WASHINGTON STATE
DEPARTMENT OF
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Lower Columbia River Bi-State Water Quality Program: Bacteria Studies

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and
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April 1993
Publication #93-28
printed on recycled paper

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September - October 1992

by Dave Hallock

November - December 1992

by William Ehinger

Environmental Investigations
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Water Body No. WA-CR-1010/1020
(Segment No. 26-00-01/02)

April 1993
Publication #93-28

Lower Columbia River Bi-State Water Quality Program: Bacteria Study September - October 1992

by
Dave Hallock
March 1993

ABSTRACT

High enterococcus bacteria counts detected during a reconnaissance survey in 1991 indicated a possible public health risk in the lower Columbia River. The purpose of this project was to determine if a chronic public health risk exists during high contact recreation periods due to bacteria contamination. Ecology sampled twelve stations between the mouth of the Columbia River and river mile 170 (Hood River) weekly from September 1 to October 12, 1992. Fecal coliform and enterococcus bacteria were monitored, as well as oxygen, temperature, pH, and conductivity. Water quality standards for temperature, pH, and percent oxygen saturation were exceeded at several stations. Fecal coliform bacteria standards were exceeded at two stations (Ilwaco Marina and Sauvie Island), but a chronic public health risk is not indicated. Enterococcus bacteria did not exceed standards.

INTRODUCTION

A key purpose of the Lower Columbia River Bi-State Water Quality Program (Bi-State Program) is to collect environmental data for evaluating the water quality condition of the lower Columbia River. A reconnaissance survey was conducted between late September and November 1991 (Tetra Tech, 1992). Bacteria samples were collected on five separate occasions at each of six stations over a 30-day period. Results of this sampling showed that mean enterococcus counts exceeded EPA and Oregon standards at all stations. Fecal coliform means exceeded Washington State marine standards at one of the two stations in the estuary. Some individual sample results showed high fecal coliform counts, even though the 30-day geometric means did not exceed freshwater standards.

Fecal coliform and enterococcus bacteria are found in the intestinal tract of mammals and birds. The fecal coliform group contains several genera, including *Eschericia*. The enterococcus group is a subgroup of the fecal streptococcus group and includes several species of *Streptococcus*. The presence of fecal coliform and enterococcus bacteria does not confirm the presence of pathogens; nor does their absence confirm the absence of pathogens. However, their presence does indicate fecal matter that may carry human pathogens. Studies have shown that both groups are related to the occurrence of swimming-associated gastroenteritis, so they are commonly used to assess the quality of water with respect to primary contact recreation.

This study was developed in response to Task Order Statement of Work Number 78-91/02-002. The purpose of this project was to confirm reconnaissance survey results and to evaluate whether there is a chronic public health problem in the lower Columbia River. Specifically, the objective was to assess fecal coliform and enterococcus bacteria contamination during a period of high contact recreation at sites sampled during the initial reconnaissance survey, as well as at additional sites.

METHODS

We sampled the same (or very near the same -- see Table 1) six stations identified in the "Task Order Statement of Work," and previously sampled during the reconnaissance survey (Tetra Tech, 1992). Six additional stations were selected based on logistical considerations, the location of potential sources of bacteria, proximity of high-use contact recreation areas, specifications in the "Task Order Statement of Work," and discussions with the Bi-State Program (Table 1 and Figure 1). Four of these additional stations were upstream of the uppermost station sampled during the reconnaissance survey.

Six two-day sample trips were completed approximately weekly between September 1, 1992, and October 12, 1992. Most sampling was conducted on Sundays and Mondays to correspond to peak recreation times. Saturday sampling could not be accommodated by the laboratory due to the short holding times for bacteria samples. Because of the short lead-time to begin the study and the set-up needed by the laboratory for the enterococci analysis, enterococci were not sampled on the first trip. Fecal coliform bacteria were not sampled on the last trip.

All stations except Station 5 (downstream of the Weyerhaeuser Longview Plant) and Station 11 (Bridge of the Gods), were sampled by wading out into the river to a depth of two to three feet and collecting a sub-surface grab sample. Triplicate samples, identified as Samples A, B, and C, were collected at 10 to 50 meter intervals, depending on accessibility. Triplicates were collected from downstream to upstream to avoid contamination. This procedure was designed to assess primary contact recreation areas and not necessarily whole-river conditions.

Stations 5 and 11 were sampled from a boat at ¼, ½, and ¾ of the cross-channel distance. Profile data were also collected at these two stations on all except the first sample trip. This sampling strategy was designed to assess whole-river conditions.

Table 1. Stations on the lower Columbia River monitored during this study.

Station No.	Recon[a] Survey No. (RM)	Name	Latitude	Longitude	River Mile	Comments
1	W2 (1.8)	Ilwaco, WA	46 16.86	124 03.55	1.5	Fort Canby State Park
2	W3 (3)	Ilwaco Marina, WA	46 18.15	124 02.11	3.0	Near boat hoist/wash station
3	W13 (32.5)[b]	Skamakowa Park, WA	46 16.13	123 27.67	32.9	
4	W16 (46.5)	Jones Beach, OR	46 08.35	123 19.07	46.1	Left on Riverfront to 100 yds from end
5	W22 (61.5)[b]	Downstream Weyerhaeuser Longview Plant, OR, WA	46 08.55	123 01.79	61.3	Marker 13 (right bank; Barlow Pt.)
--					68.0	Cowlitz River
6	W35 (98)	Sauvie Island, OR	45 43.85	122 45.93	95.9	Rt on gravel road at Columbia Co. line
--					101.5	Willamette River
7	W38 (104)	Kelly Point Park, OR	45 38.92	122 45.53	102.0	
--					~101.5 - 115.0	Vancouver, Portland
8	W40 (115)	148th and Marine, OR	45 33.84	122 30.53	115.0	
9	—[b]	Rooster Rock S.P., OR	45 32.88	122 14.25	128.0	Downstream end of park
10	—[b]	"The Fishery" Resort, OR	45 36.49	122 02.40	140.6	Downstream side of boat launch
--					146.1	Bonneville Dam
11	—[b]	Bridge of the Gods, OR, WA	45 39.81	121 54.03	148.4	100 yds upstream of bridge
12	—[b]	Hood River, OR	45 42.92	121 30.32	169.3	Columbia Sailpark Marina
--					169.4	Hood River

[a]Tetra Tech, 1992.
[b]The original reconnaissance survey did not monitor bacteria at these stations.

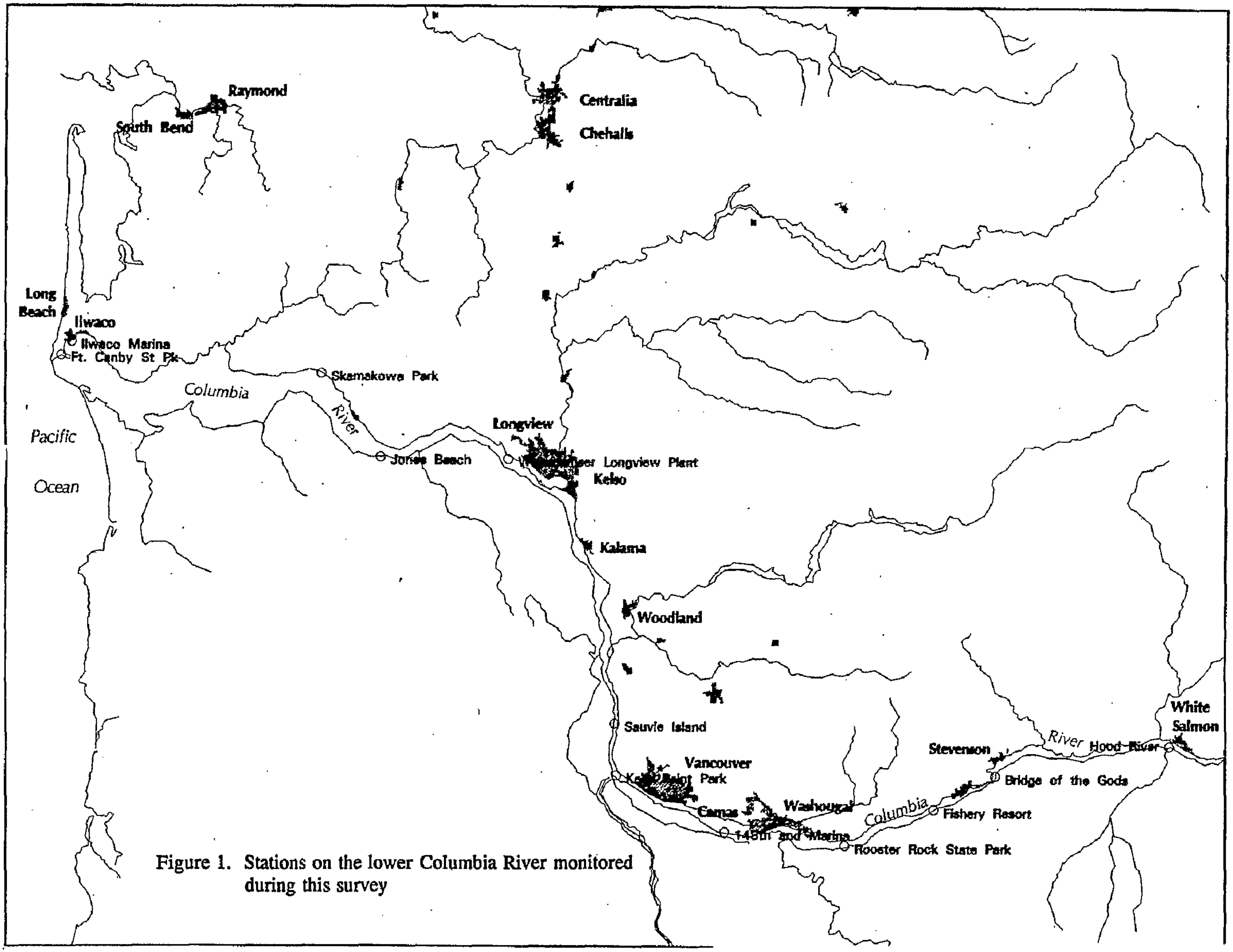

Figure 1. Stations on the lower Columbia River monitored during this survey

Bacteria

Bacteria samples were collected in sterilized 500mL glass bottles with aluminum foil over the stopper to prevent contamination during transport. Samples were collected upstream from the sampler by plunging the inverted bottle approximately 25 cm deep (to avoid collecting surface film) and then righting the bottle to fill it. The bottle was oriented into the flow to avoid contamination.

