy of data

Some trace contaminant analytes in the St. George Basin area are well-characterized by robust sampling. Chief among these analytes are the elements in sediment studied by Gardner, et al (1978a, 1978b), and in the fur seal tissue of Goldblatt and Anthony (1983). Both investigations offer larger samples, attempt to account for variability in contaminant concentrations using auxiliary variables, and

are explicit about assumptions of normality. Consequently, both sets of results may be used in detecting moderate differences in metals concentrations with other investigations.

Most available data sets for the St. George Basin area do not measure geographical trends in trace contaminant concentrations. Only the research of Gardner, et al (1978a, 1978b) measures the variation in analyte concentrations within localities. Because the other studies of sediment and tissue do not partition total variance into its local and regional sources, they can offer for each analyte only a single mean which represents the entire sampled area.

Several characteristics of the data sets detract from their usefulness in monitoring temporal changes as well. First, small sample sizes for individual tissues and areas restrict testing power for detecting differences. Secondly, some results are presented as summaries, without the original determinations, precluding most further manipulation and requiring weakly supported assumptions about frequency distributions. In addition, non-normally distributed samples do not allow confidence limits of the mean or multi-variate analyses, although differences can be tested with non-parametric methods. For these reasons, most past sampling efforts in the St. George Basin area are of limited help in measuring trends and moderate changes in levels of trace contaminants.

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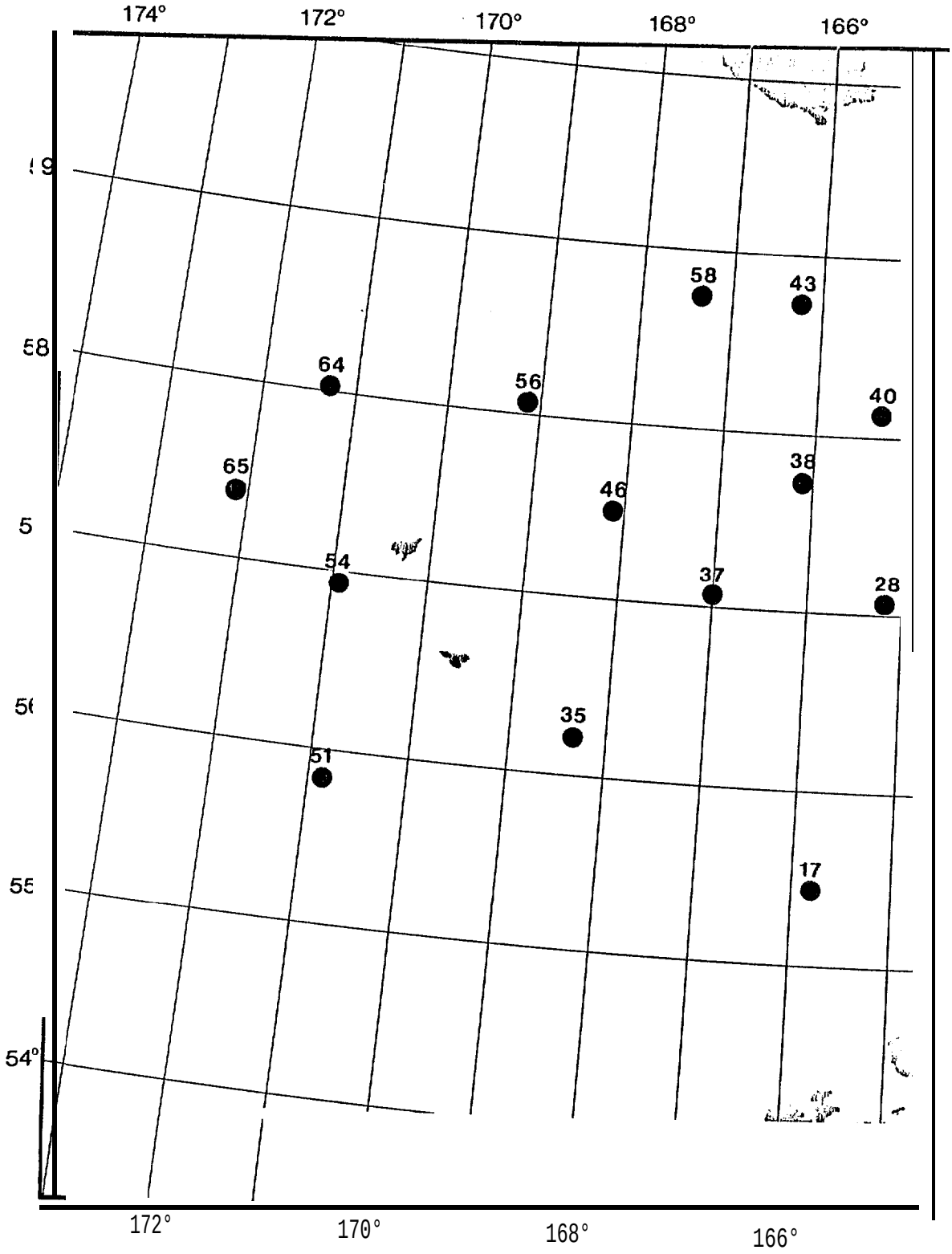

Fig. 1. Fourteen sediment grab **stations** reported for 1975 **trace** hydrocarbon sampling **in** the **St.** George Basin planning area by Kaplan, et al (1977) and Venkatesan, et al (1981). Numbers represent station labels.

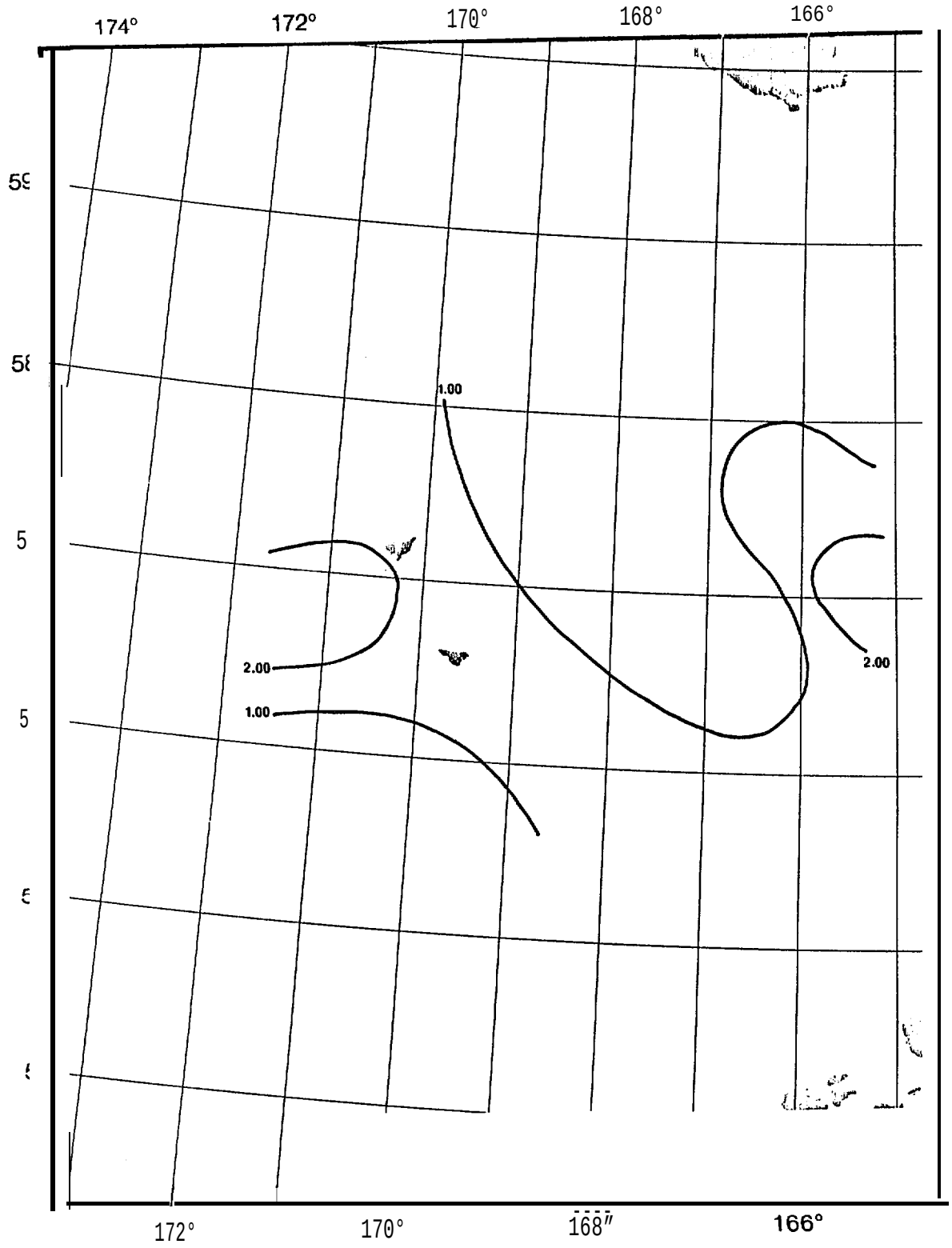

Fig. 2. Isolines of the concentration (ppm, dry weight) of total n-alkanes from c-15 to C-34 in surface sediment of greater St. George Basin. Based on 13 grab specimens in 1975 reported by Kaplan, et al (1977) and Venkatesan, et al (1981).

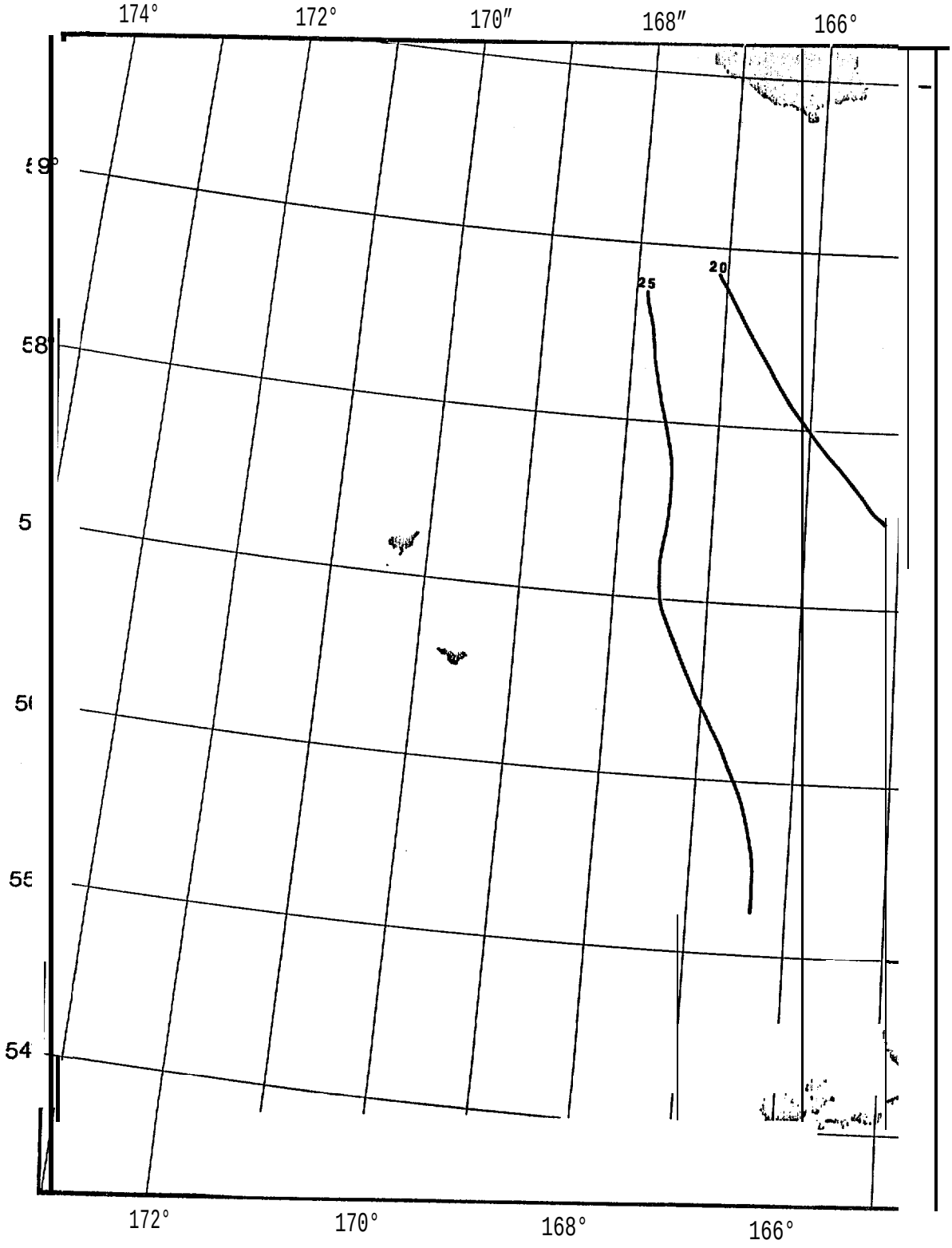

Fig. 3. **Isolines** of the **ratio** of total hydrocarbons to organic carbon x 10,000 **in** surface sediment of greater St. George Basin. Based on 14 grab specimens **in** 1975 reported by Kaplan, **et al (1977)** and **Venkatesan, et al** (1981) .

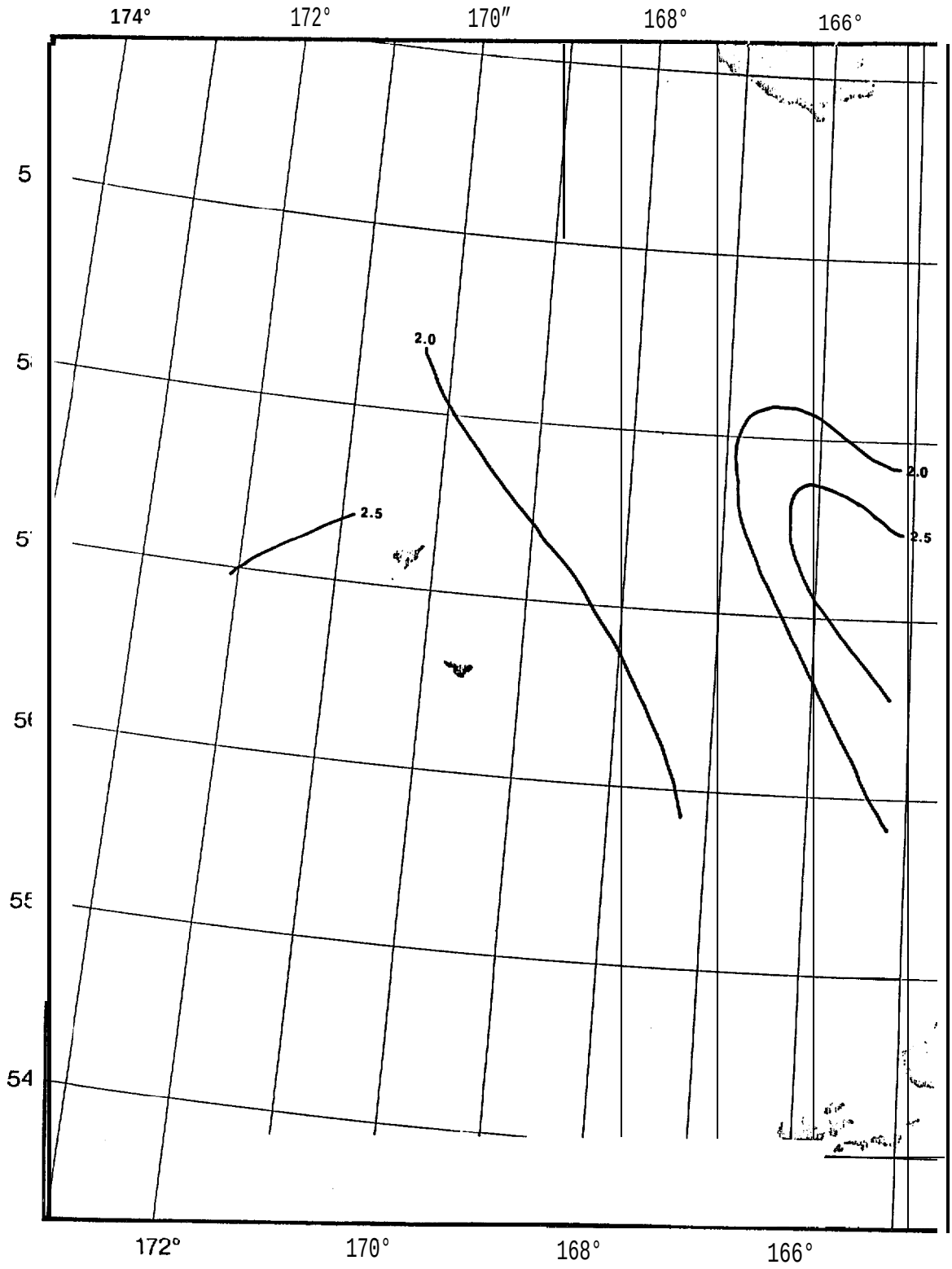

Fig. 4. **Isolines** of the **ratio** of total **n-alkanes** to organic carbon x 10,000 **in** surface sediment of greater St. George **Basin.** Based on 12 grab specimens **in** 1975 reported by Kaplan, et al (1977) and Venkatesan, et al (1981) .

Fig. 5. **Isolines** of the odd-to-even **ratio** for **alkanes** c-15 to C-34 **in** surface sediment of greater **St.** George Basin. Based on 13 grab specimens **in** 1975 reported by Kaplan, et al (1977) and **Venkatesan,** et al (1981).

