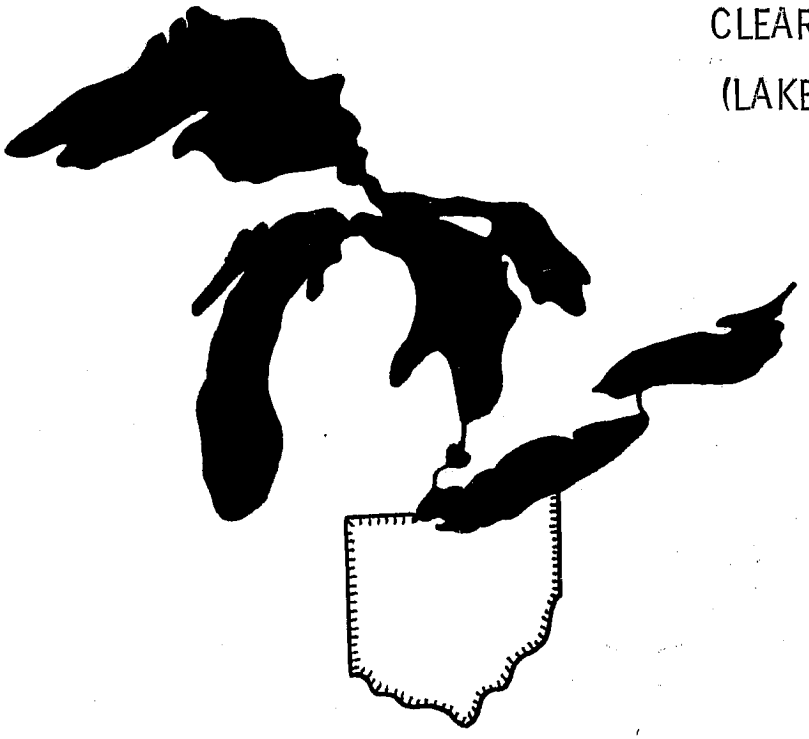

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(LAKE ERIE TAT CONTRIBUTION NO. 2)

LAKE ERIE INTENSIVE STUDY: DATA COMPATABILITY ANALYSIS

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DATA COMPATABILITY ANALYSES

The assessment of data compatability was carried out to determine whether or not data gathered by different agencies during the Lake Erie Intensive Study could be treated as one comprehensive data set. Three approaches were used in the assessment: split sample data provided an estimate of the precision associated with an analysis, "round-robin" results provided indications of bias and/or erratic results, and comparison of data across agency boundaries allowed identification of biases between agencies large enough to be detected in context of environmental variablilty.

Analysis of split sample data

An estimate of precision can be generated from the standard deviation of the population of differences between values obtained in duplicate analyses of the same samples. During the Lake Erie study, agencies split certain samples at the time of collection. These "splits" were bottled, stored, processed, and analized separately. The precision estimate thus encompasses all aspects of the collection and analysis process.

The mean and standard deviation of the differences were calculated for each parameter for each agency. Any differences that were greater than three standard deviations were excluded, and a new mean and standard deviation were calculated. This process was repeated until no further values were excluded, or until five percent of the data had been excluded. The mean of the differences in this final data

set, divided by 1.128, is an estimate of the standard deviation associated with an analysis for the parameter in question. (This standard deviation applies to the analytical result, not to the difference between a pair of analyses.)

The procedure for iterative exclusion of large differences was adopted because 1) it could be done automatically by computer, 2) it is objective, and 3) it produces a precision estimate based on most of the data (at least 95%), but not inflated by the abnormal situation when the system was, in the broadest sense, out of control.

The results of this analysis of splits are presented in Table 1. In general, these results suggest that differences in precision do not require the data sets to be treated as different. While the precision associatied with a particular parameter varies from year to year and from agency to agency, even the largest standard deviations are not large in the context of the concentrations involved (i.e. the relative standard deviations are generally quite small, of the order of 1% or less). The exception to this is the metal parameters, many of which are at levels close to detection limit. Here the limited data available suggests that precision is often not good enough to permit any but the most coarse-scale analysis of the data.

Table 1A-- Precision analysis, based on analysis of split samples, for the laboratories of the Lake Erie study. Results are for 1978. Units for concentration are mg/l except as noted.