Samples were immediately placed on ice and shipped daily via air freight or courier to Manchester Environmental Laboratory. Samples were analyzed within 30 hours of collection and often within 24 hours. Both fecal coliform and enterococcus bacteria were analyzed using membrane filter methods (American Public Health Association [APHA], 1989; methods SM9222D and SM9230C, respectively). STORET parameter codes for the fecal coliform and enterococcus bacteria methods are 31616 and 31639, respectively.

Other Parameters

Several other parameters, in addition to bacteria samples, were monitored at each of the stations sampled from the bank (Table 2). Except for temperature, which was measured *in situ*, parameters were measured from aliquots of a water sample collected in a stainless steel bucket (APHA, 1989, Figure 4500-O:1). The sample was collected from the same place as the first of the triplicate bacteria samples (Sample A). Dissolved oxygen was fixed and other measurements were made within 15 minutes of collecting the sample.

Table 2. Parameters measured at bacteria monitoring sites.

Parameter	Method	Units
Fecal Coliform Bacteria	Membrane Filter	colonies/100mL
Enterococcus Bacteria	Membrane Filter	colonies/100mL
Temperature	Mercury or Elec. Thermometer	°C
Dissolved Oxygen	Modified Winkler	mg/L
pH	Orion Model 250A	Std Units
Conductivity[a]	Beckman Model RB5	μmhos/cm
Salinity[a]	Refractometer	ppth
Barometric Pressure	Aneroid Barometer	inches Hg

[a]Salinity was measured only at Stations 1 and 2, where conductivity exceeded the upper range of the meter.

Profiles

At the two stations sampled by boat (Stations 5 and 11), a Hydrolab Surveyor II® model profiling instrument was used to measure profiles at quarter points across the river. Temperature, dissolved oxygen, pH, and conductivity were measured at one meter intervals to 10 meters depth and 5 meter intervals thereafter. Depth of the probe was determined by a pressure sensor and not by the amount of cable deployed. The boat was allowed to drift with the current while taking measurements; we stopped taking readings well short of the bottom to avoid catching the instrument on submerged debris.

Quality Assurance/Quality Control

The quality of Manchester Laboratory's data is evaluated through Manchester's continuing quality assurance/quality control (QA/QC) program which includes QC charts, check standards, in-house matrix spikes, laboratory blanks and duplicates, and regular performance evaluation standards. For bacteria samples, the sterility of laboratory glassware and media is evaluated before and after each batch is analyzed. In addition, the Ambient Monitoring Section (AMS) maintains its own QA/QC program which includes standard sampling protocols and blind field duplicates. These QA/QC procedures and QC results for AMS in general are discussed in more detail in Hopkins, *et al.* (in press).

For this study, all parameters were sampled in duplicate at all three sample points (A, B, and C) from one randomly selected station on each sampling trip. Duplicate samples were collected sequentially, that is, after collecting primary samples at that station. Duplicates were submitted blind to the laboratory. Quality control samples from each trip were split in the laboratory to assess lab variability. Duplicates at open water stations (Stations 5 and 11) were measured using the same procedures as bank samples in order to check Hydrolab performance.

Meter maintenance is performed in accordance with the user's manuals. Meters were calibrated before each sampling trip and calibration was checked after each sampling trip. In addition, pH calibration was checked at every fourth station. Oxygen, pH, and conductivity samples were collected at each of the two boat-sampled stations as a calibration check of the profiling instrument.

RESULTS AND DISCUSSION

Bacteria

Comparison to Water Quality Standards

Water quality standards for bacteria are not a simple number which no single result is to exceed. This is because bacteria behave as particulates so both the spatial and temporal distribution of bacteria is less uniform than a soluble chemical parameter. Therefore, standards often specify a geometric mean value not to be exceeded and a level that not more than 10 percent of samples should exceed. Water quality standards for the lower Columbia River are shown in Table 3. Washington's marine water standards are more restrictive than freshwater standards to protect water quality for shellfish consumption. The lower two stations in the survey, Ilwaco and Ilwaco Marina, are considered marine based on salinity results.

Geometric Mean Standard

When all dates are included, no station exceeded the geometric mean standards (for Washington or Oregon, as appropriate) for either fecal coliform or enterococcus bacteria (Table 4 and Figures 2 and 3). The geometric mean of the three samples collected at each station on individual dates was high several times during the study (Table 4, shaded type). However, EPA (1986) recommends that the geometric mean be based on not less than five samples over a thirty-day period (EPA, 1986) so these do not constitute water quality standards violations.

90th Percentile Standard

Based on our results, more than 10 percent of the data can be expected to exceed water quality standards at two stations: Station 2, Ilwaco Marina, and Station 6, Sauvie Island (Figure 2 and Appendix A). The exceedence of Washington's marine fecal coliform criterion at Station 2 is a result of high values one day out of five. This station also exceeded the geometric mean criterion during the reconnaissance survey (Tetra Tech, 1982). However, Station 2 did not exceed freshwater criteria. The exceedance of marine criteria, while a genuine violation of water quality standards, is probably of lesser concern since Ilwaco Marina is not known to be a shellfish harvesting area (Smith, pers. comm.).

The violation of Oregon's water quality standards at Sauvie Island is a result of extremely high values on September 20; results were low at all other sample times. Both fecal coliform and enterococcus bacteria were high in each of the three samples on this date (Appendix B), so this result cannot be explained as contamination or laboratory error. This station did not exceed fecal coliform criteria during the fall 1991 reconnaissance survey (Tetra Tech, 1992). The Oregon Department of Environmental Quality (DEQ) sampled a station about three miles downstream on September 15, 1992, and found no unusually high values (results were 11 organisms/100mL for fecal coliform and 25 for enterococci; Caton, pers. comm.). Bacteria concentrations have been well below standards during the last year at DEQ monitoring stations on the Willamette River, the Columbia River just above the Willamette, and the Columbia about three miles below our Sauvie Island station. There is no reason to suspect that the high values at this station are indicative of whole-river concentrations; it is more likely that these values apply to the near-shore area only. The high counts at the Sauvie Island station appear to be both localized and of short duration. The source is unknown and source tracing is outside the scope of this study. Possible local sources include birds from the wildlife refuge at nearby Sturgeon Lake (where bacteria counts often exceed 1600/100mL; Caton, pers. comm.), horses from recreational riding along the beach, human bathers, or local septic systems.

Table 3. Water quality standards for bacteria in the lower Columbia River (organisms/100mL).

	Fecal Coliform Bacteria		Enterococcus Bacteria
	Maximum Geom. Mean	<10% of sample over	Maximum Geometric Mean
Washington[a]			
Freshwater	100	200	None
Marine Water	14	43	
Oregon[b]			
Freshwater	200	400	None[d]
Marine Shellfish	14 (median)	43	
Marine non-shellfish	200	400	
Federal guidance[c]			
Freshwater	None	None	33
Marine	14 (shellfish)	43 (shellfish)	35 (bathing)

[a] Washington Administrative Code 173-201.
[b] Oregon Administrative Rules Chapter 340 Division 41 Section 202; Oregon uses the MPN method for fecal coliform bacteria.
[c] EPA (1986)
[d] Oregon's enterococcus standard was recently suspended.

Table 4. Geometric means of three replicates of fecal coliform bacteria/enterococcus bacteria (organisms/100mL) in the lower Columbia River. High values are shaded.

Station	River Mile	Sept 1-2	Sept 13-14	Sept 20-21	Sept 27-28	Oct 4-5	Oct 11-12	All Dates
1	1.5	1/--	4/1	6/1	6/4	2/1	--/18	3/2
2	3.0	6/--	3/2	117/18	4/1	21/3	--/1	10/3
3	32.9	14/--	1/1	5/1	56/17	4/2	--/3	7/2
4	46.1	4/--	7/5	8/1	57/10	6/2	--/3	9/3
5	61.3	22/--	48/3	25/6	54/3	118/7	--/4	44/4
6	95.9	37/--	12/2	1764/296	59/15	43/12	--/2	73/10
7	102.0	8/--	19/11	37/12	51/35	22/14	--/20	22/16
8	115.0	18/--	102/5	25/1	45/2	21/3	--/6	34/3
9	128.0	7/--	60/149	5/3	14/1	3/1	--/1	10/4
10	140.6	3/--	1/3	1/3	1/1	1/2	--/1	2/2
11	148.5	1/--	1/1	2/1	2/2	1/1	--/1	1/1
12	169.3	5/--	53/5	4/4	70/1	4/6	--/11	12/4