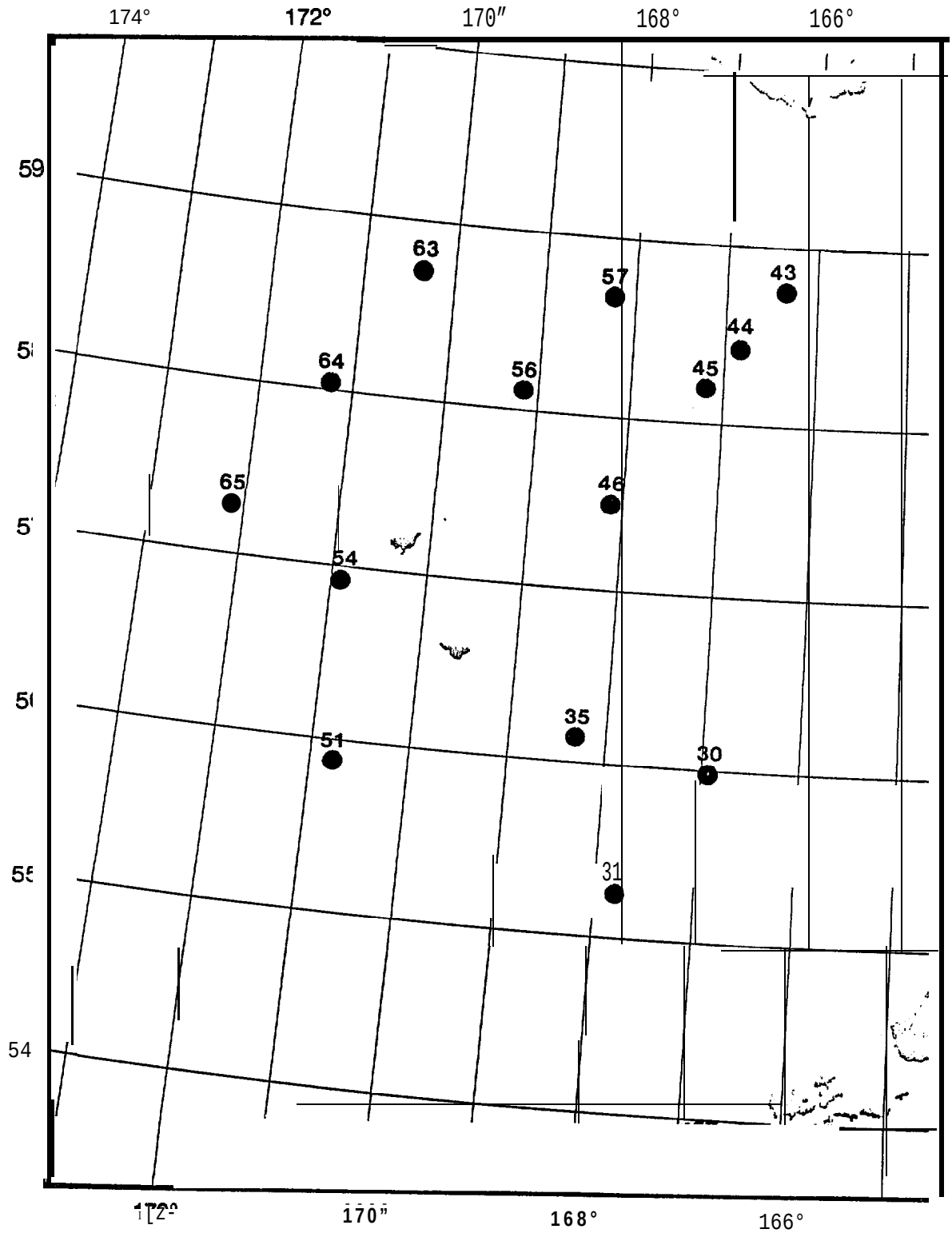

Fig. 6. Fourteen sediment grab stations reported for 1975 extractable metals sampling in the St. George Basin planning area by **Burrell** (1977, 1978). Numbers represent 0SS Discoverer station labels.

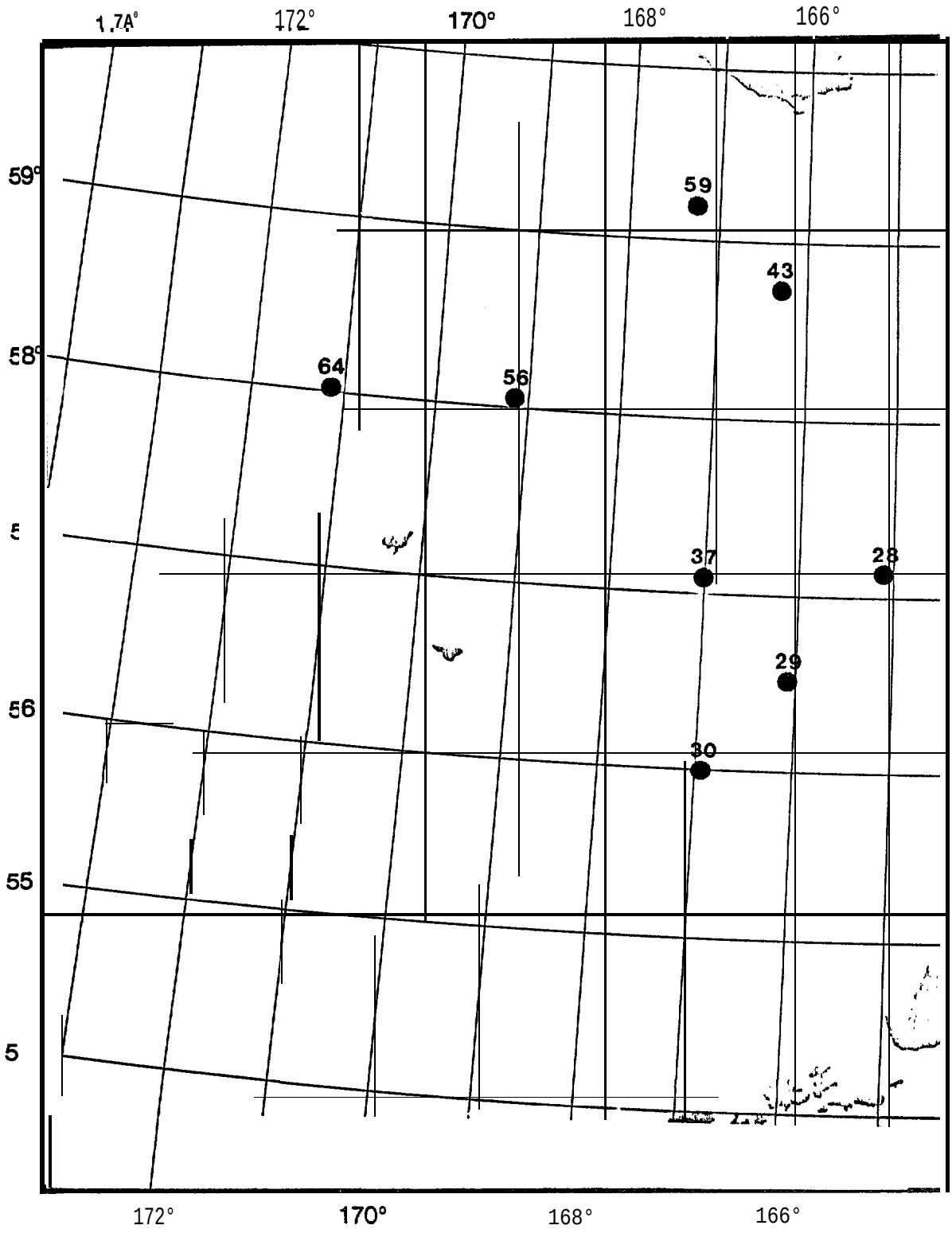

Fig. 7. Eight sediment grab stations reported for 1975 trace metals sampling in the St. George Basin planning area by Robertson and Abel (1979). Numbers represent OSS Discoverer station labels.

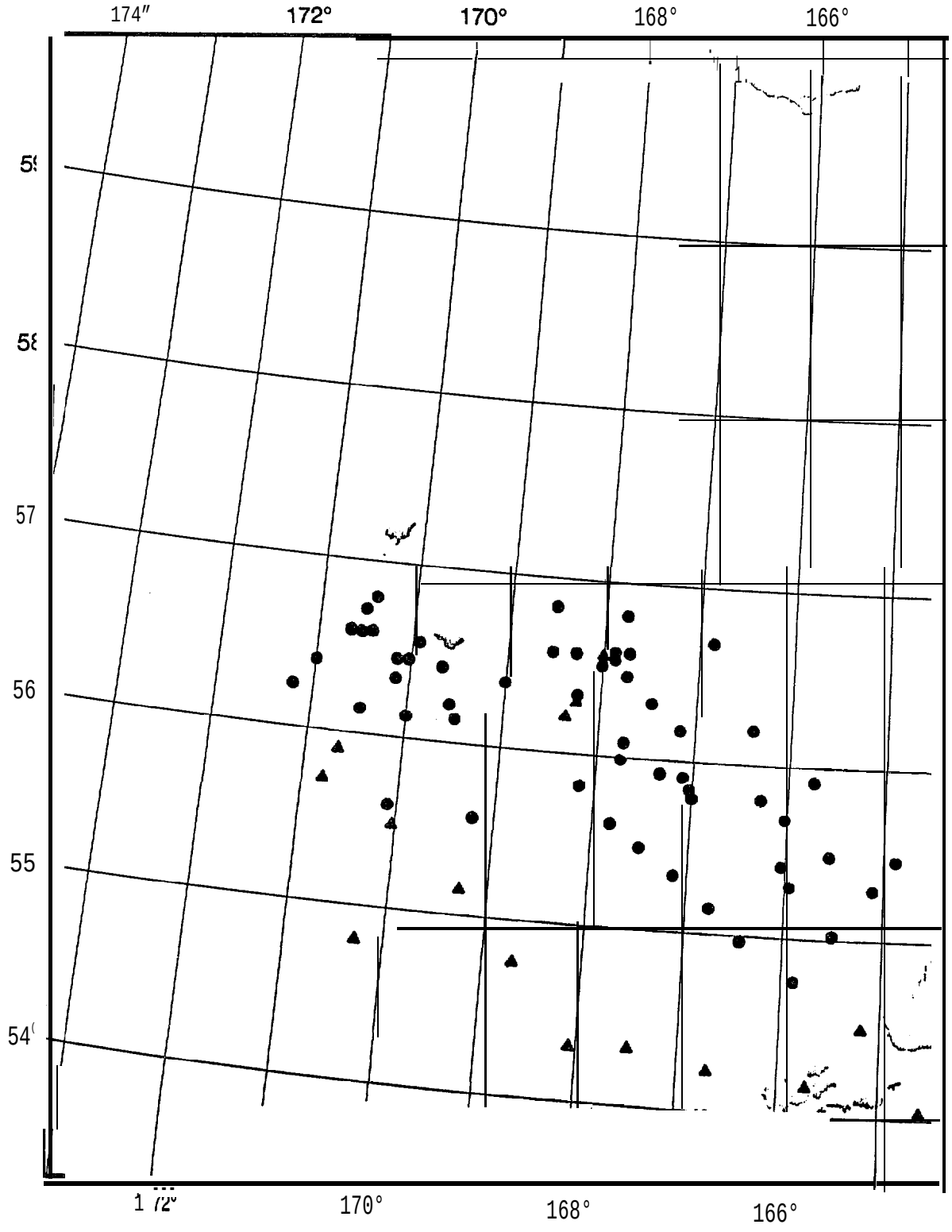

Fig. 8. Location of sediment collections for concentrations of elements in 1976 (circles) and 1977 (triangles) reported by Gardner, et al (1978b) , Latitude and longitude are from Gardner (pers. comm., 1988).

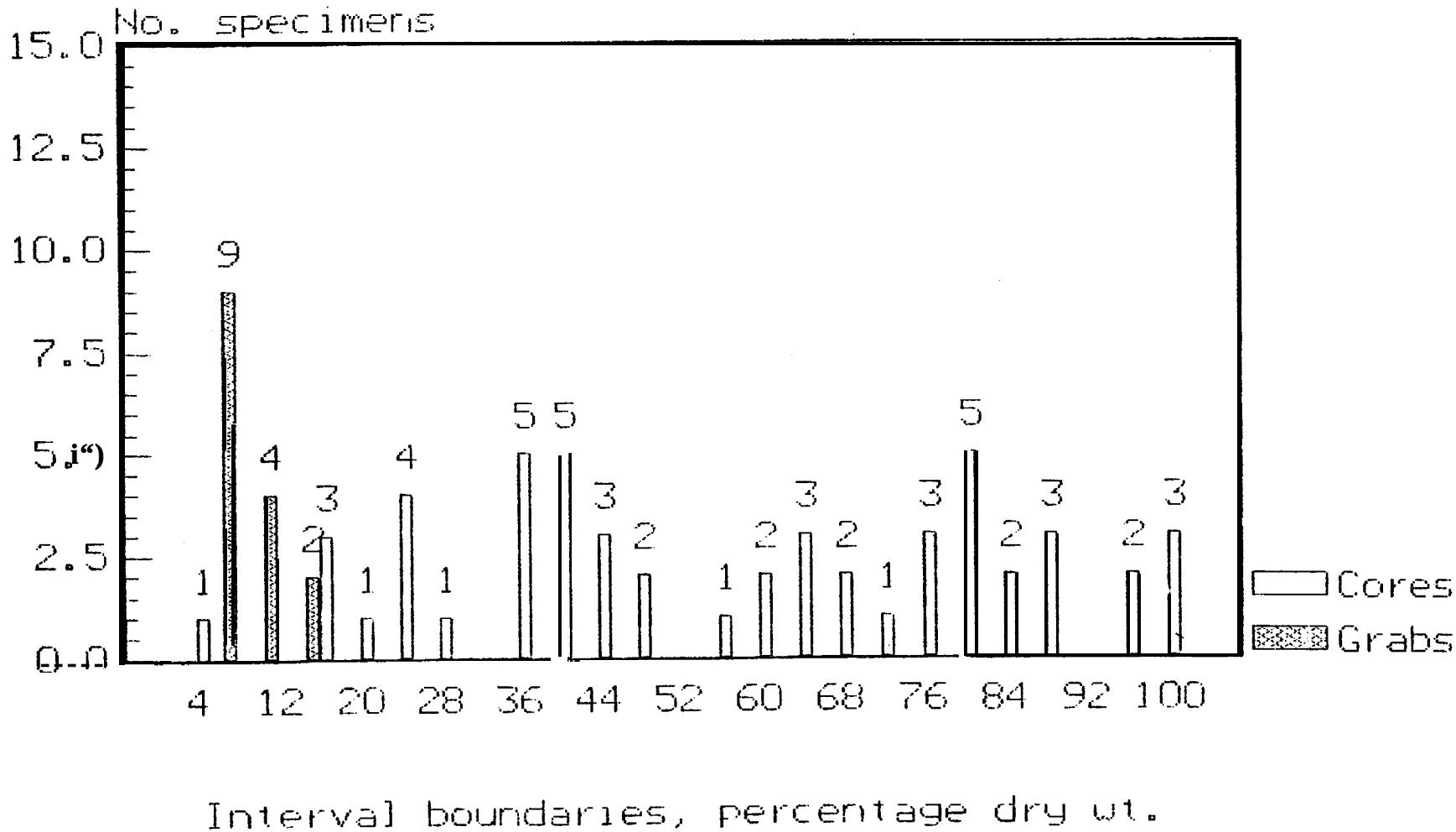

Fig. 9. Frequency of percent silt-clay in surface sediment of St. George Basin. Sample pooled for 1976 and 1977. Based on data in Gardner, et al (1978a).

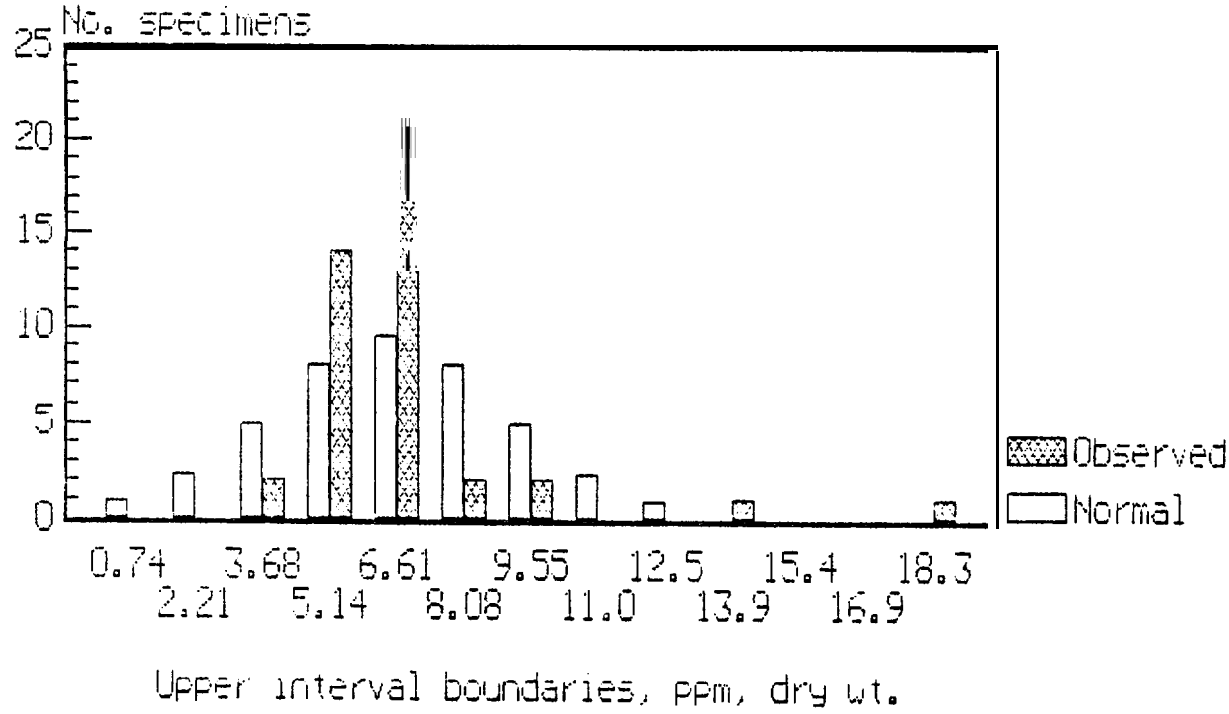

Fig. 10. Frequency distribution of arsenic in surface sediment of St. George Basin. Based on Gardner, et al (1978a) .

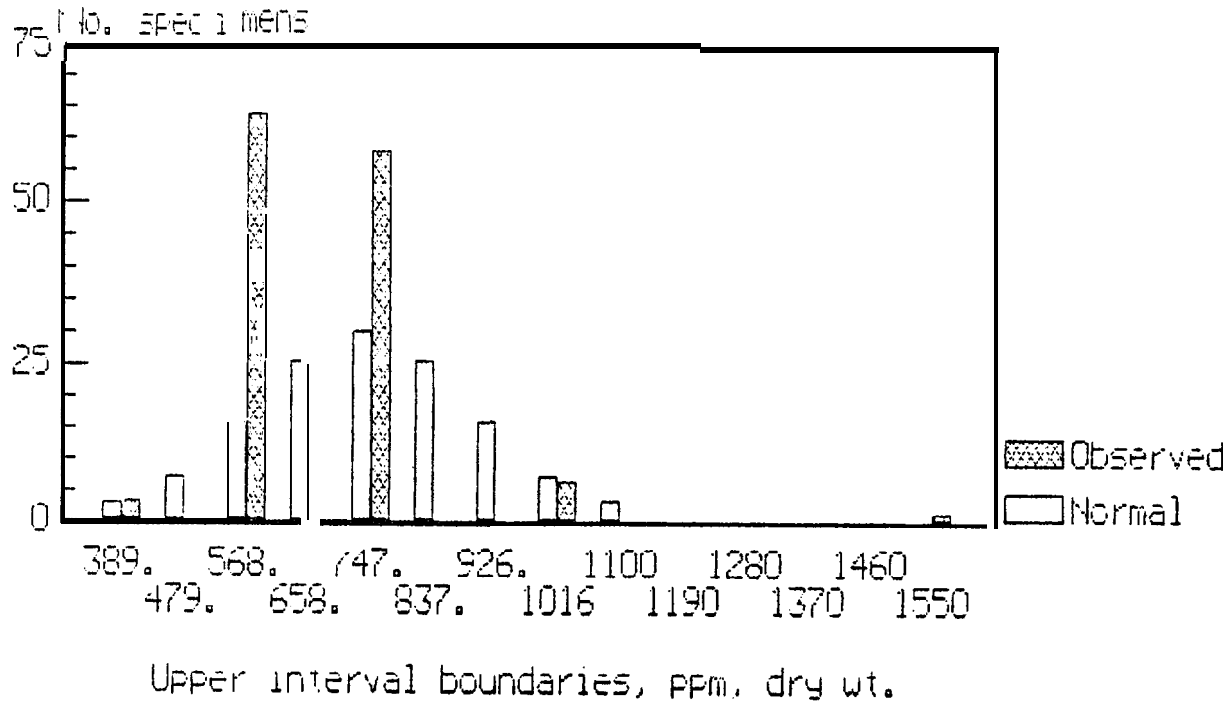

Fig. 11. Frequency distribution of barium in surface sediment of St. George Basin. Based on Gardner, et **al** (1978a) .