WBNS: Western Basin Nearshore, CBNS: Central Basin Nearshore, EBNS: Eastern Basin Nearshore, CNS: Canadian Nearshore, USOL: U.S. Open Lake, COL: Canadian Open Lake.

Parameter	Estimated Standard Deviation					
	WBNS	CBNS	EBNS	CNS[a]	USOL[b]	COL[c]
Temperature	.20	.11		----	0.0	----
pH	.058	.024		.089	.023	----
Conductance	7.1	2.84		10.0	.75	----
Alkalinity	1.26	.68		3.0	.31	.30
Dissolved Oxygen	.17	.10		----	.07	----
Turbidity	.54	.20		.66	.12	----
Chlorophyll a	.0034	.0006		----	.0004	----
Pheophytin	ND	.0003		----	.0005	----
Tot. Sol. Phos.	.0006	.0015		----	----	----
Total Phosphorus	.001	.0022		.011	.0015	.0003
Sol. React. Phos.	.0005	.0005		.004	.0002	.001
Tot. Kjeldahl N	.011	.073		.097	.041	----
Ammonia N	.0012	.007		.011	.002	.0004
Nitrate + Nitrite	.008	.006		.04	.002	.003
Dis. React. Silica	.014	.022		.38	.003	.005
Chloride	.11	.48		.53	.12	.12
Fluoride	.0172	.0008		.075	----	----
Sulfate	.32	.95		1.2	.36	.18
Calcium	NA	1.56		2.0	----	.05
Magnesium	NA	.17		.40	----	----
Sodium	NA	.23		.83	----	.1
Potassium	NA	.11		.23	----	.04
Total Metals (in ug/l)[d]:						
Aluminum	63.44	282		----	----	1
Cadmium	1.40	2.4		----	----	.1
Chromium	16.57	7.2		----	----	.1
Copper	8.05	8.1		----	----	.2
Iron	78.39	21		89	----	.5
Lead	1.38	17.4		----	----	.3
Manganese	11.14	3.4		----	----	.1
Nickel	18.12	5.8		----	----	.5
Vanadium	1.50	39		----	----	.1
Silver	0.19					

Table 1A continued

Parameter	Estimated Standard Deviation					
	WBNS	CBNS	EBNS	CNS[a]	USOL[b]	COL[c]
Zinc	6.21	77		----	----	.3
Arsenic	0.75	.71		----	----	----
Mercury	0.05	.13		----	.15	----
Selenium	9.26	.28		----	----	----
Dissolved Metals (in ug/l):						
Aluminum	26.63	77		----	----	----
Cadmium	0.11	0.0		----	----	----
Chromium	0.07	8.9		----	----	----
Copper	0.73	2.5		----	----	----
Iron	3.41	2.9		----	----	.2
Lead	0.88	17		----	----	----
Manganese	0.50	.2		----	----	----
Nickel	0.45	3.6		----	----	----
Vanadium	2.74	48		----	----	----
Zinc	7.46	5.1		----	----	----
Silver	0.02					

a. Data as published in MOE Data Quality Summary 1975, but appropriate to their Lake Erie work, according to Don King. Data is the 95 within run precision, and may be expected to be higher than data generated for this paper by a factor of about 2.7.

b. Data screened in advance by the agency for large differences between values. This has probably led to lower standard deviations for some parameters, but it is not possible to say which parameters have been affected.

c. Precision data as supplied by the agency. Method based on analytical or reagent blanks. This method will tend to give smaller standard deviations than the method used by TAT.

d. Metals data for western basin is combined for 1978 and 1979.

Table 1B-- Precision analysis, based on analysis of split samples, for the laboratories of the Lake Erie study. Results are for 1979. Units for concentration are mg/l except as noted. Region codes are as in Table 1A.