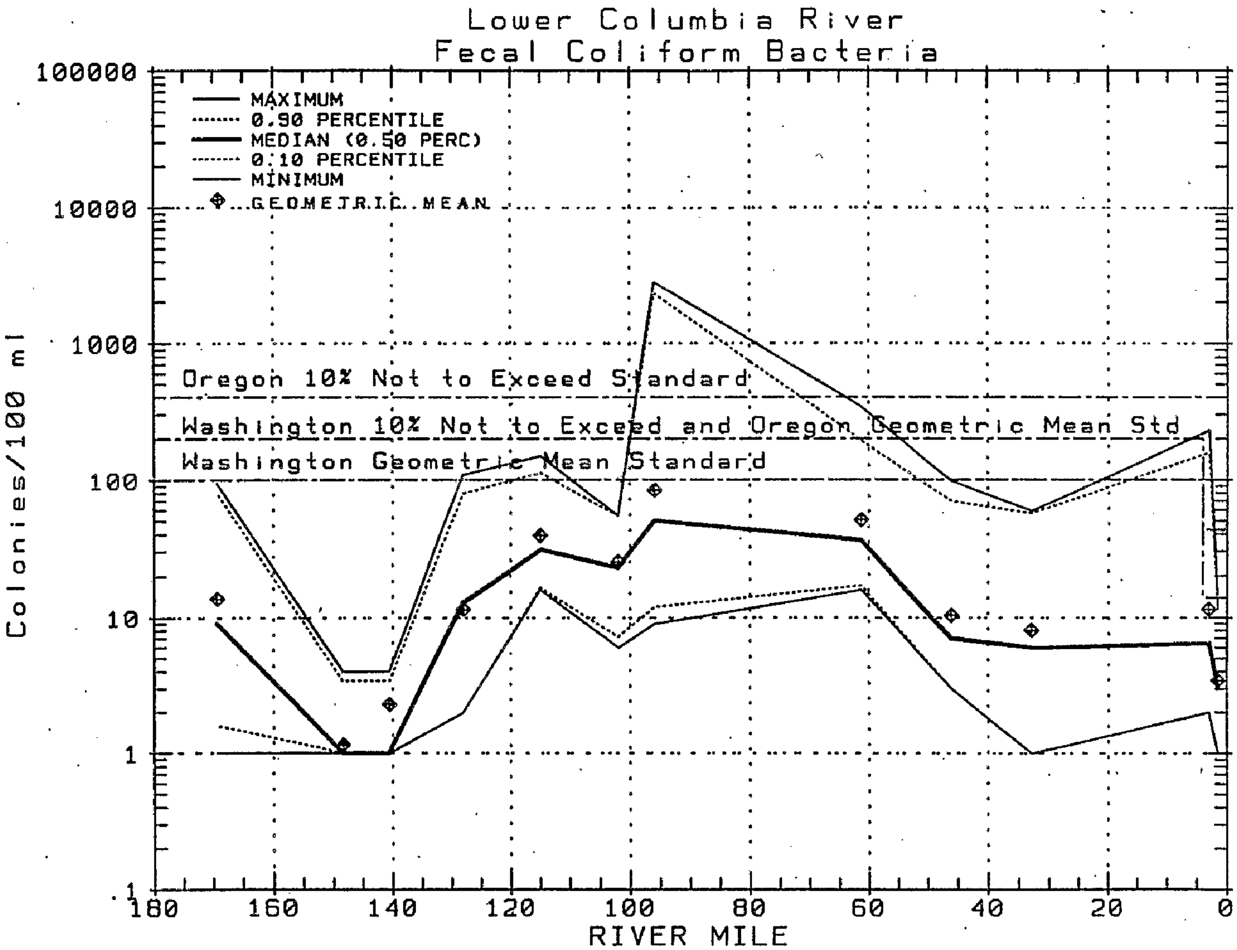

Figure 2. Fecal coliform bacteria results from approximately weekly monitoring between September 1 and October 12, 1992, on the lower Columbia River. This graph is based on geometric means of triplicate samples.

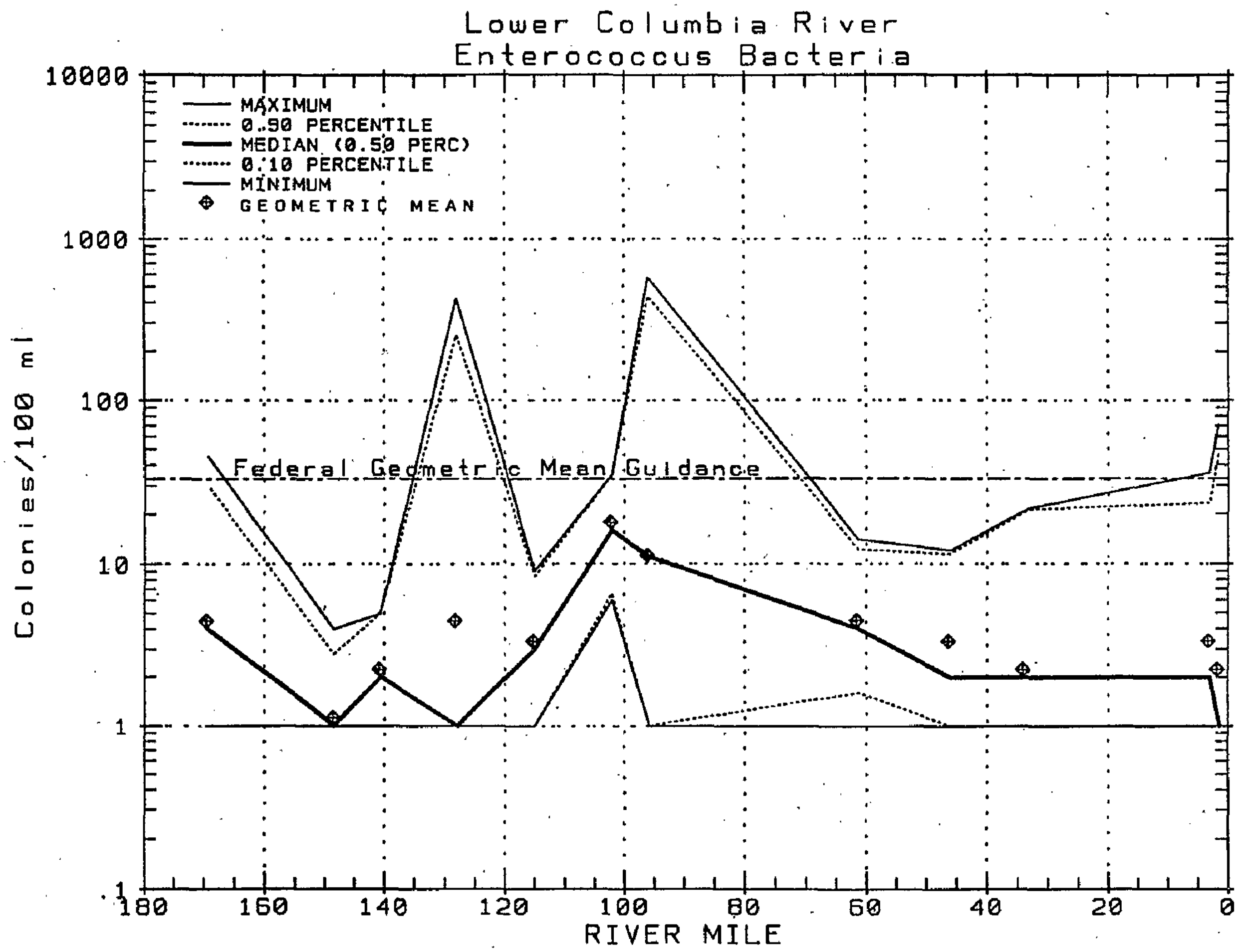

Figure 3. Enterococcus bacteria results from approximately weekly monitoring between September 1 and October 12, 1992, on the lower Columbia River. This graph is based on geometric means of triplicate samples.

Comparison to Other Data

With the exception of the one set of samples from the Sauvie Island station, the fecal coliform data from this study were not unusually high compared to other monitored stations in Washington. Ecology monitored 60 other Class A stations statewide in September 1992. The geometric mean of fecal coliform counts for these 60 stations was 40 organisms/100mL compared to an overall geometric mean of 10 organisms/100mL during this study. Statewide, 10 percent of the samples exceeded 310 organisms/100mL in September compared to 70 organisms/100mL for this study.

Because of the variability of bacteria data, these results are not directly comparable to Tetra Tech's (1992) results. However, the results of this study do not indicate a chronic public health problem during the dry season with respect to fecal coliform or enterococcus bacteria at the 12 stations monitored. Occasional localized, short-term bacterial contamination does occur and popular public swimming beaches should be monitored by local health agencies. This study was intended to assess bacteria contamination during periods of high contact recreation. Sampling began somewhat later than ideal for this purpose; however, all sampling took place during the dry season and should be representative. Higher bacteria counts may be found during the wet season, especially after the first heavy fall rains. Sampling is currently underway to assess this.

Spatial and Seasonal Patterns

Spatial patterns for fecal coliform and enterococcus bacteria were very similar (Figures 2 and 3). Counts tended to be higher in the mid-reach of the study area (river mile [RM] 60-130). This reach includes Portland, Vancouver, and Longview. However, since most stations were bank samples intended to assess discrete shoreline areas and not necessarily whole-river conditions, interpretation of spatial trends is tenuous. Of the two open-water stations, Station 11 (RM 148.4) consistently had low bacteria counts, while Station 5 (RM 61.3) consistently had more moderate counts.

The Columbia River fluctuates with the tidal cycle as far upstream as Sauvie Island (Oregon Department of Fish and Wildlife). These fluctuations were not evaluated in this study, but should be considered when attempting to identify sources.

There were no seasonal patterns in bacteria during the five weeks each bacteria group was sampled (Figure 4). The generally higher fecal coliform bacteria on September 27-28 may be the result of 1.8 inches of rain (measured at Longview) on September 24-25. This is 60% of the total precipitation received in September. September precipitation at Longview was 3.09 inches (the average for September is 2.19 inches). Precipitation data for October are not available.