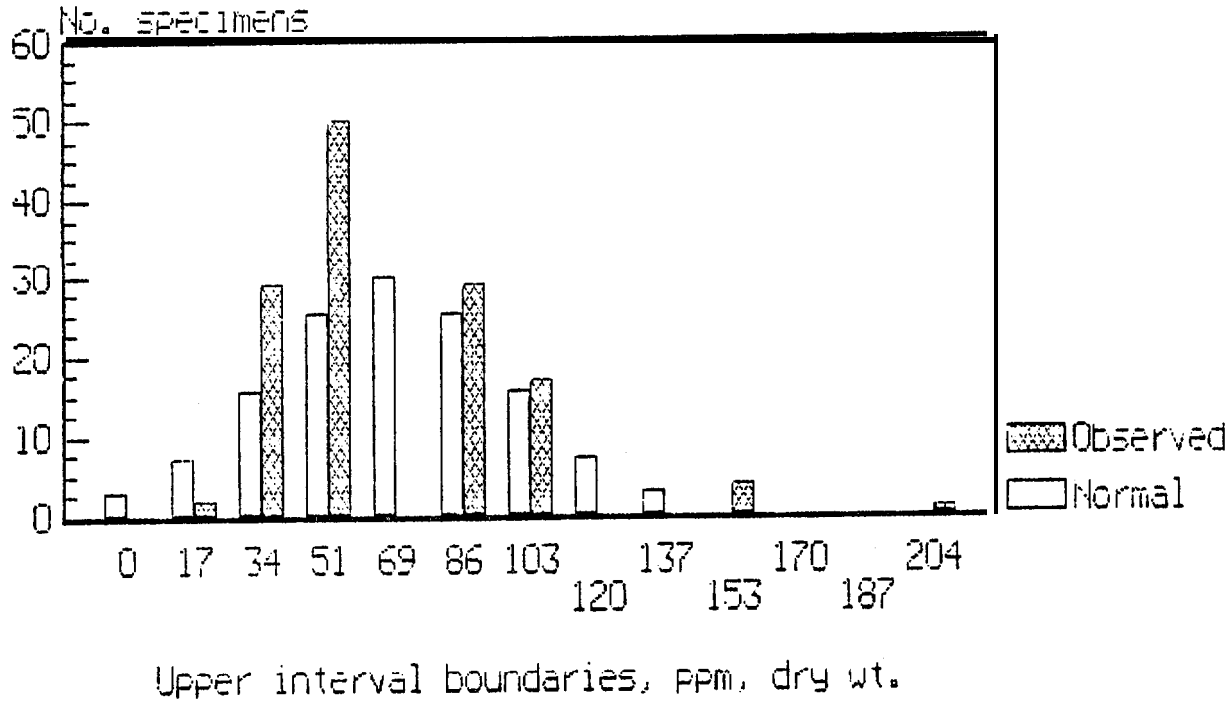

Fig. 12. Frequency distribution of chromium in surface sediment of St. George Basin. Based on Gardner, et al (1978a) .

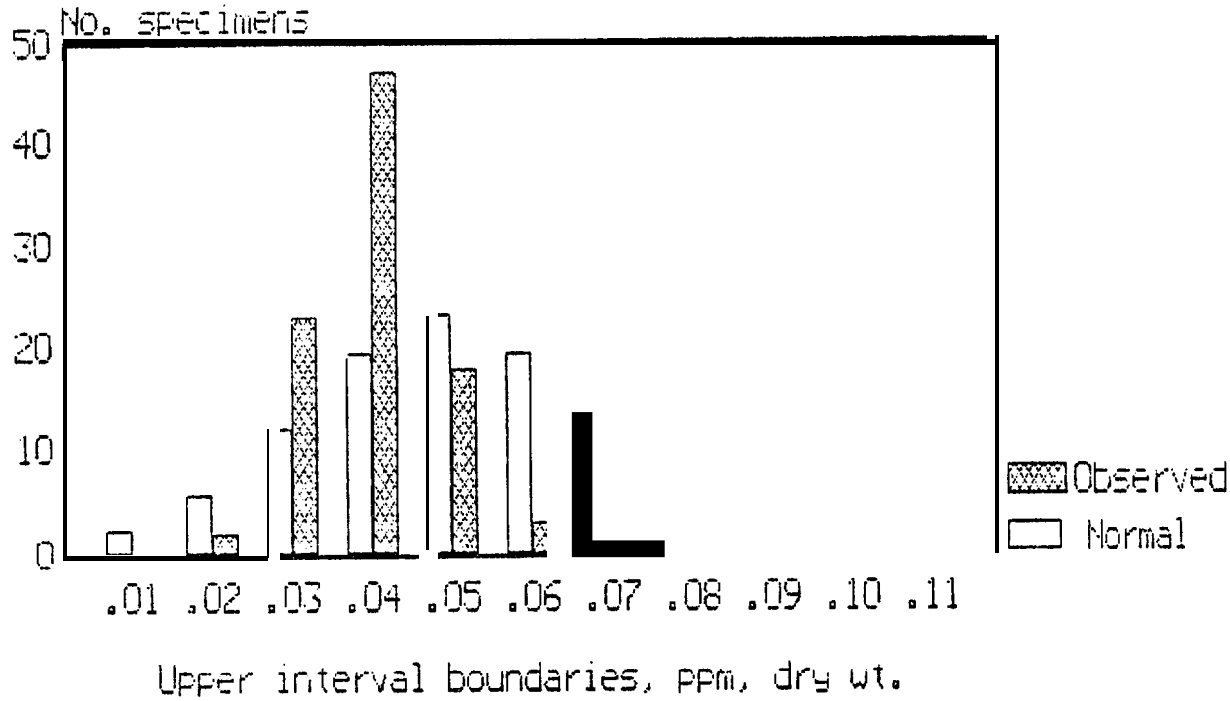

Fig. 13. Frequency distribution of mercury in surface sediment of St. George Basin. Based on Gardner, et al (1978a) .

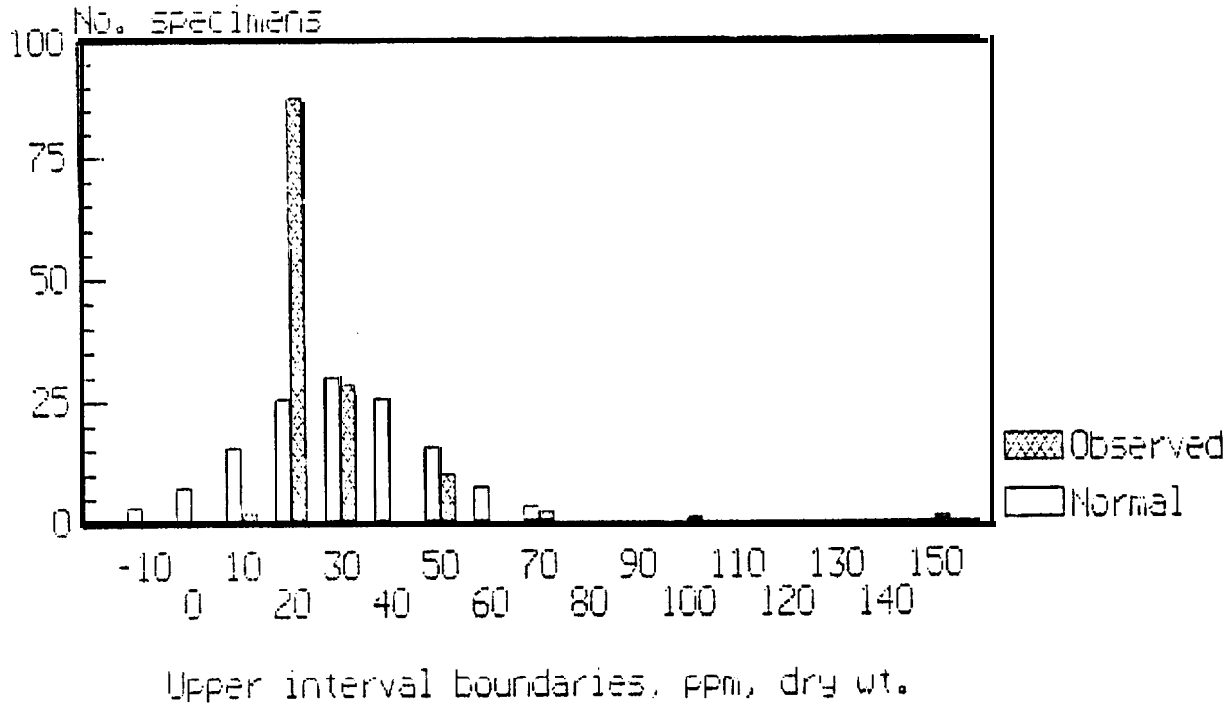

Fig. 14. Frequency **distribution** of **nickel in** surface sediment of St. George **Basin.** Based on Gardner, et al (1978a) .

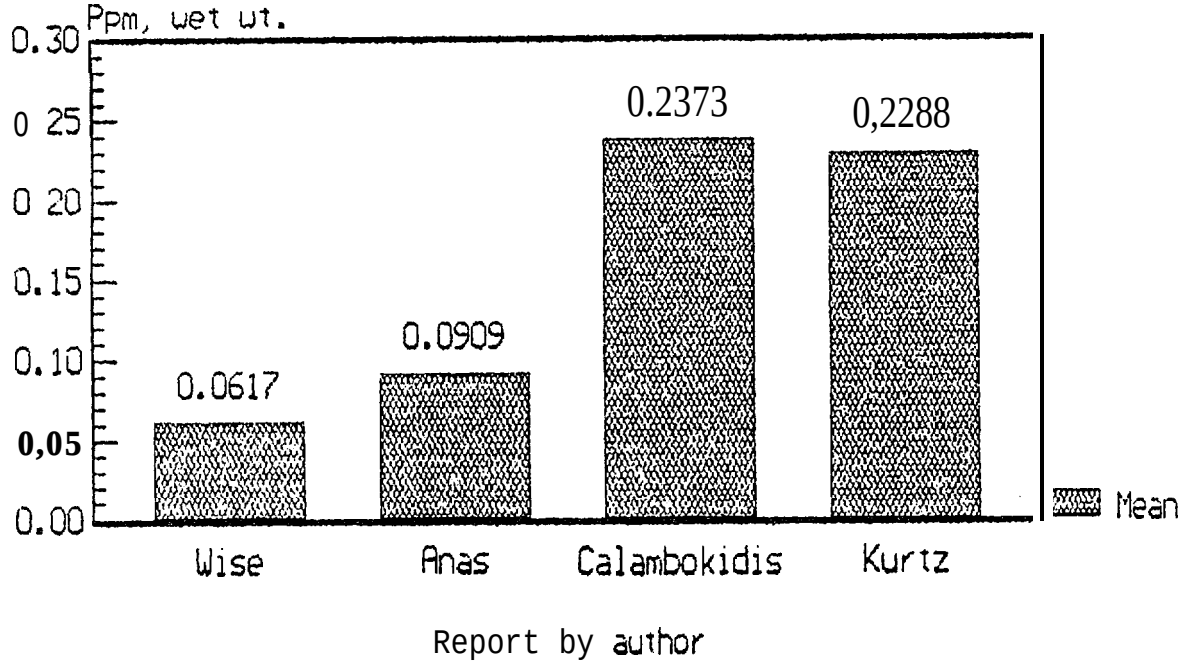

Fig. 15. Concentrations of DDE in livers of **subadult** male northern fur seals on **Pribilof** Islands.

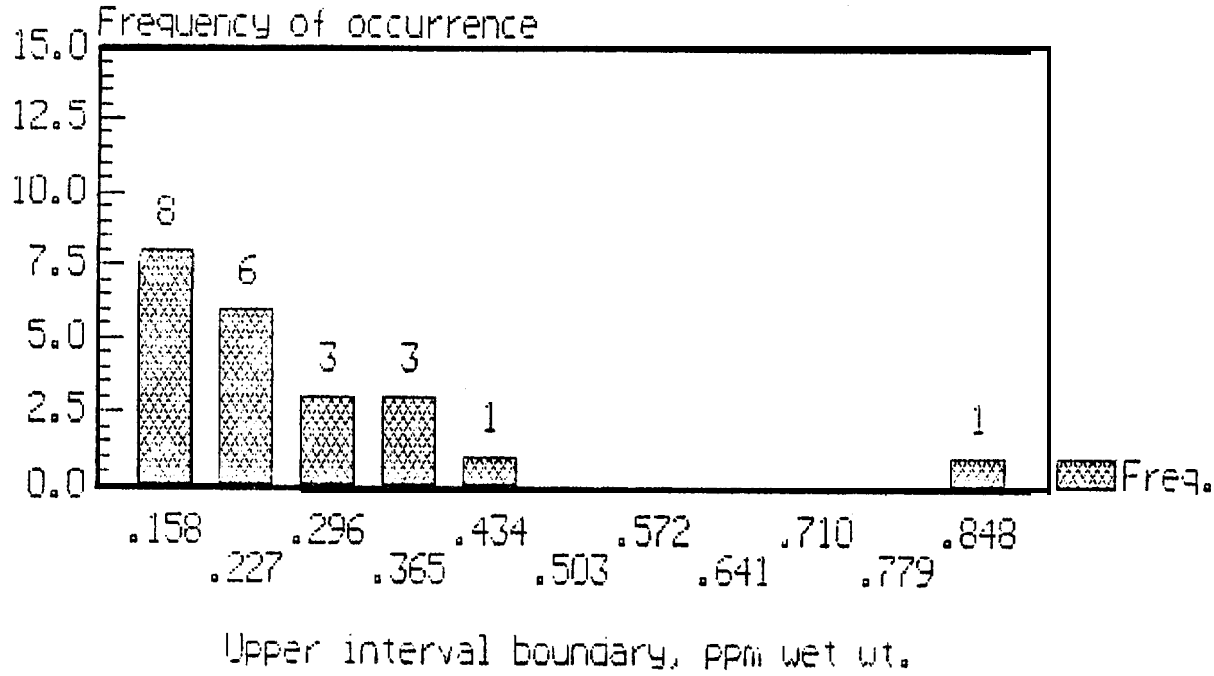

Fig. 16. **DDE** concentrations in liver of **subadult** male northern fur seals on **Pribilof** Islands. Combined from **Kurtz** (no date) and **Calambokidis** and Peard (1985).

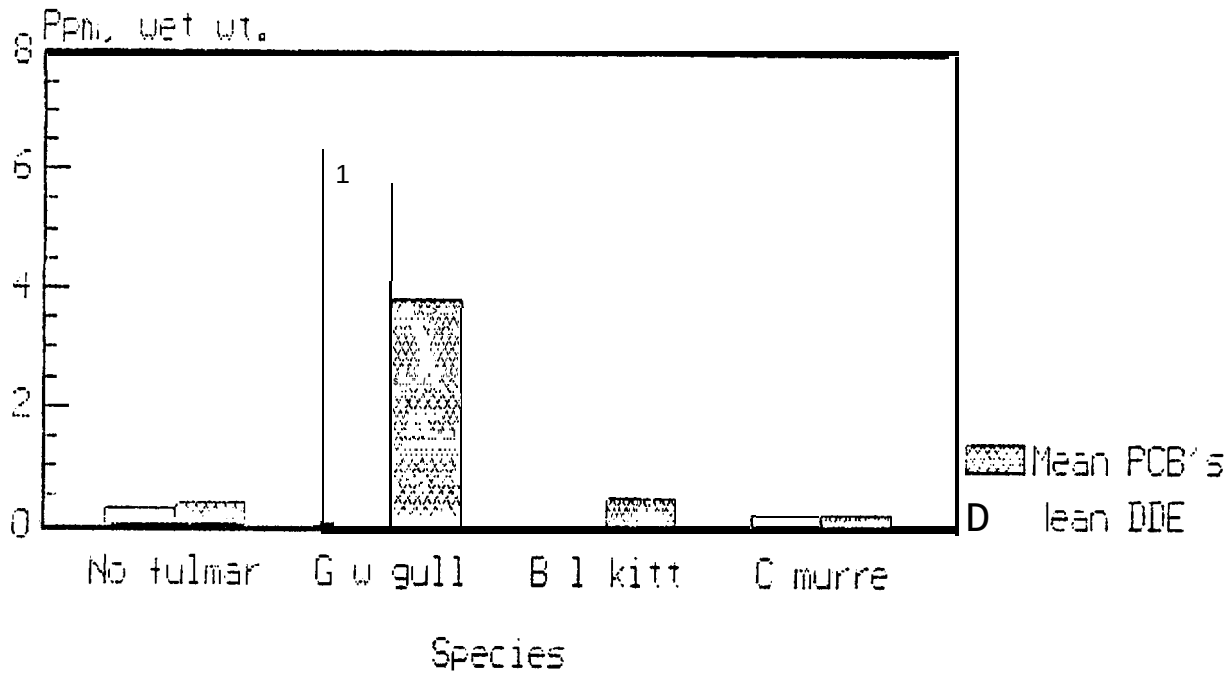

Fig. 17. **Organochlorine** residues in seabird eggs from islands in greater St. George Basin area. Based on **unsummarized** data from H. M. **Ohlendorf (pers. comm.,** 1988) .

Appendix

Tables of data from the original reports

Table Al. Concentrations of pesticides in liver and brain of subadult male northern fur seals (ppm, wet weight basis) at Pribilof Islands, July 2, 1968. Based on Anas and Wilson (1970: Table 1).

Concentrations are not corrected for percent recovery. Recovery rates are as follows: p,p'-DDE, 80-85%; p,p'-DDD (TDE), 82-95%; p,p'-DDT, 91-95%; and dieldrin, 85-90%. PCB's were not in the samples. ND means not detected at lower limit of sensitivity <0.010 ppm, dry weight. Concentrations are unsummarized, single determinations.

Tissue & field no.	Age (years)	DDE	DDD	DDT	dieldrin
Liver					
R-6683	3	0.075	ND	0.025	ND
R-8317	3	0.083	ND	0.038	ND
R-9514	3	0.042	ND	0.031	ND
Q-17766	4	0.044	ND	ND	ND
Q-19800	4	0.30	ND	ND	ND
Q-21025	4	0.068	ND	0.025	ND
Q-21777	4	0.061	ND	ND	ND
Q-24993	4	0.054	ND	0.021	ND
Brain					
R-6683	3	0.019	ND	ND	ND
R-8317	3	0.029	ND	ND	ND
R-9514	3	0.017	ND	ND	ND
Q-17766	4	0.015	ND	ND	ND
Q-19800	4	0.079	ND	ND	ND
Q-21025	4	0.019	ND	ND	ND
Q-21777	4	0.023	ND	ND	ND
Q-24993	4	0.018	ND	ND	ND

Table A2. Mercury concentrations (ppm, wet weight) in northern fur seals in 1970 and in harbor seals on Aug. 17, 1971, at Pribilof Islands. Concentrations are means of four replicates from each tissue specimen. Recoveries were over 90%. Based on Anas (1973, 1974: Tables 1 and 3).