Parameter	Estimated Standard Deviation					
				a	b	c
	WBNS	CBNS	EBNS	CNS	USOL	COL
Temperature	.03	0		----	.006	----
pH	.078	.012		.089	.02	----
Conductance	3.07	.68		10.0	.464	----
Alkalinity	2.15	.68		3.0	.26	.30
Dissolved Oxygen	.14	.00		----	.13	----
Turbidity	1.38	.11		.66	.12	----
Chlorophyll a	.0030	.0003		----	.0003	----
Pheophytin	ND	.00016		----	.00012	----
Tot. Sol. Phos.	ND	.0014		----	----	----
Total Phosphorus	.0010	.0018		.011	.0024	.0003
Sol. React. Phos.	.0004	.0003		.004	.0004	.001
Tot. Kjeldahl N	.039	.122		.097	----	----
Ammonia N	.0017	.005		.011	.0015	.0004
Nitrate + Nitrite	.0040	.0034		.04	.0026	.003
Dis. React. Silica	.010	.026		.38	.0064	.005
Chloride	ND	.17		.53	.13	.12
Sulfate	ND	.55		1.2	----	.18
Calcium	6.66	.38		2.0	----	.05
Magnesium	7.27	.12		.40	----	----
Sodium	0.11	.12		.83	----	.1
Potassium	0.01	.03		.23	----	.04
Total Metals (in ug/l)[d]:						
Aluminum		18.2		----	----	1
Cadmium		.55		----	----	.1
Chromium		8.0		----	----	.1
Copper		4.4		----	----	.2
Iron		29.7		89	----	.5
Lead		1.6		----	----	.3
Manganese		4.9		----	----	.1
Nickel		3.7		----	----	.5
Vanadium		6.7		----	----	.1
Zinc		7.4		----	----	.3
Arsenic		.05		----	----	----
Mercury		.06		----	----	----
Selenium		0.0		----	----	----
Silver		.321		----	----	----

Table 1B continued

Parameter	Estimated Standard Deviation					
				a	b	c
	WBNS	CBNS	EBNS	CNS	USOL	COL
Dissolved Metals (in ug/l):						
Aluminum		4.8		----	----	----
Cadmium		.10		----	----	----
Chromium		1.7		----	----	----
Copper		4.3		----	----	----
Iron		8.7		----	----	.2
Lead		2.2		----	----	----
Manganese		2.6		----	----	----
Nickel		2.7		----	----	----
Vanadium		2.1		----	----	----
Zinc		5.9		----	----	----

a. Data as published in MOE Data Quality Summary 1975, but appropriate to their Lake Erie work, according to Don King. Data is the 95 within run precision, and may be expected to be higher than data generated for this paper by a factor of about 2.7.

b. Data screened in advance by the agency for large differences between values. This has probably led to lower standard deviations for some parameters, but it is not possible to say which parameters have been affected.

c. Precision data as supplied by the agency. Method based on analytical or reagent blanks. This method will tend to give smaller standard deviations than the method used by TAT.

d. Metals data for the western basin is combined for 1978 and 1979.

Round-robin results

The International Joint Commission provides a continuing series of round-robin studies, in which samples are sent to participating labs for analysis. Each study involves analysis for several (usually related) parameters, with several samples covering a range of concentrations. Many of the samples are of natural waters, or natural waters spiked to raise concentrations. The results are evaluated in reference to the range of values reported by the participants, with the assumption that the median value reported is the best estimate of the true value for that sample. This assumption may be questionable for some analyses when concentrations are very close to detection limit for most labs, and may result in the one or two labs doing accurate work being flagged for poor performance. However, most of the time the approach serves to identify labs that are erratic or biased in their performance, in the context of the performance of the group of labs as a whole. All labs involved in the Lake Erie study participated in the round-robin series.

The results of the Lake Erie labs in the studies which were carried out shortly before and during the Lake Erie study were evaluated for indications of bias and erratic performance by John Clark of IJC and by me. The data includes multiple analyses, usually as part of two or three separate round-robin studies, for ** parameters. In general, the results show that substantial biases between labs are common, that erratic results are common, and that good performance on one round-robin study does not necessarily predict good performance on the next one involving the same parameters. Nor does bad performance

predict better performance on the next study. Several labs, mostly Canadian, had consistantly good performances for almost all parameters, but most labs fell down at least occasionally on some parameters, and some fell more frequently and farther than others.

These results suggest the general conclusion that combining data from different agencies is likely to be unwise, at least without careful scrutiny of the compatibility of the data, in the context of the purposes of the research in which the data is to be used.

The results of the round-robins evaluated are presented in Table 2.