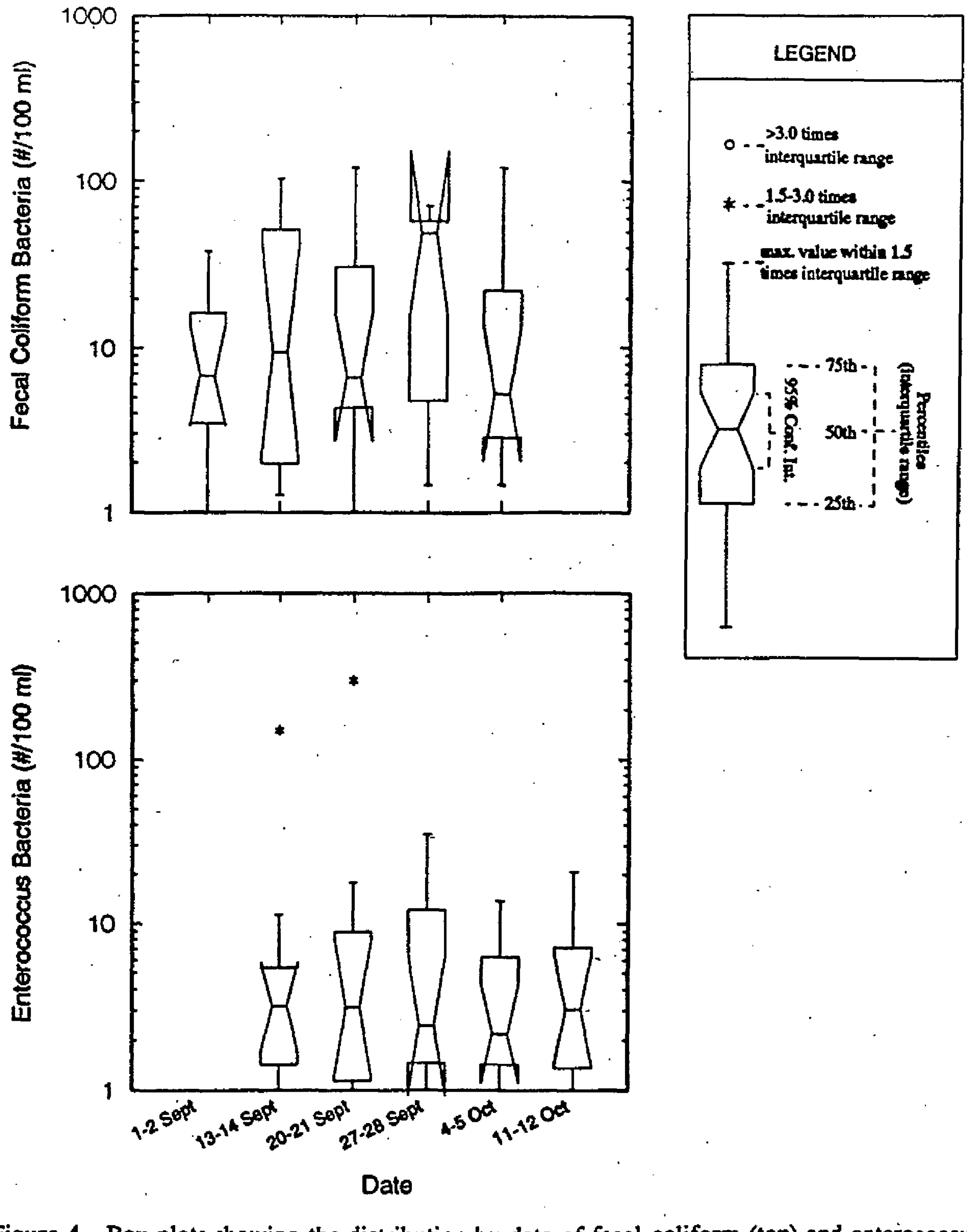

Figure 4. Box plots showing the distribution by date of fecal coliform (top) and enterococcus (bottom) bacteria collected at 12 stations on the lower Columbia River.

Other Parameters

Several other parameters exceeded Washington and Oregon's water quality standards. Temperature was the parameter that most frequently violated standards. Washington's standards specify that "temperature shall not exceed 20°C due to human activities" in the lower Columbia (the usual Class A standard is 18°C). Oregon's standard is essentially the same. Temperature exceeded this special criteria at least once at all freshwater stations (Figure 5). Although most stations were bank samples where higher temperatures might be expected, the two open-water stations also exceeded criteria. Temperature was probably even higher in July and August than they were during this survey. The relationship of temperature to human activities was not assessed, but temperature is probably significantly affected by impoundments. The high temperature in the lower Columbia should be considered when developing discharge permits.

Washington and Oregon standards (which are essentially the same) were exceeded for pH at least once at several mid-reach stations, but not at the two open-water stations (Appendix B). Percent oxygen saturation dipped below standards (90% for both states) on one occasion at Station 5 (Appendix B), although dissolved oxygen concentrations were well within Washington's standards (8.0 mg/L). Oregon has no concentration standard for dissolved oxygen.

Open Water Stations

The river was well-mixed both vertically and horizontally at the two open water stations. All profile parameters (temperature, dissolved oxygen, pH, and conductivity) were remarkably consistent from the surface to the bottom. Figure 6 shows profile data collected on September 13-14; profiles on other dates were similar. A paired normal scores test did not detect significant ($p > 0.20$) differences between the three cross-channel sample points with respect to either the profiled parameters or bacteria results. These results imply that a sub-surface grab sample may adequately represent whole-river conditions for the parameters measured. These results cannot be used to assess the adequacy of bank samples to assess whole-river conditions.

Quality Control

Bacteria

The distribution of bacteria in nature is very patchy. As a result, field duplicate results can vary greatly. Coefficients of variation (CV; the standard deviation divided by the mean) of 50 or even 100 percent are not unusual in Ecology's statewide monitoring program. Low values, in particular, often result in high CVs (CV=47% for results of 1 and 2).

The distribution of CVs for the quality control (QC) samples (collected sequentially) was very similar to the CVs for the lab splits for both fecal coliform and enterococcus bacteria (Figure 7). In other words, the difference between samples collected 15 minutes later at each sample point (A, B, and C) is not significant.

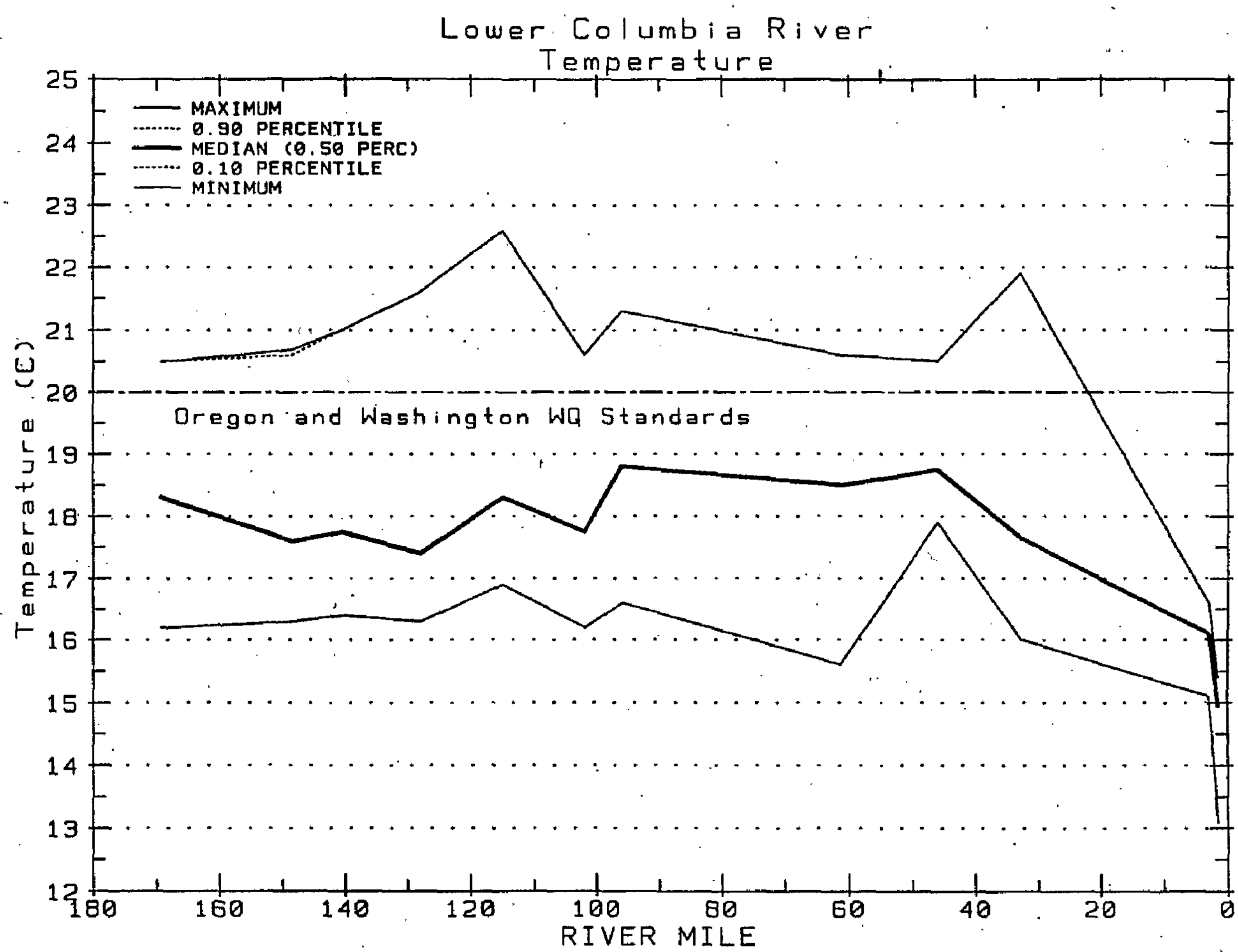

Figure 5. Temperature results from approximately weekly monitoring between September 1 and October 11, 1992, on the lower Columbia River.