Age (years)	Sex	No. seals	Tissue	Ppm, mercury mean	range
Fur seals:					
0.3 (pups)	mixed	10	liver	0.20	0.1-0.3
0.3 (pups)	mixed	5	muscle	0.06	0.05-0.11
2-3	male	29	liver	10.80	3.0-19.0
2-3	male	29	muscle	0.25	0.1-0.4
Harbor seals:					
	male	1	liver	0.6	-
	female	1	liver	3.2	-
	male	1	liver	0.9	-

Table A3. Concentrations (ppm, dry weight) of heavy metal contents of the soft tissue of legs and claws of tanner crab and soft tissue of Neptunea snails in the St. George Basin planning area. Collected in April, 1976, from Miller Freeman vessel. From OCSEAP report by Burrell (1977: Tables 25 and 26).

Sample no.	Cd	Cu	Ni	Zn
Tanner crab:				
16	<1.3	30.3	<1.3	138
29	<1.3	25.0	<1.3	182
33	<1.3	27.5	<1.3	169
37	3.8	20.4	<1.3	158
48	<1.3	21.4	<1.3	155
Neptunea:				
15	13	215.9	<0.63	72.8
31	<1.3	111.2	0.7	56.8
50	2.5	155.8	0.63	84.8

Table A4. Concentrations (ppm, dry weight) of heavy metals in seals collected in St. George Basin planning area, March 31 to April 27, 1977, from Surveyor vessel. Based on OCSEAP report by Burrell (1979: Tables 3 and 5). Concentrations which are expressed plus or minus 1 SD are for sample sizes of n=2 from duplicate determinations. b=duplicate determinations. c=single determinations.

Specimen	Latitude	Longitude	Species	Sex
Muscle:				
4	58deg 45.6min	172deg 55.4min	Spotted	M
30	58deg 34.8min	169deg 28.8min	Spotted	M
28	58deg 54.2min	169deg 13.6min	Spotted	F
6	58deg 53.0min	173deg 7min	Ribbon	M
3	58deg 56min	172deg 40min	Ribbon	M
2	58deg 51.0min	173deg 8.0min	Ribbon	M
29	58deg 54.2min	169deg 40.3min	Ribbon	M
1	58deg 51.0min	173deg 8.0min	Ribbon	F
7	58deg 43.9min	169deg 32.9min	Bearded	M
8	58deg 48.5min	169deg 41.3min	Bearded	M
Liver:				
4	58deg 45.6min	172deg 55.4min	Spotted	M
30	58deg 34.8min	169deg 28.8min	Spotted	M
28	58deg 54.2min	169deg 13.6min	Spotted	F
6	58deg 53.0min	173deg 7min	Ribbon	M
3	58deg 56min	172deg 40min	Ribbon	M
2	58deg 51.0min	173deg 8.0min	Ribbon	M
29	58deg 54.2min	169deg 40.3min	Ribbon	M
1	58deg 51.0min	173deg 8.0min	Ribbon	F
7	58deg 43.9min	169deg 32.9min	Bearded	M
8	58deg 48.5min	169deg 41.3min	Bearded	M
Kidney:				
4	58deg 45.6min	172deg 55.4min	Spotted	M
30	58deg 34.8min	169deg 28.8min	Spotted	M
28	58deg 54.2min	169deg 13.6min	Spotted	F
6	58deg 53.0min	173deg 7min	Ribbon	M
3	58deg 56min	172deg 40min	Ribbon	M
2	58deg 51.0min	173deg 8.0min	Ribbon	M
29	58deg 54.2min	169deg 40.3min	Ribbon	M
1	58deg 51.0min	173deg 8.0min	Ribbon	F
7	58deg 43.9min	169deg 32.9min	Bearded	M
8	58deg 48.5min	169deg 41.3min	Bearded	M

Table 4. con't

Specimen	Cd Mean	Cd SD	Ni Mean	Ni SD	Cu Mean	Cu SD	Zn Mean	Zn SD
Muscle:								
4	0.14	0.01	3.0	0.2	6.7	1.3	51	9
30	0.16	0.04	<0.5		4.0	O*1	133	0
28	0.11	0.01	<0.5		6.4	0.05	68	1
6	0.47	0.01	5.8	0.0	6.8	0.8	18	6
3	0.25	0	8.3	1.0	5.5	0	54	2
2	0.3	c	1.3	c	4.4	0.6	50	0
29	0.7	0.03	<0.5		1.7	0	74	2
1	0.13	0.01	2.5	0.4	6.7	0.5	37	12
7	0.57	0.04	2.8	0.2	<5	b	147	20
8	1.26	0	1.2	0.1	7.6	o	40	1
Liver:								
4	0.4	0.1	2.5	0.2	25	2.5	116	c
30	7.3	0.2	<0.5		18.5	0.2	160	o
28	4.5	0.05	<0.5		16.4	0.1	136	1
6	11.4	0.1	0.9	0.2	29	2.5	100	10
3	6.4	0.1	2.2	0,4	26.9	1.3	140	15
2	8.7	1.2	1.3		16.5	3.5	8	2
29	17.0	0.3	<0.5		5.2	1.4	130	3
1	6.4	0.1	2.6	0.9	16.5	0.2	169	7
7	22.2	1.3	0.8		22.8	0.2	170	17
8	41.1	0.9	0.5	0	44.1	2.4	87	3
Kidney:								
4	16.7	0.2	2.4	0.4	44.0	13.0	113	23
30	34	5	<0.5	b	15.0	2.5	120	17
28								
6	33.4	0.0	1.2	0.2	17.5	0.3	48	0
3	34.5	c	3.0		16.0	c	98	c
2	20.1	4.5	0.5	0.0	16.5	3.5	102	22
29	37	5	<0.5	b	5.2	,1.3	92	14
1	53.0	0.3	2.8	0.2	19.4	0.1	149	1
7	22.5	2.0	1.3	0.3	40.0	6.0	160	15
8	17.4	0.1	1.5	0.1	28.1	0.6	110	1

Table A5. Concentrations (ppm, dry weight) of heavy metal contents in extracts of surface sediment in the St. George Basin planning area. Collected with HAPS corer from Discoverer vessel in 1975. Based on OCSEAP report by Burrell (1977: Tables 34, 38, 39; 1978: Table 43). nd=not detected.

Sta.	Lat. Deg/Min	Long. Deg/Min	Mud % silt& clay	June 2-19: Cd	Cu	Ni	Zn	Fe	Mn	Cd	Cr	Sep. 25 -Ott .3: Al	Se
30	55 59	166 53		<0.25	2.5	17.3	23.9						
31			23.1	0.25	<2.5	<2.5	7.1	637	9.0				
35	56 12.4	168 20.4									0.4	102	0.09
43	58 42.5	166 16.0	14.7	0.25	<2.5	2.5	6.3				1.7	55	nd
44			14.9	0.25	<2.5	c2.5	5.9	1040	16.2				
46	57 34.5	168 4.5								1.7	0.5	84	nd
51	55 49	170 47									0.9	122	nd
54	56 56.4	170 54.8									0.3	211	.02,.0
56	58 6.5	169 5.4	37.6	0.25	9.9	8.2	19.3					60	nd
57			19.2	0.25	<2.5	<2.5	6.8						
63			49.5	0.25	<2.5	<2.5	13.3	1756	27.3				
64	58 1.5	171 17.0	43.5	0.25	<2.5	<2.5	12.0	1350	20.9	2.8			
65	57 24.9	172 4.6	40.4	0.25	<2.5	<2.5	10.5	915	18.8	2.9	1.9	138	nd
69			41.9	0.25	<2.5	<2.5	12.5	985	21.3				

Table A6. Concentrations (ppm, dry weight) of heavy metal contents in intertidal benthic tissues in the St. George Basin planning area, collected in the summer of 1976. Expressed as the means of duplicate determinations. Based on Burrell (1978: Tables 52 and 53).

	Eider Pt. 53d 57.5m N 166d 35.1m W	Otter Is. 57d 3m N 170d 23.8m W	Makushin Bay 53d 44m N 166d 45.8m W
Mytilus (blue mussel)			
Cd	4.0	4.6	6.0
Cu	9.8	6.0	6.0
Ni	1.3	1.8	1.4
Zn	122	156	81
Fucus (seaweed)			
Cd	5.5	3.1	3.8
Cu	1.5	5.0	0.8
Ni	4.9	5.1	7.1
Zn	17	8	10

Table A7. Concentrations (ppm) of metals in northern fur seals collected on St. Paul Island in the summer of 1975 (Goldblatt and Anthony, 1983). 'The authors state that the means for each metal which share a common letter are not significantly different (P>.05) by Student-Newman-Keul's test, and that they transformed all data to common logarithms for statistical analysis to ensure homogeneity of variance.

	Liver	Kidney	Muscle	Bone
Dry weight:				
Cadmium				
Mean	55.63a	266.92b	0.90c	0.09c
Range	22.50-153.72	127.0-567.76	0.372-3.70	0.035-0.26
SD	27.8	97.7	0.641	0.045
n	37	37	39	39
Zinc				
Mean	233.67a	277.91b	139.15c	119.89d
Range	183.80-331.68	187.74-420.45	60.57-221.99	92.34-142.81
SD	38.8	60.5	38.4	12.9
n	37	36	39	39
Lead				
Mean	1.13a	0.27b	0.26b	1.78c
Range	0.23-14.76	0.02-0.97	0-2.44	0.15-10.30
SD	2.42	0.22	0.4$	2.24
n	36	36	38	38
Nickel				
Mean	0.411a	0.556b	0.530b	1.220c
Range	0.0-3.38	0.10-2.45	0-3.3$3	0.47-1.65
SD	0.32	0.57	0.63	0.27
n	36	36	38	39
Wet weight:				
Mercury				
Mean	10.74			
Range	4.09-42.94			
SD	6.53			
n	37			
Cadmium	16.13	56.05	0.271	0.08
Zinc	67.76	58.36	42.16	108.38
Lead	0.328	0.057	0.081	1.61
Nickel	0.119	0.117	0.161	1.1

Table A8. Proportion of the variation in cadmium and mercury concentrations among 37 northern fur seals which is accounted for by age of seals (Goldblatt and Anthony, 1983: Table 3). The squared correlation coefficients (R-square) are calculated from the significant (P<.05) regressions of concentrations with age.

Meta l	Tissue	R-square
Cadmium	1 iver	0.4516
Cadmium	muscle	0.6593
Cadmium	bone	0.8724
Mercury	liver	0.8427

Table A9. Concentrations of selected elements and auxiliary variables in samples of surface sediment in the St. George Basin, from OCSEAP report by Gardner, et al (1978a: Appendix A and B) and personal communication of latitude and longitude (1988). The investigators state that the upper 30 cm of cores were homogenized by mixing with sea water as a result of the coring operations, and consequently, analyses from cores represent an average value for the upper 30 cm of sea floor. Samples collected by Soutar van Veen were undisturbed and representative of surface sediment to within a few centimeters below the sediment-water interface (Gardner et al, 1978b). Values were determined by x-ray fluorescence (SRF or X), atomic absorption spectroscopy (AAS or A), instrumental neutron activation (N), and emission spectroscopy (S) techniques. Percentage carbon is mean of three determinations of total carbon.

Sample label	Sampling method	Water depth (m)	Lat.	Long.	Top of interval (cm)
1976 cruise S4-76:					
g2	gravity core	248'	54.736	165.883	15
g5	gravity core	118	55.037	165.486	0
g6	gravity core	118	55.037	165.48	3
g8	gravity core	109	55,281	165.129	7
g9	gravity core	109	55.279	165.125	4
g10	gravity core	101	55.504	164.835	0
g11	gravity core	101	55.501	165.837	13
g12	gravity core	101	55.498	164.839	4
g13	gravity core	109	55.899	165.701	14
g14	gravity core	109	55.900	165.703	4
g15	gravity core	108	56.226	166.441	4
g16	gravity core	108	56.227	166.448	7
g17	gravity core	91	56.700	166.921	4
g18	gravity core	91	56.698	166.92	4
g19	gravity core	90	56.789	166.921	0
g20	gravity core	95	56.786	167.836	6
g21	gravity core	95	56.789	167.803	4
g21	gravity core	95	56.789	167.803	4
g27	gravity core	98	56.789	168.605	14
g28	gravity core	98	56.794	168.601	cc
g29	gravity core	98	56.792	168.599	4
g29	gravity core	98	56.792	168.599	4
g32	gravity core	107	56.605	168.285	6
g33	gravity core	111	56.530	167.977	8
g34	gravity core	111	56.528	167.976	4
g34	gravity core	111	56.528	167.976	4
g36	gravity core	111	56.527	167.983	2
g41	gravity core	115	56.452	167.672	6
g42	gravity core	121	56.332	167.447	0

g43	gravity core	12J-	56.327	167.451	0
g46	gravity core	128	56.148	167.116	11
g47	gravity core	129	55.982	166.746	4
g48	gravity core	129	55.982	166.757	0
g49	gravity core	126	55.800	166.332	0
g49	gravity core	126	55.800	166.332	0
g50	gravity core	120	55.668	166.027	0
g50	gravity core	120	55.668	166.027	0
g51	gravity core	120	55.667	166.027	6
g52	gravity core	114	55.517	165.701	9
g53	gravity core	122	55.289	165.984	0
g54	gravity core	122	55.291	165.985	0
g55	gravity core	127	55.432	166.351	4
g55	gravity core	127	55.432	166.351	4
g56	gravity core	128	55.432	166.351	0
g57	gravity core	128	55.431	166.351	0
g59	gravity core	130	55.596	166.669	5
g60	gravity core	131	55.592	166.678	0
g61	gravity core	135	55.795	167s023	4
g62	gravity core	135	55.798	167.029	0
g63	gravity core	133	55.949	167.402	15
g64	gravity core	134	56.106	167.776	4
g65	gravity core	134	56.107	167.769	10
g66	gravity core	157	56.316	168.293	4
g67	gravity core	157	56.328	168.289	5
g69	gravity core	122	56.090	170.05	cc
g7 o	gravity core	400	56.105	170.559	0
g71	gravity core	400	56.105	170.558	2
g75	gravity core	125	56.405	170.972	6
g75	gravity core	125	56.405	170.972	6
g77	gravity core	113	56.620	170.669	0
g80	gravity core	108	56.690	170.563	0
g90	gravity core	105	56.486	170.067	2
g91	gravity core	110	56.371	170.148	0
g105	gravity core	320	56.134	169.543	10
glo7	gravity core	411	56.131	169.544	0
g109	gravity core	135	55.790	168.214	3
g110	gravity core	135	55.800	168.208	4
gill	gravity core	132	55.616	167.84	1
g112	gravity core	133	55.616	167.833	4
g112	gravity core	133	55.616	167.833	4
g113	gravity core	138	55.449	167.481	3
g114	gravity core	138	55.450	167.483	0
g115	gravity core	140	55.289	167.111	4
g115	gravity core	140	55.289	167.111	4
g116	gravity core	140	55.291	167.111	0
g117	gravity core	144	55.132	166.76	0
g118	gravity core	144	55.139	166.76	6
g119	gravity core	145	54.984	166.431	0
g120	gravity core	145	54.983	166.423	4
g120	gravity core	145	54.983	166.423	4
g121	gravity core	57	54.132	165.748	0
V2	van Veen gra	75	57.013	168.265	0
V3	van Veen gra	74	57.121	168.558	0

v6	van Veen gra	82	56.884	168.903	0
V7	van Veen gra	122	56.097	170.048	0
V7	van Veen gra	122	56.097	170.048	0
V9	van Veen gra	60	57.024	169.548	0
v11	van Veen gra	68	56.937	169.414	0
V12	van Veen gra	68	56.861	169.521	0
V14	van Veen gra	126	56.232	169.827	0
V14	van Veen gra	126	56.232	169.827	0
V15	van Veen gra	145	56.326	169.693	0
V17	van Veen gra	85	56.707	169.18	0
v18	van Veen gra	100	56.569	168.907	0
v18	van Veen gra	110	56.569	168.907	0
V21	van Veen gra	101	56.536	168.79	0
v28	van Veen gra	57	54.130	165.744	0
p3	piston core	120	55.661	166.016	3
p5	piston core	135	55.790	167.015	0
p5	piston core	135	55.790	167.015	0
p6	piston core	133	55.944	167.415	6
p7	piston core	110	56.376	170.154	5
p8	piston core	320	56.121	169.554	3

S4-76 Misc. Seals., Pribilof Islands; EM only

g30	gravity core	107	56.638	168.637	1
g31	gravity core	108	56.635	168.637	4
g37	gravity core	107	56.579	167.904	2
g37	gravity core	107	56.579	167.904	2
g38	gravity core	107	56.607	167.862	0
g39	gravity core	107	56.607	167.862	0
g40	gravity core	100	56.678	167.774	6
g4 0	gravity core	100	56.678	167.774	6
g72	gravity core	300	56.252	171.203	4
g72	gravity core	300	56.252	171.203	4
g78	gravity core	111	56.666	170.6	0
g79	gravity core	111	56.664	170.598	0
g81	gravity core	103	56.745	170.483	30
g82	gravity core	97	56.807	170.399	20
g89	gravity core	96	56.564	169.94	0
g94	gravity core	123	56.379	169.624	cc
glo3	gravity core	125	56.361	169.041	2
V4	van Veen gra	80	56.997	168.738	0
V5	van Veen gra	81	56.995	168.805	0
v10	van Veen gra	60	56.951	169.638	0
V19	van Veen gra	110	56.562	168.748	0
V20	van Veen gra	102	56.556	168.766	0
V22	van Veen gra	102	56.504	168.837	0
V22	van Veen gra	102	56.504	168.837	0
V23	van Veen gra	103	56.491	168.857	0
V23	van Veen gra	103	56.491	168.857	0
V25	van Veen gra	125	56.362	169.031	0
p10	piston core	2850	55.634	170.085	107
p13	piston core	2080	55.513	169.258	25

1977 cruise S6-77:

g14	gravity core	1309	54.213	166.637
g16	gravity core	825	54.336	167.515
g19	gravity core	1190	54.376	168.089
g20	gravity core	2230	54.763	168.707
g22	gravity core	2151	55.173	169.332
g23	gravity core	2030	54.839	170.37
g24	gravity core	2900	55.524	170.02
g25	gravity core	2900	55.514	170.028
g26	gravity core	3158	55.719	170.79
g29	gravity core	2648	55.944	170.673
V4	van Veen gra	166	56.200	168.34
v6	van Veen gra	76	54.804	164.975

1977 cruise S6-77 data, seawater corrected:

V5	62	55.041	164.512
v6	76	54.804	164.975
v6	76	54.804	164.975
V7	142	54.478	165.153
g7	109	54.478	165.153
g12	154	56.298	168.235
g12	154	56.298	168.235
g14	1309	54.213	166.637
g16	825	54.336	167.515
g19	1190	54.376	168.089
g20	2230	54.763	168.707
g22	2151	55.174	169.332
g23	2030	54.839	170.37
g24	2900	55.524	170.02
g25	2900	55.514	170.028
g25	2900	55.514	170.028
g26	3158	55.719	170.79
g29	2648	55.944	170.573