Table 2-- Performance of the Lake Erie labs on IJC round-robin studies 21 through 29, organized by parameter.

Region codes:
WBNS: Western Basin Nearshore, CBNS: Central Basin Nearshore, EBNS: Eastern Basin Nearshore, CNS: Canadian Nearshore, USOL: U.S. Open Lake, COL: Canadian Open Lake.

Key to symbols used in chart:
ok: performance showed no serious defficiencies,
ERR: performance erratic: some analyses high and others low,
B-H: performance suggests high bias relative to other labs,
B-L: performance suggests low bias relative to other labs,
Labs that did not participate, or did not analize enough samples to permit evaluation, have a blank entered for that parameter.

Parameter	Study Number	Lake Erie Region WBNS	CBNS	EBNS	CNS	USOL	COL
pH	21			ok	ok	ok	ok
	22	ok		ERR	B-H	ok	ok
	27	ERR	B-H	ok	B-H	ERR	ok
Conductance	21			ok	ok	ok	ok
	27	ERR	B-H	B-L		B-H	
Alkalinity	21			ok	ok	ok	ok
	22	B-L			ok	ok	ok
	27	B-H		ok	ok	ok	B-L
Dissolved Oxygen	No studies						
Sospended Solids	No studies						
Chlorophyll a	No studies						
Pheophytin	No studies						
Tot. Sol. Phos.	No studies						
Total Phosphorus	24	ERR	ok		ok	ok	
	27		ok	B-H		B-L	ok
	28		ok	ERR		ok	B-L
Sol. React. Phos	No studies						
Tot. Kjeldahl N	22				ok	B-L	ok
	27		ERR	ok	ok	B-H	ok

Table 2 continued

Parameter	Study Number	Lake Erie Region WBNS	CBNS	EBNS	CNS	USOL	COL
Ammonia N	27	ok	B-H	B-L		B-H	ok
Nitrate + Nitrite	22	B-L		B-H	B-L	B-H	B-H
	27	ok	ERR	ok	ok	ok	ok
Dis. React. Silica	22	B-H	B-H		ok	ERR	B-L
	25	ok	B-H	ERR		ok	ok
	27	B-L	B-H	B-H		ok	ok
Tot. Org. Carbon	21			ok			
	27		B-H	B-H	B-H	ok	ok
Chloride	22		ok		ok	ok	ok
	27		ok	ok	ok	ok	ok
Fluoride	27					ok	
Sulfate	22		B-L		B-H	ok	ok
	27		ok			ok	ok
Calcium	22				ok	ok	ok
	27		ok	ok	ok	ok	ok
Magnesium	22				ok	ok	ok
	27		B-L	ok	ok	ok	ok
Sodium	22			ERR	ok	B-H	ok
	27		ERR	ERR	ok	B-H	ok
Potassium	22			B-L	B-L	ERR	ok
	27		ERR	B-L	ok	ERR	ok
Total metals:							
Aluminum	21				ok	ok	ok
	23	B-H				ok	ok
Cadmium	21			ok	ERR	ok	ok
	23	ok		B-H	ok	ok	ok
Chromium	21				ok	ok	ok
	23	B-H		ERR	ok	B-H	B-L
Copper	21				ok	ERR	ok
	23	ERR		ERR	ERR	B-H	ok

Table 2 continued

Parameter	Study Number	Lake Erie Region WBNS	CBNS	EBNS	CNS	USOL	COL
Iron	21			ok	ok	ok	ok
	23	B-H		B-L	ok	B-H	ok
Lead	21				ok	ok	ok
	23	B-H		ERR	ok	B-H	ok
Manganese	21			ok	ok	B-L	ok
	23	B-H		ERR	ok	B-H	ok
Nickel	21			ok	ok	B-L	ok
	23	B-H		ERR	ok	B-L	B-L
Vanadium	21				B-L	B-L	ok
	23	B-L			ok	B-H	ok
Zinc	21			ok	ok	ok	ok
	23	ERR		ok	ok	B-L	ERR
Arsenic	21				ok	ok	
	26			ERR	ok	ERR	ok
Selenium	Inadequate data						
Mercury	No studies						
Silver	No studies						
Dissolved metals:	No study for any dissolved metals except major ions						

Analysis of data at adjacent stations

Since the purpose of combining data sets is to be able to answer questions about the lake as a whole, it could be argued that the ultimate data compability test lies in the data itself, in the comparison of values at stations along the boundaries of the agencies. One could consider the data compatable if differences across boundaries were not large in comparison with day-to-day differences at each station, or in comparison with some other measure of small-scale internal variablilty.