Profiles, September 13-14

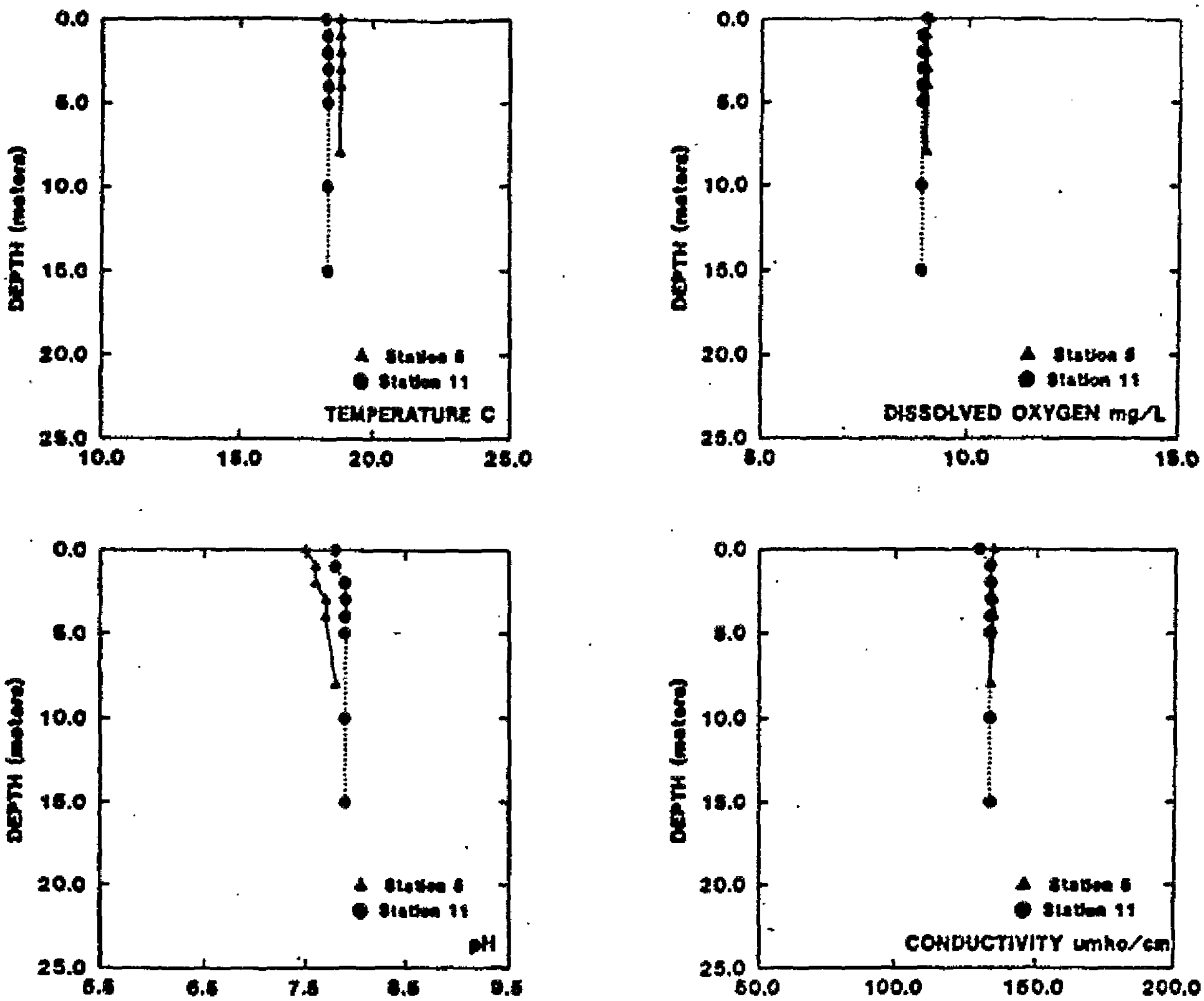

Figure 6. Profile data collected at Station 5 (downstream of Weyerhaeuser Longview Plant, RM 61.3) and Station 11 (Bridge of the Gods, RM 148.6) on September 13 to 14, 1992.

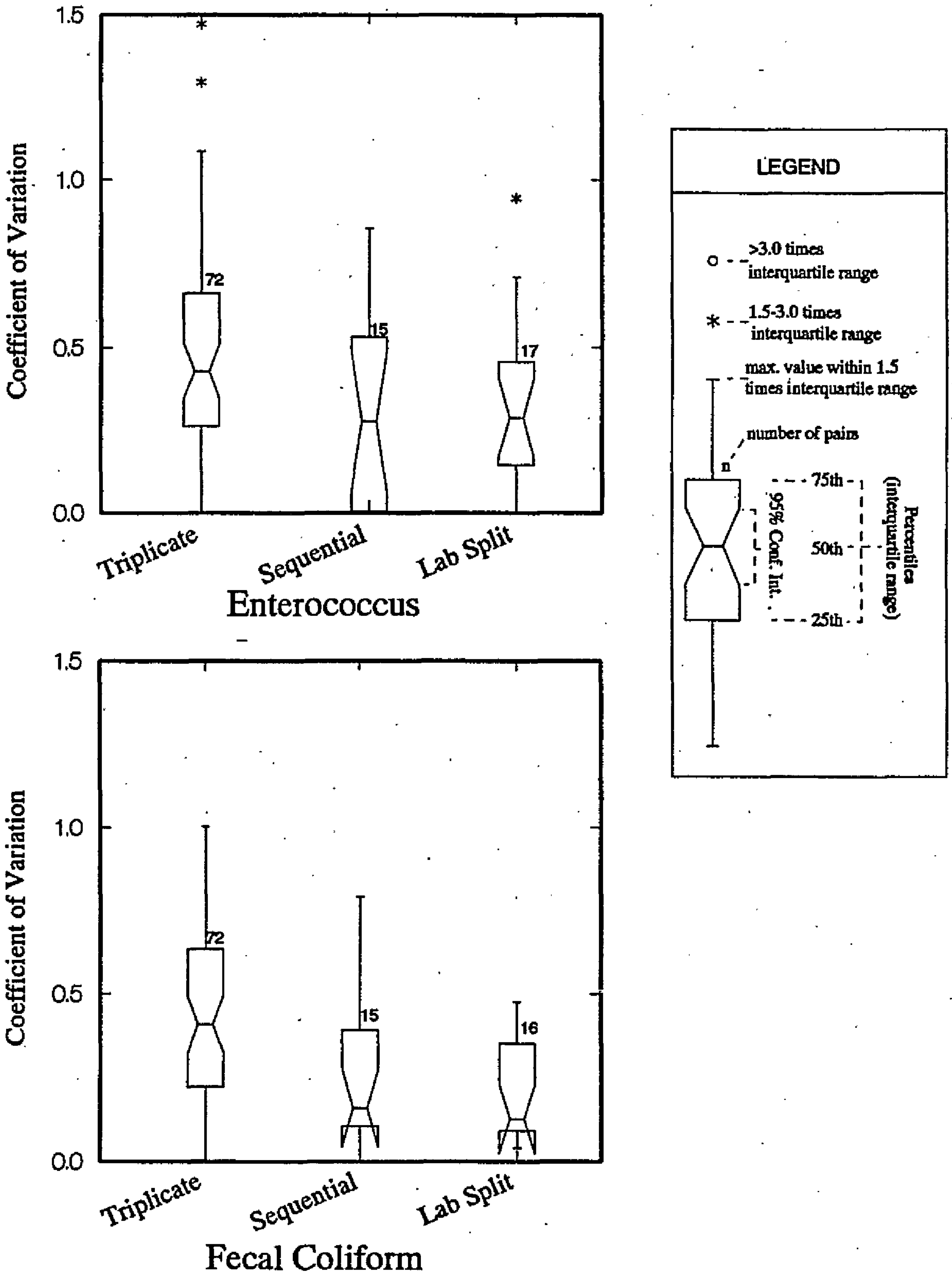

Figure 7. Box plots showing the distribution of enterococcus (top) and fecal coliform (bottom) bacteria quality control results from the lower Columbia River. Triplicate samples were collected within 10 to 50 meters, sequential samples were collected at the same location within 15 minutes. Lab splits were performed on the sequential samples.

The CVs of triplicate samples (collected at 10 to 50 meter intervals) were somewhat higher than the sequential samples or the split samples. The lack of overlap of the "notch" in the lower box plot in Figure 7 indicates that this difference was significant for fecal coliform bacteria. The CVs for the 18 triplicate samples where sequential samples were also collected were also higher than the CVs for sequential samples, although the difference was not significant. It is surprising in a riverine system that laboratory variability explains differences in sequential samples but not in co-located samples.

The pooled standard deviations of QC (sequentially-collected) samples less than 100 organisms/100mL were 14 and 5 organisms/100mL for fecal coliform and enterococcus bacteria, respectively. There were insufficient data to compute a pooled standard deviation for results greater than 100 organisms/100mL.

Other Parameters

The CVs for samples collected sequentially were low for most parameters (Figure 8). In other words, results from the original sample and the sample collected at the same site about 15 minutes later were very similar. The only exception were conductivities measured by the profiling instrument and the Beckman conductivity meter (Figure 8, bottom). About 10 percent of the time, these results were quite different. An examination of the outliers indicated that the problem was clearly with the Beckman meter (or analysis technique) and not with the profiling instrument (Appendix B). Conductivities from bank-sampled stations, which used the Beckman conductivity meter, should be used with caution.

CONCLUSIONS AND RECOMMENDATIONS

1. Water quality standards for fecal coliform bacteria were exceeded during the study. The geometric mean standard was not exceeded at any station, but the "10 percent not to exceed" standard was exceeded at two stations, Ilwaco Marina (Washington) and Sauvie Island (Oregon).