Table A9. con't

Sample label	Pet. silt &clay	Mean % carbon	Parts per million: Hg-a	Zn-a	As-x	Ba-s	Cr-a	Cu-a	Ni-s	V-s
1976 cruise S4-76:										
g2	18.88	0.39	0.03	116	4.065	500	15	70	15	150
g5	23.64	0.41	0.04	107.		300	7	70	10	200
g6			0.03	119	3.773	500	30	70	15	300
g8	36.02	0.43	0.04	91	6.023	500	30	50	15	200
g9			0.03	97	4.520	500	30	70	15	200
g10			0.05	72		700	50	30	15	150
g11	24.39	0.32	0.04	71		700	50	30	15	150
g12			0.04	71	5".825	500	50	30	15	100
g13	57.18	0.72	0.03	83		500	50	30	20	150
g14			O*04	79	5.927	500	30	30	15	100
g15			0.08	77	5.612	700	50	20	30	150
g16			0.05	82		700	100	50	15	150
g17			0.04	70	6.289	700	30	20	15	70
g18			0.04	68		700	70	30	20	100
g19	36.61	0.48	0.03	65	5.719	700	50	15	30	150
g20	23.21	0.40	0.06	63		500	30	15	20	100
g21			0.04	63	6.084	700	70	15	20	70
g21			0.04	63		700	50	15	15	100
g27	24.48	0.39	0.03	62		700	50	15	20	100
g28			0.04	58		500	50	15	15	70
g29			0.04	58		700	50	20	20	70
g29			0.04	58		700	50	15	20	70
g32	18.09	0.31	0.03	58		700	50	15	20	100
g33	26.40	0.46	0.04	65		500	30	20	20	70
g34			0.03	57	4,697	700	50	15	30	100
g34			0.04	61		500	70	15	15	100
g36			0.04	55		700	70	15	20	70
g41	36.00	0.47	0.04	70	5.726	700	30	20	20	100
g42			0.04	85	4..566	700	100	30	20	150
g43	61.26	0.69	0.06	84		500	50	50	20	100
g46	81.83	0.97	0.04	94		500	50	30	30	150
g47			0.04	101	6.265	500	50	50	20	150
g48	86.65	0.98	0:04	100		500	50	50	20	150
g49	86.09	0.83	0.04	107		500	30	70	15	150
g49	86.09	0.83	0.05	98		500	30	50	15	150
g50			0.04	102		500	30	50	15	150
g50			0.08	115		500	30	50	15	200
g51	74.58	0.67	0.05	106		500	50	50	20	200
g52	78.94	0.61	0.00	96		500	30	50	10	150
g53			0.03	112	5.108	500	30	70	15	200
g54	63.07	0.56	0.05	108	5.843	500	50	70	15	200
g55			0.05	99	5.594	500	30	50	15	200
g55			0.04	99		500	30	50	20	200
g56	77.37	0.75	0.04	99	5.726	500	30	50	15	200

g57			0.04	101		500	30	50	15	200
g59	80.48	0.88	0.04	93		500	30	50	15	150
g60			0.06	99		500	50	50	15	150
g61			0.03	108	6.048	500	50	50	30	150
g62	71.86	0.94	0.04	94		500	50	50	15	150
g63	79.00	0.99	0.04	102	3.484	700	50	50	15	150
g64			0.05	68	4.278	500	50	20	15	100
g65	36.96	0.50	0.04	69		700	50	20	20	150
g66			0.04	73	4.945	700	70	30	30	150
g67	13.65	0.31	0.04	72		500	50	20	15	100
g69	15.22	0.34	0.04	58		700	50	15	15	100
g70			0.08	111	8.549	700	100	50	20	200
g71	79.98	0.70	0.07	118		500	70	50	20	150
g75	23.17	O*OO	0.03	55		500	50	15	20	70
g75	23.17	0.00	0.04	59		500	50	15	20	100
g77	45.80	0.52	0.04	62	4.065	500	50	15	20	100
g80	62.06	0.82	0.05	72		700	70	20	20	100
g90	75.86	0.87	0.05	79		700	100	30	30	100
g91			0.04	79	4.049	700	100	20	30	150
glo5	75.71	0.91	0.08	134	18.530	700	100	70	50	150
glo7			0.11	140	13.310	1500	100	70	50	200
g109	12.53	0.34	0.02	57		700	70	30	15	100
g110			0.04	60	4.995	500	50	15	15	100
gill	32.81	0.43	0.04	66		700	50	30	15	150
g112			0.05	66	4.013	700	30	20	15	150
g112			0.04	65		500	50	20	15	150
g113	52.87	O*OO	0.03	82	5.608	500	30	50	15	150
g114			0.05	82	3.816	700	70	50	15	150
g115			0.04	97	4.897	500	30	50	15	150
g115			0.05	104		500	30	50	15	150
g116	44.97	0.41	0.05	90		500	30	50	15	150
g117			0.03	110		500	50	70	15	200
g118	58.29	0.59	0.04	97		500	30	50	15	150
g119	66.46	0.55	0.05	99		500	30	70	15	200
g120			0.03	108		500	50	70	20	200
g120			0.05	108		500	30	50	15	150
g121	67.64	0.75	0.11	102		300	30	70	15	200
V2	7.19	0.25	0.03	45	5.191	500	70	7	15	70
V3	5.94	0.22	0.03	45	5.419	700	200	7	15	70
v6	8.26	0.00	0.02	46	6.358	700	50	7	15	70
V7	14.38	0.40	0.03	59		700	50	15	15	100
V7	14.38	0.40	0.04	113		500	70	20	20	70
V9	4.14	0.22	0.04	55		500	70	7	50	70
v11	5.74	0.29	0.04	55	6.700	700	70	15	30	100
v12	5.91	0.23	0.03	48	6.984	700	100	10	30	100
v14	8.76	0.31	0.04	61	5.257	500	50	15	20	100
V14	8.76	0.31	0.04	58		500	50	15	30	70
v15	5.02	0.22	0.03	68		500	150	15	50	150
v17	7.23	0.28	0.04	71	5.639	500	150	20	150	100
v18	5.90	0.26	0.03	63	5.559	700	70	15	50	150
v18	5.90	0.26	0.03	62		500	100	15	30	150
V21	9.57	0.31	0.03	58	3.433	700	70	15	30	100
v28			0.08	102		300	30	100	70	200
p3			0.04	102		500	50	70	15	200
p5			0.03	109		700	50	50	20	150
p5			0.05	97		500	50	50	15	150

p6			0.05	96		500	50	50	20	150
p7	79.20	0.76	0.05	85		700	100	30	30	150
p8			0.09	130	8.331	700	70	50	30	200

S4-76 Misc. Seals., Pribilof Islands, EM only:

g30	700	70	15	30	100
g31	700	70	20	30	100
g37	1000	50	15	20	100
g37	700	50	15	15	70
g38	700	50	20	20	100
g39	700	100	30	30	150
g40	1000	50	15	20	100
g40	700	50	20	20	70
g72	700	100	50	50	150
g72	500	70	50	50	150
g78	700	70	15	20	70
g79	700	70	15	20	70
g81	700	70	30	30	150
g82	1000	70	30	30	150
g89	700	100	20	50	150
g94	500	150	70	100	200
glo3	700	100	20	50	150
V4	700	70	10	15	70
v5	500	150	15	20	70
Vlo	500	70	10	70	70
V19	700	70	15	30	70
V20	700	100	15	30	100
V22	500	70	20	30	70
V22	700	100	15	30	100
V23	700	70	15	30	70
v23	1000	70	15	30	150
v25	700	100	20	50	200
plo	1000	50	70	30	150
p13	1000	50	100	30	100

1977 cruise S6-77:

g14	32.17	1.46
g16	33.24	1.13
g19	39.40	1.12
g20	39.04	1.52
g22	37.56	1.70
g23	33.99	1.56
g24	41.16	1.43
g25	42.44	1.22
g26	22.76	1.15
g29	43.40	1.45
V4	89.40	0.00
v6	91.43	0.37

1977 cruise S6-77 data, seawater corrected:

V!5	0.04	135	14.000	300	50	20	30	300
v6	0.04	0	0.000	500	20	70	15	300
v6	0.01	107	4.600	500	15	70	15	150
V7	0.03	102	86.000	500	30	70	15	300
g7	0.04	56	4.900	700	70	15	30	150
g12	0.08	121	4.800	700	100	70	70	300
g12	0.09	126	9.000	700	70	70	70	150
g14	0.01	101	0.000	500	30	100	50	200
g16	0.04	119	5.200	500	30	150	30	200
g19	0.01	110	3.400	700	30	150	30	150
g20	0.04	95	0.000	1000	30	100	50	150
g22	0.01	88	0.000	1000	30	100	30	150
g23	0.01	0	0.000	1500	30	70	30	70
g24	0.08	89	0.000	1500	30	100	50	100
g25	0.12	83	0.000	700	30	70	30	150
g25	0.04	84	0.000	700	50	70	30	150
g26	0.10	105	0.000	700	50	100	30	150
g29	0.03	99	0.000	700	50	70	30	150

Table A10. Concentrations (ppm, dry weight) and ratio indices of hydrocarbons in surface sediment, 0-10 cm, of St. George Basin planning area. Bottom was sampled by steel van Veen grabs in 1975. From Venkatesan, et al (1981: Table 25-1) and OCSEAP report by Kaplan, et al (1977: Tables 1, 5, 7, 9). Total hydrocarbons = sum of hexane and benzene fractions. nd=not determined. nr=not resolved.

Station label	Latitude	Longitude	Water depth (m)	Aliphatic fraction	Aromatic fraction	Total hydrocarbons	Total n-alkanes	% organic carbon	Pristane/ phytane
17	55deg. 26.4min.	165deg. 49.1min.	119	13	5.2	18.2	1.09	0.76	3.97
28	57deg. 10.4min.	165deg. 04.4min.	70	8.7	4.1	12.8	2.93	0.59	10.2
35	56deg. 12.4min.	168deg. 20.4min.	160	180.1	60.8	240.9	nr	0.41	nr
37	57deg. 05.3min.	167deg. 00.6min.	75	5.8	4.0	9.8	0.76	0.41	1.76
38	57deg. 40.1min.	166deg. 05.8min.	66	4.9	10.6	15.5	1.64	0.66	5.18
40	58deg. 07.3min.	165deg. 15.6min.	46	1.9	2.6	4.5	0.61	0.32	3.37
43	58deg. 42.5min.	166deg. 16.0min.	37	2.4	2.7	5.1	0.52	0.30	2.26
46	57deg. 34.5min.	168deg. 04.5min.	70	4.3	7.5	11.8	0.74	0.42	17.90
51	55deg. 49min.	170deg. 47min.	-	2.8	0.6	3.4	0.77	nd	3.49
54	56deg. 56.4min.	170deg. 54.8min.	105	7.4	9.9	17.3	2.10	0.68	8.80
56	58deg. 06.5min.	169deg. 05.4min.	71	10.6	8.5	19.1	0.75	0.47	2.93
58	58deg. 43.5min.	167deg. 21.0min.	44	3.8	2.8	6*6	0.28	0.31	4.80
64	58deg. 01.5min.	171deg. 17.0min.	90	12.3	9.8	22.1	1.79	0.77	2.27
65	57deg. 24.9min.	172deg. 04.6min.	109	6.9	9.6	16.5	1.60	0.67	16.43

Table A10. con't

Pristane/ C-17	Phytane/ C-18	(Total hydrocarbons/ organic carbon) x 10exp4	(Total n-alkanes/ organic carbon) x 10exp4	Odd/even for C-15 to c-34
18.1	0.41	23.9	1.4	3.43
2.16	0.26	21.7	5.0	4.09
nr	nr	587.6	nr	nr
1.45	0.36	23.9	1.8	3.28
2.21	0.30	23.5	2.5	4.41
0.93	0.32	14.1	1.9	3.41
0.97	0.48	17.0	1.8	3.08
10.3	0.41	28.1	1.8	3.59
2.14	0.49	25.4	nd	2.56
3.06	0.36	25.4	3.1	2.57
3.34	2.71	40.6	1.6	3.78
1.26	0.32	21.3	0.9	3.33
0.96	0.96	28.7	2.3	2.75
7.74	7.74	24.6	2.3	3.77

Table All. Trace element concentrations (dry weight) in surface sediment collected by HAPS corer from Discoverer vessel, June 12-19, 1975. From OCSEAP report by Robertson and Abel (1979: Tables C.1 and C.2). The authors did not provide labels for dispersion estimates accompanying each mean, nor the sample sizes.

Station (MB label)	Lat.	Long.	Water depth (m)	Aluminum percent Mean		Calcium percent Mean		Manganese ppm Mean	
28 (0-3cm)	57d 10m	165d 04m	69	1.05	0.03	2.31	1.03	524	50
29 (0-4cm)				5.90	0.02	2.09	0.33	572	45
30 (0-4cm)	55d 59m	166d 53m	134	6.10	0.03	2.97	1.34	571	43
37 (0-2cm)	57d 06m	167d Olm	75	5.50	0.03	2.32	1.00	358	42
43 (0-2cm)	58d 42m	166d 17m	38	5.05	0.07	1.70	0.25	400	13
56 (0-2cm)	58d 06m	169d 05m	71	5.01	0.10	1.73	0.50	341	7
59 (0-2cm)	59d 12m	167d 18m	38	5.10	0.02	2.08	0.47	366	42
64 (0-2cm)	58d Olm	171d 07m	85	5.10	0.03	3.73	1.25	397	48

Vanadium ppm Mean		Arsenic ppm Mean		Barium ppm Mean		Cobalt ppm Mean		Chromium ppm Mean		Iron % Mean		Antimony ppm Mean	
92	25	2.9	0.5	490	170	9	-	63	4	2.67	-	0.56	0.14
77	23									-	-		
112	24	3.4	0.6	200	190	10	-	38	5	3.55	-	0.55	0.13
85	23	4.1	0.6	430	190	9.1	-	53	4	2.53	-	0.61	0.11
90	21	3.2	0.5	<420	-	7.0	-	61	5	2.06	-	0.57	0.1
85	17	0.7	0.6	<260	-	9	-	86		2.59	-	0.63	0.08
77	22	4.0	0.4	1070	340	9	-	107		2.52	-	0.73	0.08
82	24	2.7	0.8	1030	340	9	-	93		2.68	-	0.48	0.09

Table A12. Concentrations (ppm, wet weight) of metals in tissues of 62 male northern fur seals, aged 2 to 4 years, at 5 rookeries in the Pribilof Islands, 1985 (Skoch and Metzger, 1988).

These data have been entered by hand from tables of original lab determinations provided by the authors in a personal communication from Metzger (1987). Missing data are represented by blank spaces. Codes are m=muscle, k=kidney, l=liver, nda=no detectable amount.

Rookery & animal label	Tiss.	Parts per million: Titan."	Iron	Cadmium	Selenium
North East Point West Rookery					
14	m	nda	2100.50	17.14	237.19
14	k	nda	5230.84	259.56	192.06
14	1	nda	1350.69	163.68	191.67
10	l	nda	1085.81	56.80	184.44
10	k	nda	406.25	331.56	382.50
10	m	30.72	1066.27	4.76	386.75
21	1	13.86	2453.18	56.37	258.43
21	m	13.45	1098.65	7.31	286.10
21	k	35.11	336.41	138.85	565.65
24	k	10.44	1097.64	52.29	235.02
24	m	nda	1725.81	24.72	358.87
24	k	nda	432.31	343.80	nda
24	k	3.04	585.55	261.94	119.39
28	k	nda	192.31	105.00	171.98
28	1	5.77	1282.05	52.85	108.97
28	m	nda	1150.49	98.79	187.86
5	k	nda	255.32	159.57	160.00
5	1	9.64	2358.82	124.38	140.50
5	1	nda	1981.98,	337.12	329.73
5	m	nda	1524.75	10.64	201.98
32	m	nda	3651.38	2.94	378.90
32	l	nda	2526.98	58.70	137.46
32	k	nda	896.00	331.84	183.60
20	1	nda	1317.16	166.04	179.85
20	m	nda	1661.65	4.81	393.23
20	k	nda	813.13	339.39	276.26
25	m	nda	1581.56	10.50	312.77
25	k	nda	613.73	674.68	227.47
25	1	nda	3244.87	215.71	180.11
31	1	nda	2607.73	70.77	330.94
31	m	nda	1286.38	1.07	130.52
31	m	nda	1632.43	0.76	144.86
31	k	nda	1026.92	173.85	111.15
31	k	nda	915.32	196.37	114.11
3	1	nda	1323.08	96.86	104.62
3	k	nda	1222.41	217.74	121.82
3	m	nda	1896.71	15.45	177.00
42	m	nda	5655.17	20.23	214.94

42 k	nda	1159.29	443.66	109.49
42 1	nda	2245.17	202.80	84.61

Polovina Rookery

6 m	nda	1953.61	10.26	122.16
6 k	nda	1087.14	324.90	159.75
6 1	nda	3931.25	371.13	281.25
18 k	15.44	1007.72	271.01	145.80
18 1	36.78	2990.41	290.41	168.44
18 m				
29 m	30.82	2731.66	323.94	375.48
29 k	65.39	743.93	343*77	99.84
29 1	nda	2851.08	55.55	142.39
21 1	nda	1967.36	90.79	137.93
21 k	nda	791.67	242.08	197.08
21 m	nda	3650.79	5.89	191.73
25 m	nda	1164.31	5.95	229.33
25 k	nda	597.74	373.99	180.53
25 k	nda	577.35	351.46	227.02
25 1	nda	1182.52	156.30	125.64
23 1	nda	1273.15	313.60	273.15
23 m	45.45	1097.56	8.76	465.63
23 k	nda	567.69	247.27	224.89
11 m	nda	376.17	2.23	137.82
11 k	nda	520.45	234.94	138.66
11 1	11.92	1248.01	28.75	187.60
4 k	68.15	685.19	202.59	84.81
4 1		1672.28	114.71	142.38
4 m	67.25	1822.13	3.15	136.66
10 1				
10 m	13.09	737.53	30.79	172.25
10 k	71.26	408.91	821.86	72.87
14 m	56.06	1969.70	58.26	222.73
14 1				
14 k	18.67	307.23	556.63	204.22
2 m	56.07	549.13	18.03	106.36
2 k	36.48	435.32	130.60	112.77
2 k				
2 1	72.50	673.26	24.91	247.18
32 1	20.66	1368.23	40.86	149.68
32 m	nda	625.00	21.92	201.67
32 k	nda	506.85	218.68	118.72
5 k	nda	340.43	67.28	177.13
5 m	nda	334.19	35.58	171.59
5 1	nda	689.53	97.95	91.58

Gorbatch Rookery

19 k	nda	1836.96	59.54	104.43
19 k	nda	1821.55	60.20	101.35
19 m	nda	785.05	10.33	83.64
19 1	nda	2188.17	57.20	162.37
36 k				
36 1	nda	399.40	54.65	81.98
36 1				

36	m				
26	k				
26	m				
26	1				
26	k				
26	1				
26	m				
9	m	nda	nda	17.11	97.78
9	1	nda	1061.98	40.49	87.19
9	k				
10	m	nda	291.89	23.03	116.76
10	k				
10	l				
12	m				
12	1				
12	k				
4	1				
4	k				
4	m	nda	670.83	23.29	120.42
28	l	nda	1992.65	40.44	114.71
28	k				
28	k	nda	84.97	205.72	**132.83**
28	m				
22	1				
22	1				
22	k				
22	m				
30	k				
30	k				
30	m				
30	1	nda	334.26	26.18	162.05