This approach was followed by choosing pairs of stations which straddled agency boundaries, and comparing the data generated in three successive days' sampling at each station. If the two triads of data overlapped, the data were judged not to be different. This judgement was made for each date and level sampled at two or more pairs of stations. The results were tabulated as the number of observations judged the same, the number judged high in lab 1 relative to lab 2, and the number judged low in lab 1 relative to lab 2.

The approach is weakened by the spatial and temporal seperation of the stations. Some "nearest" station pairs across boundaries were ** miles apart, while others were at the same spot to within navigational accuracy. Some sampling intervals involved overlap of sampling dates, while others involved intervals of up to 10 days between the sampling by the two labs. Any comparisons involving sampling time separations greater than 10 days were not used in the analysis. Allowance was made for expectable seasonal changes such as

changing temperatures and dissolved oxygen concentrations in the spring. Bottom samples that showed indications of being hypolimnion samples were not included unless all samples in that comparison seemed to be hypolimnion samples.

An additional problem is that the nearshore zone was sampled three days in succession, while the open lake was sampled one day per cruise only. Thus comparisons between two agencies working in the nearshore zone involve six data points, while comparisons between nearshore and open lake agencies involve four, and comparisons between two open lake agencies involve only two data points. Where more data points are involved in the comparison, the likelihood of reaching a no-difference judgement is greater, indeed, where only two data points are involved, the values will usually be different. However, since the final assessment is usually based on ten to twenty such judgements, and only parameters which show quite consistent divergent behavior are judged to contain a between-lab bias, this difference in data density is probably not a serious problem.

The results of these boundary comparisons are shown in Table 3.

Table 3--Biases suggested by across-boundary comparisons of field data.

Table 3 cannot be prepared until all data is in. Although comparisons are made pair-wise, the final determination of who is biased can only be made when all pariwise comparisons have been made. For now, the following information is offered.

1. Comparisons between U.S. EPA and CLEAR

EPA data for conductance and pheophytin are consistantly higher than CLEAR data for these parameters.

EPA Total Soluble Phosphorus is consistantly lower than CLEAR.

EPA Total Phosphorus, Soluble Reactive Phosphorus, and TKN tend to be lower, but these patterns are less clearcut than the above.

There is a considerable amount of missing data for many parameters, much of it EPA non-data.

2. Comparisons between Heidelberg College and CLEAR

HC has higher specific conductance, lower Total Phosphorus, Total Soluble Phosphorus, and turbidity than CLEAR. The last three differences are only apparent at the station at the outer edge of the nearshore zone, because they are not pronounced enough to overcome the great scatter in the very nearshore data.

HC tends to have higher TKN, nitrate plus nitrite, DO, and Secchi depth values. These tendencies are less clearcut than the ones above.

The day-to-day variability in the data is considerable, and no dates of sampling by the two agencies were closer than 1 week. These facts make bias discrimination rather hazy.

3. Comparisons between EPA and Heidelberg College

EPA Alkalinity is higher both years about 60% of the time. It is never lower.

In 1979, 4 of 6 EPA pH values are higher (see below), and 4 of 6 EPA Nitrate plus Nitrite values are higher (but the other 2 are lower).

In 1978, 8 of 14 EPA pH values are lower, as are 4 of 4 Total Phosphorus, 3 of 4 Total Soluble Phosphorus. 5 of 10 EPA chloride values are higher.

Much EPA data is missing.

Overall conclusions

In general, data compatibility is not seriously affected by precision, except for metal parameters which are present in the waters at very low concentration levels. However, between-lab biases are commonly significant compared to the temporal and spatial variability which characterize the lake as a whole. The question of data compatibility is a relative one, and judgements about the compatibility of the data must ultimately be made in context of specific research questions to which the data is to be applied. However, the implications of the analyses presented here are that it is not safe to assume that data gathered by different agencies, or even by the same agency in different years, are compatable.