2. Federal water quality guidance for enterococci was not exceeded during the study.

3. Bacteria results from this study do not indicate a chronic human health risk in the lower Columbia during the dry season. There may, however, be high bacteria concentrations that are localized and of short duration.

4. Local health agencies should routinely monitor popular public swimming areas for bacteria contamination.

5. Bacteria monitoring should continue through the onset of wet weather to identify the effects of "first flush" on concentrations.

6. Washington and Oregon's water quality standards for temperature, pH, and percent oxygen saturation were occasionally exceeded. Temperature exceedences, in particular, are likely to be chronic during the warmer months.

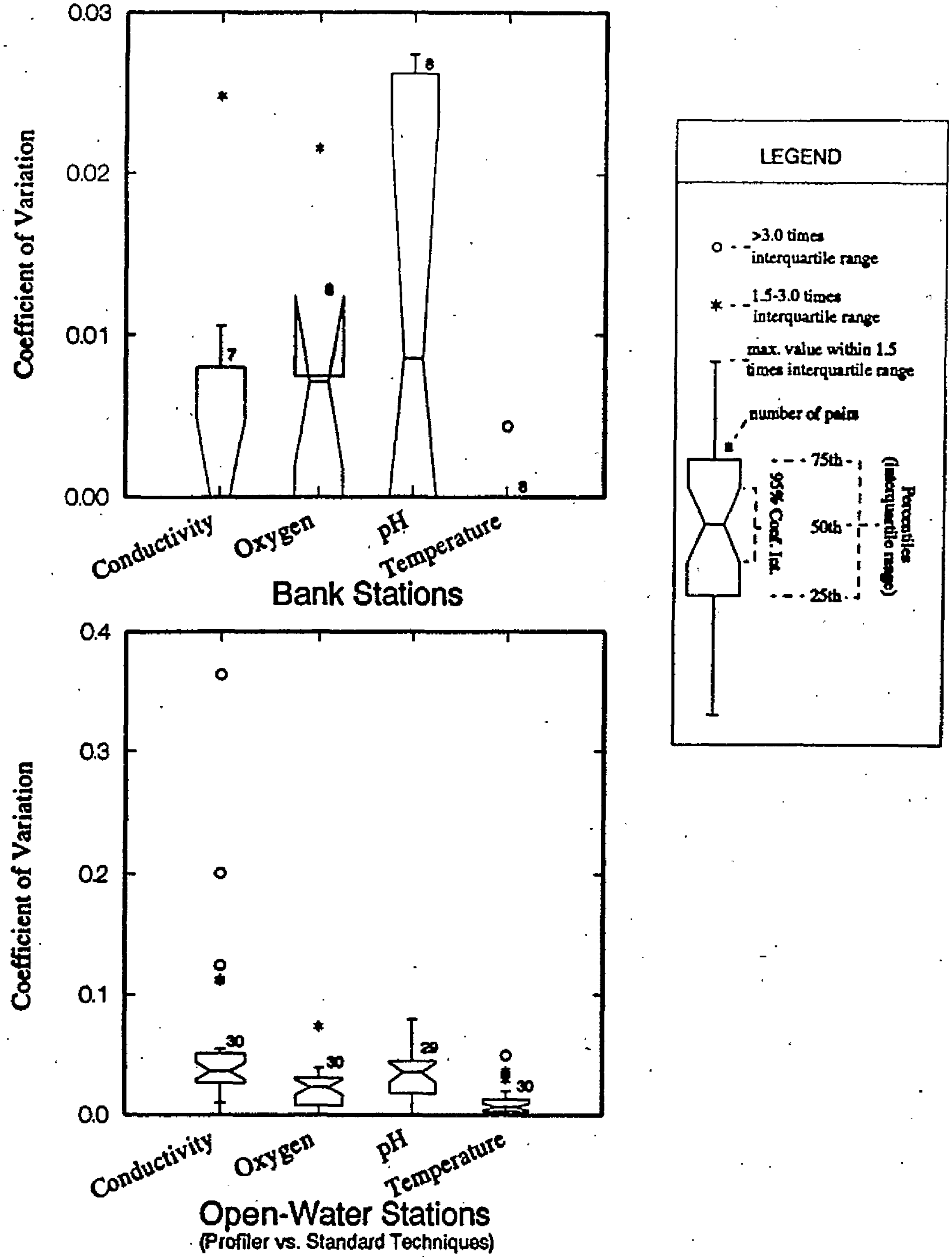

Figure 8. Box plots showing the distribution of bank station (top) and open-water station (bottom) quality control results from the lower Columbia River. Note the difference in scales.

ACKNOWLEDGEMENTS

Larry Lake, Craig Graber, and Brad Hopkins all gave up one or more Sundays and put in 15-hour days to complete the field work. Larry Lake did the data entry and Kim Douglas did the typing. My thanks to all of them.

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APPENDICES

Appendix A. Distribution of data collected from the lower Columbia River, Sept 1 to Oct 12, 1992. This table is based on individual samples, and not the mean of the triplicates. In most cases there was insufficient data to compute 10 and 90th percentiles.

Station name	Number of samples	Minimum	PERCENTILES 10	25	50 (median)	75	90	Maximum
Temperature (C)								
Ilwaco at Fort Canby SP (RM 1.8)	6	13.1	--	13.2	15.0	15.3	--	15.4
Ilwaco Marina (RM 3.0)	6	15.1	--	15.1	16.0	16.3	--	16.6
Skamokawa Park (RM 32.9)	6	16.0	--	16.1	17.6	20.1	--	21.9
Jones Beach (RM 46.1)	6	17.9	--	18.0	18.8	19.9	--	20.5
Marker 13 (RM 61.3)	18	15.6	15.6	17.0	18.5	19.4	20.6	20.6
Sauvie Island (RM 95.9)	6	16.6	--	17.4	18.8	19.5	--	21.3
Kelly Point SP (RM 102.0)	6	16.2	--	16.6	17.8	19.3	--	20.6
148th and Marine (RM 115.0)	6	16.9	--	17.4	18.3	20.5	--	22.6
Rooster Rock SP (RM 128.0)	6	16.3	--	16.6	17.4	19.9	--	21.6
"The Fishery" Resort (RM 140.6)	6	16.4	--	16.9	17.8	19.4	--	21.0
Bridge of the Gods (RM 148.5)	18	16.3	16.3	16.5	17.6	18.5	20.6	20.7
Hood River (RM 169.3)	6	16.2	--	16.7	18.3	19.3	--	20.5
Oxygen (mg/L)								
Ilwaco at Fort Canby SP (RM 1.8)	6	7.8	--	8.3	8.6	9.1	--	9.8
Ilwaco Marina (RM 3.0)	6	8.3	--	8.5	9.5	10.0	--	10.0
Skamokawa Park (RM 32.9)	6	8.5	--	8.9	9.1	9.2	--	9.2
Jones Beach (RM 46.1)	6	9.0	--	9.1	9.5	9.7	--	9.8
Marker 13 (RM 61.3)	18	8.5	8.7	8.8	9.0	9.3	9.3	9.8
Sauvie Island (RM 95.9)	6	8.9	--	8.9	9.1	9.8	--	10.0
Kelly Point SP (RM 102.0)	6	8.9	--	9.1	9.3	9.4	--	9.6
148th and Marine (RM 115.0)	6	9.5	--	9.9	10.3	10.4	--	10.4
Rooster Rock SP (RM 128.0)	6	9.0	--	9.1	9.3	9.5	--	9.6
"The Fishery" Resort (RM 140.6)	6	9.2	--	9.2	9.4	9.4	--	9.5
Bridge of the Gods (RM 148.5)	18	8.5	8.5	8.8	8.8	8.9	9.0	9.1
Hood River (RM 169.3)	6	8.8	--	9.0	9.2	9.3	--	9.4
Percent Saturation								
Ilwaco at Fort Canby SP (RM 1.8)	6	85.5	--	91.7	95.4	100.3	--	110.5
Ilwaco Marina (RM 3.0)	6	90.3	--	92.8	102.8	109.5	--	111.3
Skamokawa Park (RM 32.9)	6	89.5	--	92.7	95.8	100.3	--	102.7
Jones Beach (RM 46.1)	6	97.7	--	98.3	102.8	106.4	--	107.8
Marker 13 (RM 61.3)	18	88.6	90.1	94.0	95.9	101.3	102.5	106.2
Sauvie Island (RM 95.9)	6	94.3	--	96.5	100.3	105.3	--	109.3
Kelly Point SP (RM 102.0)	6	95.5	--	96.5	97.7	102.4	--	105.8
148th and Marine (RM 115.0)	6	99.7	--	105.8	110.6	116.3	--	119.9
Rooster Rock SP (RM 128.0)	6	97.6	--	97.8	98.9	103.0	--	103.1
"The Fishery" Resort (RM 140.6)	6	95.6	--	97.6	101.2	102.4	--	102.9
Bridge of the Gods (RM 148.5)	18	90.5	91.2	91.9	92.4	97.3	98.6	99.7
Hood River (RM 169.3)	6	94.5	--	96.1	98.6	100.5	--	102.6

Appendix A. Continued.