Zapadni Rookery

27	k	nda	386.53	10.89	97.52
27	m	nda	1633.99	16.47	114.87
27	1				
27	1				
28	1	nda	180.34	7.97	104.49
28	m				
28	k	nda	266.72	9.30	99.61
20	1				
20	m	nda	210.94	18.05	232.03
20	k	nda		9.08	116.80
4	k	nda	387.15	9.23	135.50
4	1	nda	4166.67	9.65	168.86
4	m				
5	k	nda	74.51	8.51	103.53
5	1	nda	316.92	6.59	110.77
5	m				
26	m	nda	315.53	**10.29**	139.81
26	1				
26	k				
16	1	nda	401.69	7.06	91.55
16	m				
16	k				

	17	l			
	17	m			
	17	k	nda	28.97	725.99	162.67
	3	1				
	3	1				
	3	m				
	3	k	nda	166.79	265.77	159.54
	25	k	nda	nda	185.87	263.04
	25	m	nda	1181.82	24.55	279.39
	25	1	nda	1262.30	16.93	182.38
	11	1	nda	2342.22	19.38	204.00
	11	k	nda	nda	95.34	182.63
	11	m	nda	411.03	2.08	206.56
	2	m	nda	854.55	11.16	203.18
	2	k	nda	nda	400.96	204.19
	2	1	nda	2897.11	153.05	159.16
	19	m	nda	44.78	244.28	200.00
	19	k	nda	nda	298.75	174.17
	19	1				
	18	k	nda	217.21	107.33	186.97
	18	1	nda	3428.08	21.10	179.79
	18	m	nda	699.45	4.75	253.55
	13	m	nda	805.88	4.38	270.00
	13	k	nda	nda	183.54	214.21
	13	1	nda	340.98	87.85	152.20
Tolstoi Rookery						
	32	1	nda	232.82	37.48	195.80
	32	m	nda	nda	6.48	344.12
	32	k	nda	nda	5.63	317.36
	19	l	nda	1466.44	48.83	208.40
	19	m	nda	1250.00	5.44	239.48
	19	k	nda	547.12	108.49	225.47
	19	k	nda	529.91	144.02	200.43
	5	m	nda	1943.82	10.34	285.39
	5	k	nda	555.56	186.75	196.15
	5	1	nda	1260.07	52.01	167.40
	12	k	nda	478.63	122.65	198.72
	12	1	nda	931.37	43.43	146.41
	12	m	nda	907.69	9.23	393.08
	14	m				
	14	k	nda	65.22	185.65	180.00
	14	1	nda	2221.09	81.29	165.65
	14	1	nda	1545.82	6.22	176.49
	17	k	nda	535.86	166.67	184.39
	17	m	nda	1669.81	2.03	243.87
	17	1	nda	1750.00	38.40	162.85
	15	1	nda	1766.69	44.44	133.51
	15	k	nda	670.48	144.32	166.80
	15	m	nda	1325.58	4.59	154.07
	28	k	nda	539.42	368.46	101.24
	28	m	nda	702.97	7.28	128.22
	28	1	nda	555.98	44.86	191.12
	2	k	nda	352.14	184.62	189.74
	2	1	nda	916.40	21.00	151.45

2	m	nda	1567.25	3.63	266.67
29	m	nda	2601.23	4.05	324.54
29	1	nda	1981.35	29.22	198.91
29	k	nda	1179.49	147.01	227.35
31	1	nda	1614.46	**33.13**	225.30
31	k	nda	1324.00	181.60	198.80
31	m	nda	2103.31	2.77	206.61
9	1	nda	2692.31	42.95	217.09
9	k	nda	1722.66	213.67	201.56
9	m				
41	1	nda	1642.86	35.06	179.55
41	k	nda	1197.37	164.47	235.96
41	**m**	nda	3492.19	6.02	414.84

Redo **'s**
Polovina Rookery

10	1	nda	1281.55	91.77	212.07
10	k	101.22	934.20	894.86	358.22
10	m	103.32	1147.69	16.52	397.69

Zapadni Rookery

16	1	171.41	1883.69	46.99	392.63
16	k	nda	**591.77**	492.85	94.63
16	m	nda	1775.60	6.93	558.06
20	1	69.06	1396.85	33.53	161.57
20	k	118.94	642.02	306.34	186.82
28	k	nda	892.40	184.06	186.22
28	1	nda	5189,98	32.96	144.73
28	m	119.94	334.73	2.08	245.96
19	k	69.26	66.64	388.93	119.35
19	1	395.09	54.64	19.40	346.82
26	m	nda	1050.28	4.37	374.01
26	1	33.88	nda	21.96	273.88
26	k	68.94	265.44	4001	137.72
4	m	394.90	404.98	306.06	234.82
4	k	nda	202.65	49.67	73.67
4	1	120.22	2029.75	29.66	252.76
5	1	31.90	437.93	232.67	52.76
5	k	108.26	nda	266.87	161.03
27	k	nda	nda	4.16	106.49
27	m	nda	1608.22	22.20	63.89
27	1	196.84	2897.13	154.91	95.24
3	k	10.77	nda	3.29	144.81
3	m	253.68	578.95	35.68	38.42
3	1	nda	4325.38	356.41	75.01
17	k	nda	**nda**	46.59	159.29
17	1	683.56	598.00	46.59	193.33
17	m	nda	**482.95**	9.54	nda

Tolstoi Rookery

14	k	nda	nda	316.83	144.36
14	1	60.11	nda	56.01	83.12

Gorbatch Rookery

30 k	150.18	565.84	174.38	64.59
22 m	nda	nda	3.26	186.16
22 1	nda	733.98	70.33	29.53
22 k	1526.21	nda	224.36	nda
28 1	nda	1109.94	33.oO	nda
36 k	178.11	118.97	196.92	nda
26 k	nda	136.89	217.55	37.00
26 1	nda	637.39	49.47	42.44
24 m	314.14	nda	17.24	108.20
24 k	nda	125.66	755.45	nda
24 k	47.10	121.48	616.79	19.61
12 k	122.19	186.17	596.92	nda
10 1	nda	211.95	71.27	23.79
10 k	98.83	113.07	53.18	nda
10 k	nda	255.77	40.87	nda
9 m	nda	421.08	6.21	65.95
9 k	250.47	520.18	161.21	59.64
9 k	nda	nda	178.53	nda
4 m	134.67	430.88	21.35	95.76

North East Point West

32 k	108.34	296.22	134.28	nda
32 m	310.12	1331.33	2.39	nda
32 1	445.49		22.64	nda
14 k	nda	303.50	377.47	nda
14 m	58.24	306.82	14.20	nda
14 m	613.23	nda	3.30	113.74
14 1	nda	1513.08	22.00	nda
14 1	448.55	1540.39	21.94	93.76

Tolstoi Rookery

9 1	nda	1382.75	44.45	30.21
9 k	175.96	218.43	10.90	56.60
9 m	80.45	1258.87	5.85	95.52
15 m	nda	1087.40	3.05	31.25
15 l	271.56	1900.83	21.24	133.33
15 k	nda	643.68	143.98	104.32

Table A12. con't

Rookery & animal label	Tiss.	Nickel	Copper	Zinc	Chrom.	Lead	Alum.
North East Point West Rookery							
14	m	11.66	4.12	44.74	1.51	17.09	18.59
14	k	8.68	29.32	84.16	nda	10.16	7.85
14	1	11.22	52.10	60.52	0.80	9.72	6.25
10	1	7.36	58.18	31.62	1.22	9.24	6.60
10	k	12.81	24.44	56.06	1.81	18.13	nda
10	m	11.99	4.52	54.94	1.93	17.47	30.12
21	l	7.30	64.08	65.38	1.27	10.86	7.12
21	m	7.49	4.62	46.10	1.84	12.11	nda
21	k	15.14	30.70	56.34	2.06	20.61	9.16
24	k	8.11	65.25	56.90	0.91	8.08	8.42
24	m	9.35	12.82	34.52	1.77	10.89	nda
24	k	8.52	28.12	70.66	1.62	12.23	nda
24	k	8.10	26.84	57.38	1.52	10.65	20.91
28	k	14.40	25.93	54.18	2.14	15.38	29.12
28	1	4.36	59.42	55.29	0.99	8.33	15.06
28	m	7.62	7.86	‘28.83	1.80	12.62	11.65
5	k	9.40	29.10	75.62	1.62	11.49	20.00
5	1	1.00	48.80	55.75	1.34	7.92	10.33
5	1	12.97	56.31	50.45	3.24	22.52	24.32
5	m	3.12	3.91	26.73	2.23	13.86	nda
32	m	4.08	.6.24	38.35	3.85	25.69	nda
.32	l	4.54	65.05	53.94	1.56	13.33	nda
32	k	5.20	21.40	61.08	1.88	16.80	nda
20	1	3.43	108.51	77.87	2.24	14.55	nda
20	m	5.64	6.77	33.23	3.68	29.32	nda
20	k	4.75	28.99	100.96	2.37	20.20	nda
25	m	2.41	5.32	160.71	3.55	27.66	nda
25	k	5.56	29.27	99.83	2.23	16.74	nda
25	1	3.18	124.42	73.92	1.91	14.15	nda
31	l	1.66	45.64	61.27	2.43	22.65	nda
31	m	5.26	4.04	35.49	2.16	18.78	40.85
31	m	1.84	5.35	44.86	3.03	22.70	47.03
31	k	9.38	32.54	70.23	2.09	15.00	nda
31	k	8.99	33.99	71.98	2.14	15.73	7.66
3	1	6.06	67.82	62.95	1060	11.69	11.69
3	k	19.06	36.97	103.61	4.91	18.25	42.02
3	m	9.15	4.79	29.06	2.82	19.81	nda
42	m	8.39	5.63	69.02	3.05	22.41	19.54
42	k	5.34	25.87	73.81	1.80	10.62	nda
42	1	5.10	53.40	62.23	2.30	10.66	nda
Polovina Rookery							
6	m	12.73	6.03	27.06	4.48	18.04	nda
6	k	7.84	30.33	95.06	2.16	17.01	17.43

6 1	9.06	77.44	76.56	3.69	25.00	8.75
18 k	8.49	32.72	103.17	2.40	18.87	67.75
18 1	12.21	190.41	93.66	3.30	22.92	52.77
18 m						
29 m	26.25	154.15	60.52	9.27	38.61	47.30
29 k	2.74	20.44	87.55	2.82	12.92	56.77
29 1	5.78	51.86	50.59	2.12	13.72	21.55
21 l	5.39	79.00	47.44	1.85	12.93	11.39
21 k	10.56	30.63	65.25	3.33	17.08	40.00
21 m	10.74	8.19	62.55	3.34	17.13	53.47
25 m	10.74	5.29	62.28	2.92	20.16	19.66
25 k	8.36	30.65	63.61	2.75	16.16	17.77
25 k	9.81	29.88	88.45	3.92	24.10	85.20
25 1	7.42	99.55	50.13	2.25	12.85	16.07
23 1	10.01	80.79	88.02	4.05	24.31	36.46
23 m	22.39	9.98	174.61	8.54	51.00	210.64
23 k	10.44	24.02	84.77	4.75	22.93	15.83
11 m	6.99	7.99	36.42	4.16	13.32	34.95
11 k	8.29	29.44	59.18	3.42	15.99	31.60
11 1	39.67	191.02	116.93	14.55	31.00	62.80
4 k	5.93	44.48	55.96	3.07	14.44	14.07
4 1	9.98	69.92	66.55	4.47	17.69	32.86
4 m	4.23	5.64	83.19	4.77	20.07	29.28
10 l						
10 m	10.68	4.82	64.05	0.79	12.04	nda
10 k	7.98	36.32	101.38	1.09	9.31	nda
14 m	18.26	7.58	78.79	2.23	18.94	nda
14 l						
14 k	15.00	27.29	134.64	2.29	14.46	nda
2 m	10.06	5.38	48.38	3.47	14.45	nda
2 k	6.88	20.02	85.32	2.28	9.95	nda
2 k						
2 1	5.89	14.83	40.49	0.94	13.65	nda
32 1	5.97	88.48	91.97	0.60	18.37	16.99
32 m	18.00	6.92	61.50	2.92	23.33	31.67
32 k	16.35	30.73	91.23	1.92	11.87	nda
5 k	11.38	26.86	121.28	1.12	12.23	18.62
5 m	13.43	4.69	72.69	0.64	16.71	nda
5 1						

Gorbatch Rookery

19 k	6.69	100.26	78.93	0.64	8.26	0.38
19 k	6.50	87.34	74.95	1.31	7.41	nda
19 m	8.32	7.52	48.22	2.29	10.28	nda
19 1	11.34	101.83	118.92	1.45	13.44	18.28
36 k						
36 1	4.08	144.59	67.57	0.87	6.91	nda
36 1						
36 m						
26 k						
26 m						
26 1						
26 k						
26 1						
26 m						

9	m	10.94	5.33	51.44	1.61	20.56	11.67
9	1	10.33	94.13	87.81	2.11	17.36	nda
9	k						
10	m	10.22	6.00	56.11	3.19	21.08	19.46
10	k						
10	1						
12	m						
12	1						
12	k						
4	1						
4	k						
4	m	8.96	6.00	60.29	1.33	6.34	nda
28	1	8.46	94.08	82.54	2.13	15.07	8.09
28	k						
28	k	10.60	26.61	101.25	1.48	25.49	nda
28	m						
22	1						
22	1						
22	k						
22	m						
30	k						
30	k						
30	m						
30	1	5.79	74.46	62.37	1.03	11.98	nda

Zapadni Rookery

27	k	1.91	‘26.72	87.41	2.08	16.21	12.49
27	m	1.31	6.73	84.18	2.22	33.33	45.75
27	1						
27	1						
28	1	1.30	35.98	7.94	1.11	13.02	21.16
28	m						
28	k	0.55	18.44	70.74	1.50	10.94	5.86
20	1						
20	m	2.89	6.64	57.50	5.94	35.94	nda
20	k	2.20	32.96	85.73	3.32	15.60	nda
4	k	2.06	26.61	87.11	2.25	14.42	9.88
4	1	0.39	140.53	101.36	3.16	16.67	17.11
4	m						
5	k	1.06	34.71	79.18	3.65	17.65	nda
5	1	0.62	185.54	68.65	2.52	12.31	11.38
5	m						
26	m		6.17	56.12	4.90	18.45	nda
26	1						
26	k						
16	1	1.28	49.09	73.72	3.72	12.50	18.58
16	m						
16	k						
17	1						
17	m						
17	k	3.02	43.92	100.12	1.20	15.31	12.42
3	1						
3	1						
3	m						
3	k	1.92	31.80	77.92	1.02	14.14	nda

25 k	1.36	28.21	110.05	1.30	20.11	11.96
25 m	3.33	5.45	111.33	1.39	22.42	33.33
25 1	1.11	92.21	73.77	1.23	15.16	nda
11 1	1.16	72.67	88.58	1.38	15.56	nda
11 k	2.88	20.89	88.52	1.06	14.83	9.32
11 m	3.54	5.05	75.70	1.30	18.21	9.89
2 m	2.73	4.82	67.27	1.36	16.82	nda
2 k	2.57	28.01	98.21	1.18	17.02	nda"
2 1	5.14	201.61	75.63	0.90	12.54	nda
19 m	2.84	24.88	114.68	1.94	17.91	nda
19 k	2.13	27.08	92.71	1.46	15.00	nda
19 1						
18 k	1.66	11.42	82.45	0.85	16.61	nda
18 1	1.27	65.14	81.22	1s20	14.04	31.51
18 m	1.09	6.83	76.39	1.91	24.59	nda
13 m	1.24	5.12	64.41	1.88	21.18	22.35
13 k	1.84	21.63	97.96	1.43	18.40	nda
13 1	0.90	73.90	64.63	1.12	11.78	5.58

Tolstoi Rookery

32 1	3.51	69.54	70.65	1.45	13.74	nda
32 m	2.43	6.18	86.25	2.35	25.74	22.79
32 k	1.68	4.79	99.74	2.07	24.61	36.27
19 1	0.87	113.42	75.12	1.38	15.10	8.72
19 m	1.61	8.62	67.74	1.86	17.14	16.13
19 k	1.42	20.14	93.65	1.84	18.40	nda
19 k	0.85	19.19	89.53	1.75	16.67	nda
5 m	9.10	4.94	57.70	2.13	30.34	nda
5 k	0.98	20.90	94.79	1.41	17.09	23.50
5 1	0.48	75.49	80.77	1.32	14.29	nda
12 k	0.26	24.36	77.52	1.37	14.96	10.26
12 1	3.95	54.71	68.92	1.27	12.75	nda
12 m	6.23	7.31	79.77	2.,54	29.92	nda
14 m						
14 k	4.43	21.00	92.26	1.65	15.65	nda
14 1	3.61	71.50	81.80	1.19	12.59	nda
14 1	5.50	78.57	60.28	1.27	13.94	1.20
17 k	5.27	27.05	92.78	2.07	16.46	nda
17 m	5.66	5.71	90.85	3.11	16.51	9.43
17 1	4.17	96.98	78.61	0.63	11.51	nda
15 1	4.05	95.25	68.61	0.94	12.14	nda
15 k	1.88	24.49	84.01	0.98	14.31	nda
15 m	2.79	4.77	58.76	1.04	28.49	nda
28 k	3.03	47.22	90.54	1.69	15.35"	0.41
28 m	2..48	4.85	67.82	1.39	17.33	nda
28 1	1.97	133.32	79.58	0.89	18.92	8.11
2 k	2.09	30.94	94.32	1.28	21.79	nda
2 1	1.03	66.75	69.45	0.74	12.86	nda
2 m	0.99	6.26	66.08	1.35	22.81	nda
29 m	3.07	6.07	68.71	0.98	24.54	nda
29 1	0.85	74.98	84.15	1.01	15.54	nda
29 k	2.18	31.62	86.84	1.20	17.09	nda
31 1	0.75	60.12	73.22	0.96	17.17	nda
31 k	7.32	27.28	92.00	1.10	18.40	nda
31 m						

9 1	1.32	129.19	92.91	1.37	20.09	10.68
9 k	1.33	27.73	96.64	0.86	19.14	13.28
9 m						
41 1	1.95	83.46	72.37	0.78	16.23	nda
41 k	1.71	24.87	93.07	0.96	21.93	nda
41 m	2.11	6.33	77.97	2.27	39.84	nda

Redo 's
Polovina Rookery

10 1	2.18	191.34	46.19	nda	39.56	6.69
10 k	4.46	34.77	49.40	nda	55.83	13.04
10 m	19.10	24.97	65.70	0.78	77.48	9.96

Zapadni Rookery

16 1	39.84	69.19	72.22	0.80	77.32	51.71
16 k	10.96	26.46	28.70	0.43	26.16	14.58
16 m	15.45	39.23	94.35	1.65	166.40	47.89
20 1	6.26	400.77	60.55	8.47	64.90	76.82
20 k	4.42	37.75	38.67	0.72	42.84	12.91
28 k	7.73	36.97	67.68	0.26	71.28	nda
28 1	3.23	31.97	38.50	nda	38.82	nda
28 m	9.48	34.28	79.28	2.34	104.12	59.18
19 k	3.53	23.55	40.95	0.65	41.40	14.54
19 1	7.47	100.96	83.11	0.37	98.18	28.69
26 m	10.27	102.69	92.10	4.23	139.42	137.40
26 1	15.12	36.29	105.71	2.24	123.88	48.24
26 k	4.03	75.27	45.61	0.20	49.16	14.72
4 m	7.53	24.90	62.42	0.56	86.37	16.67
4 k	2.94	32.20	38.71	0.76	38.07	9.09
4 1	12.76	117.29	141.49	1.65	167.05	nda
5 1	3.45	331.38	35.14	0.38	30.52	6.55
5 k	5.16	31.28	56.40	nda	59.03	nda
27 k	12.15	36.33	110.09	1.77	120.05	nda
27 m	5.85	10.78	49.94	nda	61.73	nda
27 1	8.96	115.09	60.37	1.63	76.74	17.42
3 k	14.28	59.01	90.10	2.95	118.74	19.68
3 m	6.48	11.68	40.39	0.89	58.16	nda
3 1	2.85	382.37	23.68	1.38	26.55	9.13
17 k	11.48	71.75	129.64	1.24	158.77	nda
17 1	10.33	91.28	92.44	nda	127.44	0.56
17 m	3.88	10.57	46.69	nda	56.53	nda

Tolstoi Rookery

14 k	13.43	32.97	138.03	1.48	167.72	nda
14 1	4.75	61.75	58.62	nda	64.83	nda

Gorbatch Rookery

30 k	3.79	18.35	34.41	0.41	40.21	0.36
22 m	27.61	18.66	112.47	3.26	286.16	nda
22 1	3.69	273.26	27.41	0.45	28.97	nda
22 k	24.41	52.36	166.21	2.62	286.46	nda
28 1	14.99	78.82	115.31	1.28	168.90	nda

36 k	7.24	31.37	59.12	nda	73.94	nda
26 k	4.92	32.75	50.11	nda	56.23	nda
26 1	4.46	141.43	58.20	nda	64.82	nda
24 m	15.27	26.04	92.98	1.13	180.57	nda
24 k	3.88	41.10	49.81	nda	54.12	nda
24 k	3.79	36.98	41.84	0.45	44.97	nda
12 k	11.06	31.39	50.45	nda	55.26	nda
10 1	11.89	84.31	53.03	nda	61.31	nda
10 k	9.48	20.77	39.91	0.50	42.42	nda
10 k	4.66	14.22	46.34	0.55	52.91	nda
9 m	27.74	110.82	101.23	7.62	277.40	nda
9 k	7.83	26.84	43.36	0.78	49.78	nda
9 k	16.61	30.66	87.00	0.79	106.52	nda
4 m	15.66	19.35	73.19	0.63	104.52	nda

North East Point West

32 k	9.64	16.80	31.97	0.70	34.02	5.37
32 m	35.27	21.94	98.15	0.42	360.12	nda
32 1	14.71	65.72	99.97	0.21	137.62	nda
14 k	3.87	22.91	27.94	0.35	30.21	nda
14 m	7.45	10.23	50.77	0.77	60.80	nda
14 m	13.17	5.77	52.84	0.06	116.31	nda
14 1	5.41	37.48	55.92	0.68	67.78	nda
14 1	6.28	37.84	66.56	0.28	87.48	nda

Tolstoi Rookery

9 1	3.26	97.63	41.08	nda	50.37	nda
9 k	10.26	28.05	95.31	0.37	128.65	nda
9 m	4.57	7.62	58.51	nda	108.37	nda
15 m	6.15	6.96	38.16	0.46	63.01	nda
15 1	27.03	84.36	103.89	0.79	260.40	nda
15 k	15.70	29.32	93.80	1.16	145.13	nda

Table A13. Concentrations (ppm, dry weight) of elements in tissues collected in St. George Basin planning area, April, 1976, from Freeman Miller vessel. From OCSEAP report by Robertson and Abel (1979: Tables A.9, G.1 and G.2). The authors did not label the dispersion estimates accompanying the means, nor provide sample sizes.

Station	Latitude	Longitude	Water depth (m)	Taxon	Ag ppm Mean		As ppm Mean	
MF 3	54d 47.3m	165d 18.3m	161.9	king crab	0.82	0.03	<0.25	
MF 5	54d 43.6m	165d 17.2m	167.9	rock sole	<.034		21	1
MF 25	54d 50.4m	166d 35.8m	183.8	pollock	<.015		11	1
MF 27	55d 0m	166d 15.2m	112.8	rock sole	<.011		19	1
MF 29	55d 9.3m	166d 2m	134.6	king crab	0.93	0.01	34	1
MF 31	55d 32.1m	165d 26m	114.3	Neptunea	8.6		10	1
MF 39	56d 1.6m	166d 19.2m	124.2	pollock	0.032	0.01	4.6	0.2
MF 48	55d 18.3m	167d 28.9m	151	k. crab leg	1.20	0.02	57	1
MF 49	55d 15.4m	167d 37.7m	178.3	pollock	<.025		7.3	0.2
Otter Is.	57d 3.0m	170d 23.8m		Mytilus	0.12	0.02	6.2	0.7
Makushin Bay	53d 44.0m	166d 45.8m		Mytilus	0.075	0.03	4.4	1
Eider Pt.	53d 57.5m	166d 35.1m		Mytilus			1.0	1

Cr ppm Mean		Fe ppm Mean		Hg ppm Mean		Sb ppm Mean		Se ppm Mean		Zn ppm Mean	
<0.10		17	8	0.31	0.20	0.028	0.006	10.7	0.2	134	-
5.60	0.20	19	5	0.47	0.10	0.010	0.007	3.4	O*1	36	-
0.24	0.08	6	2	0.15	0.04	0.019	0.002	0.97	0.01	18	-
0.30	0.05	15	2	0.27	0.03	0.030	0.001	1.7	0.1	30	-
0.44	0.05	26	3	0.20	0.01	0.009	0.003	13	1	136	-
0.69	0.06	1130	10	0.61	0.03	0.110	0.005	3.7	0.1	870	-
<0.6		8	2	0.04	0.03	0.012	0.002	1.15	0.03	31	-
<0.06		<7.5		0.39	0.03	0.087	0.004	4.45	0.03	83	-
<0.10		14	2	0.16	0.04	0.008	0.005	1.5	0.1	27	-
1.60	0.10	230	10	0.12	0.03	0.008	0.006	2.3	0.1	77	-
4.70	0.20	530	10	0.31	0.05	0.084	0.010	2.5	0.1	77	-
1.20	O*10	150	10	0.19	0.04	<.009		2.5	0.1	170	-

Table A14. Concentrations of metals (ppm, dry weight)., in subadult male northern fur seals collected on St. George Island in late summer, 1986. Based on Smith (1986: Tables 1 and 2). ND means not detected, i.e., below lower detection limit. Lower detection limits are <.005 ppm for Ag, and <.034 ppm for Pb. Concentrations are single, unsummarized determinations.

Animal label	Age (yr)	% moist.	Tissue	Cd	Zn	Hg	Ag	Cu	Pb
1	1	68.6	liver	118	276	50.73	0.37	46	ND
		74.4	heart	3.2	105	0.64	0.07	13	ND
		75.7	kidney	410	278	4.95	0.01	28	ND
2	2	76.5	neck muscle	1.4	97	0.89	0.01	4.5	ND
		69.1	liver	99	229	89.76	0.56	35	ND
		78.9	heart	2.9	174	0.63	0.02	26	ND
		75.1	kidney	297	291	5.59	0.01	22	ND
3	1	76.2	neck muscle	0.3	76	2.24	ND	5.6	ND
		69.6	liver	34	164	36.1	0.44	35	ND
		74.8	heart	0.6	111	1.01	0.01	18	ND
		73.6	kidney	146	185	6.67	0.01	22	ND
4	2	74.6	neck muscle	0.2	96	1.03	ND	5.0	ND
		68.9	liver	18	170	67.77	0.34	14	ND
		75.1	heart	0.4	105	0.84	0.01	15	ND
		75.2	kidney	144	194	4.62	0.01	18	ND

Table A15. Concentrations (ppm) of organic contaminants in four subadult male northern fur seals collected on St. Paul Island in 1980. From Calambokidis and Peard (1985: Table 26).

Tissue & specimen	label	% lipids	Wet weight DDE	Wet weight PCB	Lipid weight DDE	Lipid weight PCB
Liver						
	486	5.2	0.136	0.092	2.61	1.77
	487	2.6	0.197	0.094	7.59	3.61
	491	3.7	0.259	0.123	6.95	3.31
	488	3.0	0.357	0.106	11.80	3.51
Mean		3.6	0.237	0.104	7.23	3.05
SD		1.1	0.094	0.014	3.74	0.86
Blubber						
	486	83.8	2.69	1.51	3.21	1.80
	487	78.6	7.77	2.21	9.89	2.81
	491	70.3	7.13	2.24	10.10	3.19
	488	71.5	12.50	4.00	17.50	5.60
Mean		76.1	7.52	2.49	10.20	3.35
SD		6.3	4.01	1.06	5.84	1.61

Table A16. Concentrations (ppm) of organic contaminants in four northern fur seals collected on St. George Island, 1986. Trace levels of DDD, DDT, and lindane were also detected but were below quantifiable levels. Based on Calambokidis (1987: Tables 1, 2 and appendix data sheets).

Smith (1986) analyzed these four animals for metals and categorized them as subadult males.

Dry weight:

Sample label	Rookery	Age (yr)	Tissue	% moist.	4-4'-DDE
303	Zapadni	1	heart	74	0.067
304	Zapadni		muscle	76	0.220
305	Zapadni	1	liver	69	0.083
306	Northeast	1	muscle	75	0.061

Wet weight:

Sample size	Tissue	DDT	PCB	dieldrin	lindane
1	liver	0.026	<.06	<.005	trace
2	muscle	0.034	<.06	<.005	trace
1	heart	0.017	<.06	<.005	trace

Table A17. Concentrations (ppm, wet weight) of organic contaminants in northern fur seals collected at Pribilof Islands, July, 1972. From Kurtz and Kim (1976: Tables 1 and 2).

The range of recoveries of DDT and metabolizes was 55 to 66 percent from seal fat and 56 to 58 percent from blood. Analyses for all fat residues except dieldrin and o,p'-TDE were corrected for recovery. TR = trace (approx. 0.01 ppm). ND = no detectable residue, <.003 ppm.

Specimen	Aroclor 1254	dieldrin	o,p'-TDE	o,p'-DDT	p,p'-DDE	p,p'-TOE	p,p'-DDT	Sum p,p'-DDT's
Fat tissue:								
nursing cow #2	6.8	0.16	0.4	1.5	3.8	1.0	2.2	7.0
newborn pup #2	3.8	0.12	0.2	1.0	3.3	0.6	1.4	5.3
nursing cow #3	4.7	0.07	0.1	0.6	2.0	0.4	0.9	3.3
newborn pup #3	7.2	T	0.3	1.0	3.9	0.6	1.3	5.8
mean of cows	5.8	0.12	0.3	1.1	2.9	O*7	1.6	5.2
mean of pups	5.5	0.06	0.3	1.0	3.6	0.6	1.4	5.6
Two-month old								
pup #13	16	ND	TR	0.6	98	4.7	3.1	106
pup #14	81	TR	TR	2.0	70	3.3	3.2	77
pup #15	1.3	TR	ND	TR	5.1	0.1	0.1	5.3
mean of pups	33	TR	TR	0.9	58	2.7	2*1	63
Blood tissue:								
nursing cow #2	T	0.02	ND	ND	ND	ND	ND	ND
newborn pup #2	T	0.02	ND	ND	ND	ND	ND	ND
nursing cow #3	T	0.02	ND	ND	ND	ND	ND	ND
newborn pup #3	T	0.02	ND	ND	TR	ND	ND	ND
Two-month old								
pup #13	T	0.07	ND	ND	2.8	0.2	TR	3.0
pup #14	T	0.06	ND	ND	0.6	0.1	TR	0.7
pup #15	3.4	0.05	ND	ND	10	0.3	0.1	10
mean of pups		0.06			4.5	0.2		4.6

Table A18. Concentrations (ppm, wet weight) of organic contaminants in northern fur seals on St. Paul Island. Six seals, whose sex is unreported, were collected in July in each of three years. Collections were at Northeast Point Rookery in 1975, Reef Rookery in 1978, and Tolstoi Rookery in 1981. Seals collected in 1975 and 1981 were 3 to 4 years old. Based on Kurtz (no date: Tables 2 to 5)".

Tissue, animal & year	PIP' DDE	P/P'- TDE	p,p'- DDT	o,p'- DDT	Total DDT	Aroclor 1242	Aroclor 1254
Fat, 1975:							
FS-2	5.30	0.27	0.28	0.11	5.96	0.10	3.00
FS-7	,4.17	0.31	0.53	0.29	5.30	0.07	3.29
FS-8	3.33	0.21	0.29	0.11	3.94	0.12	2.94
FS-10	2.83	0.23	0.39	0.16	3.61	0.07	3.34
FS-12	5.33	0.57	0.67	0.41	6.98	0.14	5.84
FS-14	4.11	0.50	0.72	0.16	5.49	0.15	3.68
1978:							
K78-9	2.51	0.17	0.25	0.10	3.03	0.06	1.63
K78-11	4.33	0.40	0.62	0.17	5.52	0.18	4.62
K78-13	2.43	0.36	0.35	0.33	3.47	0.12	2.31
K78-15	6.70	0.40	0.51	0.23	7.84	0.11	4.21
K78-17	16.2	0.96	1.38	0.72	19.3	0.25	9.38
K78-19	5.90	0.41	0.50	0.66	7.47	0.08	3.17
1981:							
81-M-1	1.41	0.19	0.23	0.11	1.94	0.06	1.29
81-M-2	3.54	0.36	0.39	.0.10	4.39	0.09	3.65
81-M-3	3.84	0.46	0.54	0.32	5.16	0.10	3.47
81-M-4	3.26	0.39	0.51	0.24	4.40	0.09	2.71
81-M-5	6.13	0.58	0.67	0.39	7.77	0.21	5.14
81-M-6	3.44	0.27	0.33	0.15	4.19	0.09	3.02
Liver, 1975:							
FS-2	0.17	0.02	<.01	<.01	0.19	<.05	0.14
FS-7	0.19	0.04	<.01	<.01	0.23	<.05	0.22
FS-8	0.28	0.02	0.01	<.01	0.31	<.05	0.39
FS-10	0.32	0.05	<.01	<.01	0.37	<.05	0.48
FS-12	0.35	0.06	<.01	<.01	0.41	<.05	0.05
FS-14	0.15	0.03	<.01	<.01	0.18	<.05	0.22
1978:							
K78-9	0.12	0.02	<.01	<.01	0.14	<.05	0.16
K78-11*	0.19	0.03	<.01	<.01	0.22	<.05	0.29

K78-13	0.11	0.02	<.01	<.01″	0.13	<.05	0.17
K78-15	0.19	0.03	0.02	<.01	0.24	<.05	0.15
K78-17	0.78	0.07	0.02	<.01	0.87	<.05	0.50
X78-19	0.37	0.03	<.01	<.01	0.40	<.05	0.31
1981:							
81-M-1	0.09	0.02	0.01	<.01	0.12	<.05	0.15
81-M-2	0.16	0.03	0.02	0.01	0.22	<.05	0.27
81-M-3	0.13	0.03	0.90	<.01	0.18	<.05	0.20
81-M-4	0.14	0.03	0,03	0.01	0.21	<.05	0.19
81-M-5	0.23	0.03	0.02	0.01	0.29	<.05	0.30
81-M-6	0.15	0.02	0.01	<.01	0.18	<.05	0.21
Brain, 1975:							
FS-2	0.06	<.01	<.01	<.01	0.06	<.05	0.06
FS-7	0.06	0.01	0.01	0.01	0.09	<.,05	0.10
FS-8	0.04	0.01	<.01	<.01	0.05	<.05	0.07
FS-10	0.03		<.01	<.01	0.03	<.05	0006
FS-12	0.08	0.01	<.01	<.01	0.09	<.05	0.11
FS-14	0.03″	0.01	<.01	<.01	0.04	<.05	0.06
1978:							
K78-9	0.03	0.01	<,01	<.01	0.04	<.05	0.05
K78-11	0.05	0.01	<.01	<.01	0.06	<.05	0.08
K78-13	0.03	0.01	<.01	<.01	0.04	<.05	0.05
K78-15	0.09	0.01	<.01	<.01	0.10	<.05	0.09
K78-17	0.23	0.02	0.02	<.01	0.27	<.05	0.14
K78-19	0.06	0.01	<.01	<.01	0.07	<.05	0.07
1981:							
81-M-1	0.02	<.01	<,01	<.01	0.02	<.05	0.03
81-M-2	0.05	0.01	0*01	<.01′	0.07	<.05	0.08
81-M-3	0.04	0.01	0.01	0.01	0.07	<.05	0.07
81-M-4	0.04	0.01	0.01	<.01	0.06	<.05	0.07
81-M-5	0.06	0.01	0.01	<.01	0.08	<.05	0.06
81-M-6	0.03	<.01	0.01	<.01	0.04	<.05	0.06
Blood, 1975:							
FS-2	0.014	<.0013	<.0013	<.0013	0.014	<.013	0.03
FS-7	0.008	<.0013	<.0013	<.0013	0.008	<.013	<.013
FS-8	0.007	<.0013	<.0013	<.0013	0.007	<.013	<.013
FS-10	0.009	<.0013	<.0013	<.0013	0.009	<.013	<.013
FS-12	0.005	<.0013	<,0013	<.0013	0.005	<.013	0.02
FS-14	0.006	<.0013	<.0013	<.0013	0.006	<.013	<.013
1978:							
K78-9	0.008	<.0013	<.0013	<.0013	0.008	0.02	0.02
K78-11	0.012	<.0013	<.0013	<.0013	0.012	<.013	0.02

K78-13	0.012	<.0013	<.0013	<.0013	0.012	<.013	<.013
K78-15	0.039	<.0013	<.0013	<.0013	0.039	<.013	0.03
K78-17	0.046	0.002	<.0013	<.0013	0.048	<.013	0.05
K78-19	0.028	<.0013	<.0013	<.0013	0.028	<.013	<.013
1981:							
8 l-M-l	0.004	<.0013	<.0013	<.0013	0.004	<.013	0.02
81-M-2	0.01	<.0013	<.0013	<.0013	0.01	<.013	0.02
81-M-3	0.009	<.0013	<.0013	<.0013	0.009	<.013	<.013
81-M-4	0.009	<.0013	<.0013	<.0013	0.009	<.013	0.02
81-M-5	0.015	<.0013	<.0013	<.0013	0.015	<.013	<.013
81-M-6	0.006	<.0013	<.0013	<.0013	0.006	<.013	<.013

*Approximate losses of 15% in extraction.

Table A19. Percent frequency of occurrence of organochlorine residues in eggs of Pribilof Island seabirds, 1973-1976. In addition to compounds listed here, DDE was found in all samples and PCB's were detected in all eggs. Frequency index is computed as total occurrences/possible occurrences. Total occurrences = no. times an organochlorine was present in eggs; possible occurrences = no. clutches from that species. From Ohlendorf, et al (1982: Table 2).