Station name	Number of samples	Minimum	10	25	50 (median)	75	90	Maximum
			PERCENTILES					
pH (Std Units)								
Ilwaco at Fort Canby SP (RM 1.8)	6	7.5	--	7.7	7.9	8.1	--	8.2
Ilwaco Marina (RM 3.0)	6	7.7	--	7.9	8.1	8.1	--	8.2
Skamokawa Park (RM 32.9)	6	7.2	--	7.7	8.0	8.1	--	8.2
Jones Beach (RM 46.1)	6	7.2	--	7.2	8.2	8.5	--	8.8
Marker 13 (RM 61.3)	18	7.0	7.0	7.6	8.1	8.2	8.4	8.5
Sauvie Island (RM 95.9)	6	8.1	--	8.1	8.1	8.3	--	8.6
Kelly Point SP (RM 102.0)	5	8.1	--	8.1	8.2	8.5	--	8.7
148th and Marine (RM 115.0)	6	8.1	--	8.2	8.3	8.6	--	8.7
Rooster Rock SP (RM 128.0)	6	8.0	--	8.0	8.2	8.2	--	8.3
"The Fishery" Resort (RM 140.6)	6	7.9	--	8.1	8.1	8.5	--	8.6
Bridge of the Gods (RM 148.5)	18	6.2	7.5	8.0	8.1	8.2	8.3	8.3
Hood River (RM 169.3)	6	7.9	--	8.1	8.1	8.2	--	8.2
Conductivity (µmhos/cm)								
Skamokawa Park (RM 32.9)	4	140.	--	140.	145.	158.	--	160.
Jones Beach (RM 46.1)	6	122.	--	151.	162.	215.	--	275.
Marker 13 (RM 61.3)	18	119.	123.	130.	141.	167.	262.	276.
Sauvie Island (RM 95.9)	6	132.	--	132.	137.	163.	--	176.
Kelly Point SP (RM 102.0)	6	127.	--	129.	132.	143.	--	155.
148th and Marine (RM 115.0)	6	125.	--	133.	137.	142.	--	148.
Rooster Rock SP (RM 128.0)	6	125.	--	130.	141.	146.	--	149.
"The Fishery" Resort (RM 140.6)	6	118.	--	123.	129.	139.	--	143.
Bridge of the Gods (RM 148.5)	18	125.	130.	132.	141.	149.	180.	220.
Hood River (RM 169.3)	6	130.	--	134.	136.	149.	--	167.
Salinity (ppth)								
Ilwaco at Fort Canby SP (RM 1.8)	6	12.	--	14.	18.	26.	--	27.
Ilwaco Marina (RM 3.0)	6	9.	--	10.	12.	15.	--	17.
Fecal Coliform Bacteria (#/100 mL)								
Ilwaco at Fort Canby SP (RM 1.8)	15	1.	1.	2.	3.	6.	11.	12.
Ilwaco Marina (RM 3.0)	15	2.	2.	3.	6.	41.	145.	230.
Skamokawa Park (RM 32.9)	15	1.	1.	3.	6.	31.	57.	59.
Jones Beach (RM 46.1)	15	3.	3.	6.	7.	11.	70.	98.
Marker 13 (RM 61.3)	15	16.	17.	22.	36.	72.	194.	340.
Sauvie Island (RM 95.9)	15	9.	12.	27.	50.	71.	2320.	2800.
Kelly Point SP (RM 102.0)	15	6.	7.	16.	23.	45.	54.	54.
148th and Marine (RM 115.0)	15	16.	17.	18.	31.	51.	113.	150.
Rooster Rock SP (RM 128.0)	15	2.	2.	4.	13.	16.	80.	110.
"The Fishery" Resort (RM 140.6)	15	1.	1.	1.	1.	3.	3.	4.
Bridge of the Gods (RM 148.5)	15	1.	1.	1.	1.	2.	3.	4.
Hood River (RM 169.3)	15	1.	2.	4.	9.	58.	80.	95.

Appendix A. Continued.

Station name	Number of samples	Minimum	PERCENTILES 10	25	50 (median)	75	90	Maximum
			Enterococcus Bacteria (#/100mL)					
Ilwaco at Fort Canby SP (RM 1.8)	15	1.	1.	1.	1.	4.	45.	71.
Ilwaco Marina (RM 3.0)	15	1.	1.	1.	2.	10.	23.	36.
Skamokawa Park (RM 32.9)	15	1.	1.	1.	2.	9.	21.	22.
Jones Beach (RM 46.1)	15	1.	1.	2.	2.	7.	11.	12.
Marker 13 (RM 61.3)	15	1.	2.	2.	4.	7.	12.	14.
Sauvie Island (RM 95.9)	15	1.	1.	2.	11.	20.	438.	570.
Kelly Point SP (RM 102.0)	15	6.	7.	11.	16.	26.	35.	35.
148th and Marine (RM 115.0)	15	1.	1.	2.	3.	6.	8.	9.
Rooster Rock SP (RM 128.0)	15	1.	1.	1.	1.	7.	252.	420.
"The Fishery" Resort (RM 140.6)	15	1.	1.	1.	2.	4.	5.	5.
Bridge of the Gods (RM 148.5)	15	1.	1.	1.	1.	1.	3.	4.
Hood River (RM 169.3)	15	1.	1.	2.	4.	9.	30.	45.

Appendix B. Surface water data collected from the Lower Columbia River, Sept 1 to Oct 12, 1992. (U=Not detected at the level reported; J=Reported result is an estimate; X=High background count; P=Greater than.)

River Mile	Date	Time	Temp (C°)	Oxygen (mg/L)	Pct Sat (%)	pH (S.U.)	Cond (µmhos)	Pressure (in Hg)	Salinity (ppt)	Fecal (#/100mL)	Enterococcus (#/100mL)
Ilwaco at Fort Canby SP (RM 1.8)											
1.5	01-Sep-92	1300	15.4	7.8	85.5	7.9	28300	30.20	16	1 U	
1.5	01-Sep-92	1305								3	
1.5	01-Sep-92	1310								1	
1.5	13-Sep-92	1425	15.2	10.1	110.5	7.8		30.15	19	10	1
1.5	13-Sep-92	1427								3	1 U
1.5	13-Sep-92	1430								2	1 U
1.5	20-Sep-92	1150	15.1	9.1	94.8	7.5		30.23	12	5	1 U
1.5	20-Sep-92	1153								12	1 U
1.5	20-Sep-92	1155								3	1
1.5	27-Sep-92	1020	14.8	9.2	95.9	8.1		30.44	14	6	4
1.5	27-Sep-92	1025								9	3
1.5	27-Sep-92	1030								4	4
1.5	04-Oct-92	1145	13.2	8.6	93.8	8.0		30.50	27	3	1 U
1.5	04-Oct-92	1148								2	1 U
1.5	04-Oct-92	1153								2	1 U
1.5	11-Oct-92	1230	13.1	8.9	96.9	8.2		30.32	26		3
1.5	11-Oct-92	1235									27
1.5	11-Oct-92	1240									71
Ilwaco Marina (RM 3.0)											
3	01-Sep-92	1335	15.8	9.6	105.0	8.0	25800	30.20	17	6	
3	01-Sep-92	1340								5	
3	01-Sep-92	1345								7	
3	13-Sep-92	1515	16.6	10.3	111.3	8.1		30.14	12	2	1
3	13-Sep-92	1517								3	1
3	13-Sep-92	1530								3	10
3	20-Sep-92	1240	16.2	10.3	108.9	7.7		30.23	10	230	36
3	20-Sep-92	1245								80	10
3	20-Sep-92	1247								88	15
3	20-Sep-92	1300	16.3	10.0	105.8	8.0		30.23	10	670	53
3	20-Sep-92	1305								110	17
3	20-Sep-92	1310								140	36
3	27-Sep-92	1120	15.1	8.6	90.3	8.1		30.42	14	4	1
3	27-Sep-92	1123								6	1 U
3	27-Sep-92	1130								2	1
3	04-Oct-92	1235	16.1	9.7	100.5	8.2		30.57	9	41	2
3	04-Oct-92	1238								16	4
3	04-Oct-92	1245								15	3
3	11-Oct-92	1305	15.1	9.0	93.7	8.1		30.33	12		3
3	11-Oct-92	1310									1 U
3	11-Oct-92	1315									1
Skamokawa Park (RM 32.9)											
32.9	01-Sep-92	1510	21.9	9.1	102.7	8.2	140	29.96		9	
32.9	01-Sep-92	1515								31	
32.9	01-Sep-92	1520								10	
32.9	01-Sep-92	1510	21.9	9.1	102.7	8.3	145	29.96		29	
32.9	01-Sep-92	1515								32	
32.9	01-Sep-92	1520								35	
32.9	13-Sep-92	1240	9.5	9.3	99.5	7.2	160	30.19		3	1 U
32.9	13-Sep-92	1242								1	2
32.9	13-Sep-92	1245								1	1
32.9	20-Sep-92	1015	17.9	9.3	96.3	8.0	140	30.21	2 U	9	1 U
32.9	20-Sep-92	1017								6	1 U
32.9	20-Sep-92	1020								2	1 U
32.9	27-Sep-92	855	17.4	8.8	89.5	7.9	150	30.47	2 U	55	21
32.9	27-Sep-92	858								59	22
32.9	27-Sep-92	900								54	11
32.9	04-Oct-92	1010	16.0	9.5	93.8	8.0	ND	30.50	2 U	3	2
32.9	04-Oct-92	1015								4	1
32.9	04-Oct-92	1020								5	2
32.9	11-Oct-92	1025	16.1	9.6	95.3	8.0	ND	30.40	2 U		9
32.9	11-Oct-92	1028									2
32.9	11-Oct-92	1034									1

Appendix B. Continued.