Species	N	DDD	DDT	Dieldrin	Heptachlor epoxide	Mirex
Northern fulmar	6	83.3	100	83.3	50	33.3
Black-legged kittiwake	10	0	0	10	50	0
Common murre	21	52.4	47.6	61.9	95.2	0

	N	Oxychlordane	cis-chlordane	cis-nonachlor	HCB	Toxaphene
Northern fulmar	6	100	33.3	33.3	100	100
Black-legged kittiwake	10	100	0	0	100	100
Common murre	21	100	4.8	9.5	100	81

Table A20. Geometric means of DDE and PCB residue concentrations (ppm, wet weight) in eggs of seabirds at Pribilof Islands. Asterisk denotes species significantly different (P<.05) within a compound. Species were included only if 5 or more eggs were collected. From Ohlendorf, et al (1982: Table 5).

	DDE	PCB'S
Black-legged kittiwake	0.033*	0.472
Common murre	0.205	0.239*
Northern fulmar	0.307	0.387

Table A21. Geometric mean concentrations (ppm, wet weight) of organochlorines in eggs of seabirds on islands in St. George Basin planning area. Samples are included only for 5 eggs or more at each of 2 or more sites. Compounds were omitted if there were no significant differences (P>.05) among sites for a species. For each species, the means that do not share the same letter are significantly different, according to the authors. Based on Ohlendorf, et al (1982: Table 6).

Species, site, & compound	Geometric mean
Northern fulmar, St. George Is.	
DDT	0.015
heptachlor epoxide	0.005
oxychlordane	0.067
cis-chlordane	0.001
cis-nonachlor	0.003
HCB	0.055
toxaphene	0.051
Black-legged kittiwake, St. Paul Is.	
dieldrin	Cool
Mirex	not determined
cis-chlordane	not determined
HCB	0.043
toxaphene	0.025
PCB'S	0.472
Common murre	
DDE	
St. Gee. Is.	0.273 B
St. Paul Is.	0.135 B
Bogoslof Is.	0.119 B
DDD	
St. Gee. Is.	0.035 A
St. Paul Is.	<.001 A
Bogoslof Is.	0.001 A
DDT	
St. Gee. Is.	0.013 A
St. Paul Is.	not determined
Bogoslof Is.	not determinedB
dieldrin	
St. Gee. Is.	0.009 A
St. Paul Is.	0.005 A
Bogoslof Is.	0.034 A
heptachlor epoxide	
St. Gee. Is.	0.012 A
St. Paul Is.	0.011 A
Bogoslof Is.	0.004 A

oxychlordane		
St. Gee. Is.	0.018	B
St. Paul Is.	0.026	B
Bogoslof Is.	0.005	c
cis-chlordane		
St. Gee. Is.	not determined	
St. Paul Is.	<.001	B
Bogoslof Is.	<.001	B
cis-nonachlor		
St. Gee. Is.	not determined	
St. Paul Is.	0.080	B
Bogoslof Is.	0.066	B
toxaphene		
St. Gee. Is.	0.037	**A**
St. Paul Is.	0.019	**AB**
Bogoslof Is.	not determined	
PCB 'S		
St. Gee. Is.	0.270	B
St. Paul Is.	0.205	B
Bogoslof 1s.	0.126	B

Table A22. Concentrations of organochlorine residues (ppm, wet weight) in eggs of seabirds in St. George Basin area, 1973-1976. Chemicals not listed were not detected. ND = not detected. N = sample size, i.e., no. eggs. From Ohlendorf, et al (1982: Appendix III).

Northern fulmar St. George Island N=6 ; 1975	No. eggs	Geometric mean	95% confid. interval	Range
DDE	6	0.307	0.19-0.44	.14-.45
DDD	5	0.008	0.002-0.013	nd-.015
DDT	6	0.015	.001-.029	.006-.041
dieldrin	5	0.008	.003-.013	nd-.015
heptachlor epoxide	3	0.005	0-.011	nd-.013
Mirex	2	0.002	o-*006	rid-. 008
oxychlordane	6	0.067	.021-.12	.007-.14
cis-chlordane	2	0.001	0-.004	nd-.005
cis-nonachlor	2	0.003	0-.007	nd-.008
HCB	6	0.055	.033-.077	.028-.089
toxaphene	6	0.051	.028-.074	.029-.081
PCB 's	6	0.387	.19-.61	.26-.81
Glaucous-winged gull Bogoslof Island N=3; 1973				
DDE	3	5.16	0-42.0	1.6-11.0
DDT	2	0.037	0-.13	nd-. 073
dieldrin	3	0.214	0-1.1	.049-.58
Mirex	3	0.036	.013-.59	.025-.042
oxychlordane	3	0.251	0-1.1	.054-.56
HCB	3	0.058	0-.12	.030-.073
PCB 's	3	3.55	.38--14.0	1.8-6.3
Black-legged kittiwake St. Paul Island N=10; 1975				
DDE	10	0.033	.022-.044	.014-.066
dieldrin	1	<.001	0-.002	nd-.006
heptachlor epoxide	5	0.003	0-.006	nd-.013
oxychlordane	10	0.034	.029-.039	.023-.043
HCB	10	0.043	.033-.054	.015-.060
toxaphene	10	0.025	.021-.030	.019-.036
PCB ' S	10	0.472	.35-.60	.23-.68
Common murre Bogoslof Island N=7 ; 1973				
DDE	7	0.119	.11-.13	.10-.13
DDD	1	0.001	0-.004	rid-. 008
dieldrin	6	0.034	0-.073	nd-.12

heptachlor epoxide	4	0.004	0-.008	nd-.009
oxychlordane	6	0.005	.002-.008	rid-. 009
cis-chlordane	1	<.001	0-.003	nd-.005
cis-nonachlor	4	0.008	0-.016	nd-.020
HCB	6	0.066	.034-.098	nd-.096
PCB ' S	7	0.126	.092-.16	.08-.18
St. George Island N=11; 1975				
DDE	11	0.273	.14-.43	.084-.79
DDD	10	0.035	.022-.047	nd-.068
DDT	10	0.013	.007-.019	nd-.023
dieldrin	7	0.009	.002-.016	nd-.025
heptachlor epoxide	11	0.012	.009-.015	.005-.019
oxychlordane	11	0.018	.012-.024	.004-.032
HCB	11	0.079	.059-.098	0.048-0.16
toxaphene	9	0.037	.003-.072	rid-. 19
PCB ' S	11	0.270	.22-.32	.12-.35
St. Paul Island N=10; 1975				
DDE	10	0.135	.098-.17	.069-.26
DDD	1	<.001	0-0.002	nd-.006
dieldrin	6	0.005	.001-.008	nd-.015
heptachlor epoxide	9	0.011	.005-.016	nd-.024
oxychlordane	10	0.026	.020-.033	.012-.041
cis-chlordane	1	<.001	0-.002	rid-. 006
cis-nonachlor	2	0.002	0-.004	nd-.013
HCB	10	0.08	.062-.098	.044-.11
toxaphene	8	0.019	.008-.029	nd-.044
PCB ' S	10	0.205	.16-.25	.11-.31

Table A23. Concentrations of organochlorine residues (ppm, wet weight) in individual eggs of seabirds in St. George Basin planning area. Based on the unpublished, raw data of H. M. Ohlendorf (personal communication, 1988). These data are published in a summarized form in Ohlendorf, et al (1982).

	DDE	DDD	DDT	dieldrin	heptachlor epoxide	Mirex
Northern fulmar St. George Is. 1975	0.26	0.0052	0.0076	0.0067	0.0079	
	0.30	0.0070	0.0086	0.0086		
	0.44	0.0110	0.0160	0.0150	0.0079	0.0081
	0.45	0.0080	0.0110	0.0110	0.0130	0.0040
	0.14		0.0057			
	0.28	0.0150	0.0410	0.0074		
Glaucous-winged gull Bogoslof Is. 1973	6.5		0.073	0.580		0.040
	11.0		0.038	0.080		0.042
	1.6			0.049		0.025
Black-legged kittiwake St. Paul Is. 1975	0.028					
	0.028					
	0.014					
	0.033				0.0047	
	0.035				0.0048	
	0.036				0.0051	
	0.019				0.0043	
	0.020					
	0.066			0.0062	0.0130	
	0.052					
Common murre Bogoslof Is. 1973	0.13	0.0075		0.120	0.0092	
	0.12			0.012		
	0.11			0.033	0.0073	
	0.13				0.0057	
	0.12			0.059	0.0075	
	0.12			0.011		
	0.10			0.011		
St. George Is. 1975	0.180		0.004	0.0250	0.0160	
	0.150	0.068		0.0210	0.0190	
	0.700	0.048	0.021	0.0055	0.0150	
	0.410	0.016	0.007		0.0057	
	0.140	0.025	0.011		0.0092	
	0.084	0.025	0.081		0.0052	
	0.790	0.045	0.022	0.0048	0.0120	
	0.200	0.048	0.023	0.0190	0.0170	
	0.160	0.036	0.014	0.0044	0.0120	
	0.160	0.043	0.023	0.0190	0.0120	
	0.220	0.026	0.013		0.0084	

Table A23. con't

St. Paul Is. 1975	0.150	-				0.0068		
	0.150	-				0.0081		
	0.160	-			0.0088	0.0064		
	0.130	-				0.0060		
	0.120	-			0.0044	0.0095		
	0.140	-			0.0082	0.0170		
	0.260	-			0.0150	0.0240		
	0.093	-				0.0070		
	0.087	-			0.0039			
	0.069	0.0064			0.0062	0.0230		

oxy-chlordane	cis-chlordane	cis-nonachlor	HCB	toxaphene	PCB
0.0074			0.063	0.052	0.28
0.0530	0.0048		0.052	0.036	0.27
0.1400		0.0081	0.089	0.081	0.81
0.1000		0.0081	0.028	0.075	0.48
0.0600	0.0042		0.057	0.029	0.26
0.0490			0.041	0.033	0.30
0.560			0.030		6.3
0.190			0.073		3.6
0.054			0.072		1.8
0.026			0.031	0.028	0.28
0.043			0.044	0.019	0.65
0.028			0.029	0.019	0.23
0.036			0.060	0.020	0.68
0.038			0.050	0.029	0.48
0.033			0.056	0.024	0.60
0.023			0.058	0.019	0.27
0.034			0.015	0.026	0.47
0.043			0.045	0.032	0.53
0.040			0.046	0.036	0.62
0.0042		0.0130	0.070		0.160
0.0048		0.0046	0.050		0.110
0.0086		0.0180	0.096		0.084
0.0042			0.063		0.140
0.0089	0.0054	0.0200	-		0.180
0.0044			0.088		0.130
			0.096		0.080

0.0160			0.077	0.1900	0.33
0.0320			0.068	0.0660	0.34
0.0250			0.078	0.0310	0.26
0.0094			0.160	0.0071	0.15
0.0160			0.053	0.0150	0.27
0.0110			0.081		0.12
0.0044			0.048		0.32
0.0320			0.094	0.0360	0.35
0.0170			0.074	0.0150	0.26
0.0170			0.070	0.0390	0.26
0.0190			0.065	0.0210	0.33
0.0377			0.100	0.0340	0.25
0.0410			0.082	0.0440	0.28
0.0270			0.110	0.0270	0.16
0.0270			0.100		0.13
0.0200			0.062	0.0110	0.19
0.0290			0.100	0.0150	0.31
0.0310	0.0064	0.0025	0.093	0.0250	0.25
0.0120		0.0130	0.065	0.0061	0.11
0.0140			0.044		0.19
0.0260			0.044	0.0270	0.20

Table A24a. Concentrations (ppb, "wet weight) of PCB's in two male northern fur seals collected at North East Point Rookery, St. Paul Island, July 29, 1987. Ages of Animal Nos. 1 and 2 are 3 and 2 years, respectively. Based on Wise (pers. comm., 1988).

Means of two tissue extracts analyzed in triplicate; concentration value is the mean value, and numbers in parentheses are one standard deviation. The < values indicate the minimum detectable level for a compound in a sample.

IUPAC PCB #	MM1L013 Liver	MM1K014 Kidney	MM1M015 Muscle	MM1B016 Blubber
Animal No. 1:				
8 (2,4′)	<1	O*2 (0.0)	0.1 (0.0)	1.8 (0.0)
18 (2,2′ ,5)	0.1 (0.0)	0.2 (0.0)	0.1 (0.0)	0.9 (0.0)
28 (2,4,4s)	0.4 (0.0)	0.9 (0.0)	O*5 (0.0)	11.5 (0.7)
52 (2,2', 5,5')	1.3 (0.0)	1.2 (0.0)	0.8 (0.0)	21.7 (0.4)
44 (2,2′ ,3,5′)	<1	<1	<1	2.8 (0.1)
66 (2,31,3,5′)	2.7 (0.0)	1.4 (0.0)	102 (0.0)	29.7 (0.2)
101 (2,2',4,5,5')	0.4 (0.0)	0.8 (0.0)	0.4 (0.0)	7.8 (0.2)
77 (3,3′,4,4′)	<1	<1	<1	<1
118 (2,3′,4,4′ ,5)	1.4 (0.0)	0.9 (0.0)	0.8 (0.0)	31.3 (1.9)
153 (2,2',4,4',5,5')	5.7 (0.1)	5.2 (0.1)	4.7 (0.3)	120 (6.0)
105 (2,3,3',4,4')	0.5 (0.0)	0.6 (0.0)	0.4 (0.0)	15.2 (0.7)
138 (2,2',3,4,4',5')	4.3 (0.2)	3.6 (0.1)	3.2 (0.1)	17.5 (0.9)
126 (3,3′ ,4,41,5)	<1	<1	<1	<1
187 (2,2′, 3,4′,5,5′,6)	<1	<1	<1	<1
128 (2,2',3,3',4,4',)	<1	<1	<1	<1
180 (2,2' ,3,4,4$,5,51)	1.1 (0.0)	1.4 (0.1)	1.1 (0.0)	1.5 (0.0)
170 (2,2′, 3,3′,4,4′ ,5)	0.4 (0.0)	0.6 (0.0)	0.4 (0.0)	12.0 (0.2)
195 (2,2′ ,3,31,4,4$,5,6)	<1	<1	<1	<1
206 (2,2', 3,3',4,4',5,5',6)	<1	<1	<1	<1
209 (deca)	<1	<1	<1	<1
Animal No. 2:				
8 (2,4′)	<1	<1	<1	<3
18 (2,2′,5)	<1	0.3 (0.0)	<1	<3
28 (2,4,4′) $-	0.8 (0.0)	2.3 (0.0)	007 (0.0)	13.5 (0.4)
52 (2,2', 5, [illegible])	1.0 (0.0)	1.8 (0.1)	0.5 (0.0)	12.5 (0.3)
44 (2,2',3,5' [illegible]	<1	<1	<1	<2
66 (2,3′ ,4,4′)	5.2 (0.3)	7.8 (0.3)	3.1 (0.1)	111 (3.7)
101 (2,2′ ,4,5,5′)	0.9 (0.1)	3.0 (0.1)	0.8 ((0.1)	8.5 (0.9)
77 (3,3′ ,4,4′)	<1	<1	<1	<3
118 (2,3',4,4',5)	6.7 (0.2)	9.0 (0.1)	1.3 (0.1)	95.5 (5.0)
153 (2,2',4,4',5,5')	15.8 (0.9)	30.8 (0.5)	12.4 (1.0)	191 (6.1)
105 (2,3,3',4,4')	1.3 (0.1)	3.9 (0.1)	1.3 (0.0)	18.6 (1.0)
138 (2,2',3,4,4',5')	10.8 (0.3)	20.4 (0.7)	7.1 (0.1)	91.6 (1.8)
126 (3,3',4,4',5)	<2	<2	<2	<10
187 (2,2', 3,4',5,5',6)	<1	<1	<1	<3
128 (2,2',3,3',4,4',)	<1	<1	<1	<3
180 (2,2', 3,4,4',5,5')	3.7 (0.1)	5.9 (0.1)	2.3 (0.1)	32.6 (1.2)
170 (2,2',3,3',4,4' ,5)	1.4 (0.1)	1.8 (0.1)	0.9 (0.0)	11.6 (0.4)
195 (2,2′, 3,3′,4,4′ ,5,6)	<1	<1	<1	<2
206 (2,2', 3,3',4, 4',5,5',6)	<1	<1	<1	<2
209 (deca)	<1	<1	<1	<2

Table A24b. Concentrations (ppb, wet weight) of pesticides in two male northern fur seals collected at North East Point Rookery, St. Paul Island, July 29, 1987. Ages of Animal Nos. 1 and 2 are 3 and 2 years, respectively. Based on Wise (pers. comm., 1988).

Means of two tissue extracts analyzed in triplicate; concentration value is the mean value, and numbers in parentheses are one standard deviation. The < values indicate the minimum detectable level for a compound in a sample.

Pesticide	MM1L013 Liver	MM1K014 Kidney	MM1M015 Muscle	MM1B016 Blubber
Animal No. 1:				
Hexachlorobenzene	<1	0.2 (0.0)	<1	1.8 (0.0)
Aldrin	<1	<1	<1	<1
2,4′-DDE	<1	<1	<1	1.1 (0.1)
4,4'-DDE	36.6 (0.4)	34.4 (1.4)	36.0 (1.4)	1330 (46.9)
2,4'-DDD	1.2 (0.0)″	<1	<1	12.1 (0.5)″
4,4'-DDD	3.5 (0.1)	3.0 (0.1)	2.9 (0.1)	118 (4.2)
2,4'-DDT	<1	<1	<1	<1
4,4'-DDT	2.8 (0.1)	1.9 (0.1)	1.8 (0.1)	34.8 (2.0)
Lindane	1.0 (0.0)	1.4 (0.1)	1.0 (0.0)	25.7 (0.6)
Heptachlor epoxide	1.1 (0.1)	2.0 (0.1)	2.3 (0.1)	34.1 (0.8)
alpha-chlordane	0.2 (0.0)	0.2 (0.0)	0.2 (0.0)	4.3 (0.1)
Trans-nonachlor	5.9 (0.2)	8.0 (0.2)	8.8 ((0.3)	302 (13.6)
Dieldrin	0.9 (0.0)	1.1 (0.0)	0.7 ((0.0)	26.3 (0.7)
Heptachlor	<1	<1	<1	<1
Mirex	<1	<1	<1	<1
Animal No. 2:				
Hexachlorobenzene	<1	<1	<1	<2
Aldrin	<1	<1	<1	<2
2,4'-DDE	<1	<1	<1	<3
4,4'-DDE	85.1 (4.3)	187 (6.7)	72.0 (4.6)	1050 (42.4)
2,4'-DDD	0.9 (0.0)	0.5 (0.0)	0.2 (0.0)	0.4 (0,0)
4,4'-DDD	4.2 (0.2)	9.2 (0.4)	3.3 (0.1)	19.0 (1.2)
2,4'-DDT	<1	<1	<1	<1
4,4'-DDT	3.3 (0.1)	7.2 (0.3)	2.9 (0.1)	16.5 (0.7)
Lindane	0.4 (0.0)	1.9 (0.1)	0.5 (0.0)	2.8 (0.2)
Heptachlor epoxide	2.4 (0.1)	4.3 (0.2)	1.8 (0.1)	14.7 (0.4)
alpha-chlordane	<1	<1	<1	<1
Trans-nonachlor	6.8 (0.2)	32.7 (0.9)	11.3 ((0.4)	64.8 (2.7)
Dieldrin	0.3 (0.0)	0.8 (0.0)	0.3 (0.0)	1.2 (0.0)
Heptachlor	<1	<1	<1	<2
Mirex	<1	<1	<1	<2