River Mile	Date	Time	Temp (C°)	Oxygen (mg/L)	Pct Sat (%)	pH (S.U.)	Cond (µmhos)	Pressure (in Hg)	Salinity (ppt)	Fecal (#/100mL)	Enterococcus (#/100mL)
Jones Beach (RM 46.1)											
46.1	01-Sep-92	1050	20.5	9.7	106.0	8.4	122	30.12		7	
46.1	01-Sep-92	1105								3	
46.1	01-Sep-92	1110								3	
46.1	13-Sep-92	1655	19.7	10.0	107.8	7.2	275	30.10		8	6
46.1	13-Sep-92	1657								6	3
46.1	13-Sep-92	1700								7	6
46.1	20-Sep-92	1425	18.7	9.5	100.0	7.2	161	30.22		9	1
46.1	20-Sep-92	1430								8	1 U
46.1	20-Sep-92	1435								6	2
46.1	27-Sep-92	1300	18.8	9.3	97.7	8.2	160	30.33		98	11
46.1	27-Sep-92	1305								51	12
46.1	27-Sep-92	1307								38	7
46.1	04-Oct-92	1405	17.9	9.6	98.5	8.8	195	30.51		4	2
46.1	04-Oct-92	1410								11	2
46.1	04-Oct-92	1415								6	1 U
46.1	11-Oct-92	1500	18.0	10.2	105.7	8.2	162	30.27			2
46.1	11-Oct-92	1503									2
46.1	11-Oct-92	1508									10
Marker 13 (RM 61.3)											
61.3	01-Sep-92	850	20.6	9.3	102.0	8.2	198	30.08		16	
61.3	01-Sep-92	900	20.6	9.3	102.1	8.4	260	30.08		36	
61.3	01-Sep-92	905	20.6	9.3	102.1	8.5	276	30.08		18	
61.3	13-Sep-92	825	18.9	9.6	101.1	7.0	150	30.30		96	2
61.3	13-Sep-92	855	18.8	10.1	106.2	7.6	130	30.30		33	3
61.3	13-Sep-92	905	18.7	9.4	98.6	7.8	127	30.30		36	4
61.3	20-Sep-92	800	18.0	9.0	93.0	7.0	133	30.21		22	7
61.3	20-Sep-92	810	18.3	9.1	94.7	7.3	130	30.21		22	7
61.3	20-Sep-92	820	18.2	9.1	94.5	7.5	130	30.21		32	5
61.3	27-Sep-92	1430	19.3	9.2	97.7	8.1	139	30.30		37	4
61.3	27-Sep-92	1440	19.6	9.1	97.2	8.1	148	30.30		51	1
61.3	27-Sep-92	1450	19.2	9.1	96.4	8.1	132	30.30		83	4
61.3	04-Oct-92	810	16.8	9.0	90.3	7.9	189	30.52		340	14
61.3	04-Oct-92	825	17.0	8.8	88.6	8.2	119	30.52		67	11
61.3	04-Oct-92	830	17.0	9.0	90.6	8.2	123	30.52		72	2
61.3	11-Oct-92	810	15.6	9.6	94.3	8.1	159	30.39			8
61.3	11-Oct-92	820	15.6	9.7	95.3	8.2	143	30.39			2
61.3	11-Oct-92	825	15.6	9.6	94.3	8.2	142	30.39			4
61.3	11-Oct-92	810	15.6			8.1	159	30.39			10
61.3	11-Oct-92	820	15.6			8.2	143	30.39			2
61.3	11-Oct-92	825	15.6			8.2	142	30.39			5
Marker 13 (Hydrolab results)											
61.3	13-Sep-92		18.5	9.1		7.4	140				
61.3	13-Sep-92		18.8	9.1		7.5	135				
61.3	13-Sep-92		18.8	9.2		7.4	135				
61.3	20-Sep-92		18.3	9.1		7.8	136				
61.3	20-Sep-92	840	18.3	9.1		7.9	136				
61.3	20-Sep-92	830	18.2	9.1		8.0	136				
61.3	27-Sep-92	1530	18.4	9.4		7.7	137				
61.3	27-Sep-92	1515	18.2	9.2		7.6	137				
61.3	27-Sep-92	1500	18.2	9.2		7.2	140				
61.3	04-Oct-92	850	16.8	9.4		7.8	142				
61.3	04-Oct-92	845	16.9	9.2		7.8	142				
61.3	04-Oct-92	835	16.8	9.5		8.2	144				
61.3	11-Oct-92	855	15.5	10.1		7.9	150				
61.3	11-Oct-92	845	15.5	9.9		7.9	147				
61.3	11-Oct-92	835	15.5	10.0		8.2	146				
Sauvie Island (RM 95.9)											
95.9	01-Sep-92	1810	21.3	9.3	104.0	8.1	139	29.89		35	
95.9	01-Sep-92	1815								55	
95.9	01-Sep-92	1820								27	
95.9	13-Sep-92	1905	18.8	10.3	109.3	8.1	132	30.04		9	1

Appendix B. Continued.

River Mile	Date	Time	Temp (C°)	Oxygen (mg/L)	Pct Sat (%)	pH (S.U.)	Cond (µmhos)	Pressure (in Hg)	Salinity (ppt)	Fecal (#/100mL)	Enterococcus (#/100mL)
Sauvie Island (RM 95.9)											
95.9	13-Sep-92	1907								14	2
95.9	13-Sep-92	1910								15	2
95.9	20-Sep-92	1640	18.9	9.3	98.4	8.1	132	30.17		2000 J	350 J
95.9	20-Sep-92	1642								980 J	130 J
95.9	20-Sep-92	1645								2800 J	570 P
95.9	27-Sep-92	1720	18.8	9.2	97.2	8.2	135	30.16		59	11
95.9	27-Sep-92	1725								71	20
95.9	27-Sep-92	1730								50	15
95.9	04-Oct-92	1605	17.7	9.2	94.3	8.6	158	30.40		44	9
95.9	04-Oct-92	1609								57	16
95.9	04-Oct-92	1615								32	11
95.9	11-Oct-92	1745	16.6	10.1	102.1	8.1	176	30.16			2
95.9	11-Oct-92	1750									2
95.9	11-Oct-92	1754									1
Kelly Point SP (RM 102.0)											
102	01-Sep-92	2000	20.6	9.6	105.8	8.3	139	29.95		8	
102	01-Sep-92	2005								9	
102	01-Sep-92	2110								6	
102	13-Sep-92	2000	18.0	9.7	101.3	8.2	131	30.03		16	21
102	13-Sep-92	2002								21	6
102	13-Sep-92	2005								19	11
102	20-Sep-92	1740	18.9	9.2	97.5	8.1	130	30.13		45	24
102	20-Sep-92	1745								34	7
102	20-Sep-92	1748								33	11
102	27-Sep-92	1820	17.5	9.4	96.8	8.1	132	30.14		45	35
102	27-Sep-92	1824								54	35
102	27-Sep-92	1830								54	34
102	04-Oct-92	1700	16.7	9.5	95.5	8.7	127	30.37		23	14
102	04-Oct-92	1705								17	16
102	04-Oct-92	1710								27	11
102	11-Oct-92	1850	16.2	9.8	97.8	ND	155	30.28			15
102	11-Oct-92	1855									22
102	11-Oct-92	1857									26
148th and Marine (RM 115.0)											
115	02-Sep-92	1340	22.6	10.4	119.9	8.6	135	29.72		16	
115	02-Sep-92	1345								17	
115	02-Sep-92	1350								22	
115	14-Sep-92	1305	18.4	10.6	112.2	8.1	125	29.87		150	9
115	14-Sep-92									88	6
115	14-Sep-92									80	3
115	21-Sep-92	1435	19.8	10.6	115.1	8.7	140	29.93		33	3
115	21-Sep-92	1440								20	1
115	21-Sep-92	1445								24	1 U
115	28-Sep-92	1400	18.2	10.3	107.9	8.3	135	30.05		45	3
115	28-Sep-92	1405								41	2
115	28-Sep-92	1410								51	2
115	28-Sep-92	1410	18.2	10.2	107.0	8.4	133	30.02		52	10
115	28-Sep-92	1412								33	6
115	28-Sep-92	1415								59	4
115	05-Oct-92	1315	17.5	9.8	99.7	8.2	138	30.50		18	2
115	05-Oct-92	1318								31	6
115	05-Oct-92	1325								17	3
115	12-Oct-92	1330	16.9	10.8	109.0	8.2	148	30.40			4
115	12-Oct-92	1337									8
115	12-Oct-92	1345									3
Rooster Rock SP (RM 128.0)											
128	02-Sep-92	1240	21.6	9.1	103.0	8.3	149	29.72		13	
128	02-Sep-92	1245								16	
128	02-Sep-92	1250								2	
128	14-Sep-92	1210	17.5	9.9	103.1	8.0	125	29.83		32	56
128	14-Sep-92	1212								110	420 J

Appendix B. Continued.

River Mile	Date	Time	Temp (C°)	Oxygen (mg/L)	Pct Sat (%)	pH (S.U.)	Cond (µmhos)	Pressure (in Hg)	Salinity (ppt)	Fecal (#/100mL)	Enterococcus (#/100mL)
Rooster Rock (RM 128.0)											
128	14-Sep-92	1215								60	140
128	21-Sep-92	1330	19.3	9.3	99.8	8.0	132	29.99		8	1
128	21-Sep-92	1332								4	3
128	21-Sep-92	1335								5	7
128	28-Sep-92	1300	17.3	9.5	97.6	8.2	145	30.10		14	1 U
128	28-Sep-92	1305								15	3
128	28-Sep-92	1310								14	1 U
128	05-Oct-92	1215	16.7	9.8	98.1	8.2	138	30.50		4	1
128	05-Oct-92	1220								2	1
128	05-Oct-92	1227								5	1
128	05-Oct-92	1230	16.7	9.7	97.1	8.5	138	30.50		6	1
128	05-Oct-92	1235								2	1 U
128	05-Oct-92	1240								4	1 U
128	12-Oct-92	1245	16.3	9.8	97.8	8.2	144	30.36			2
128	12-Oct-92	1250									1 U
128	12-Oct-92	1257									1 U
"The Fishery Resort" (RM 140.6)											
140.6	02-Sep-92	1155	21.0	9.2	102.0	8.2	118	29.98		2	
140.6	02-Sep-92	1200								3	
140.6	02-Sep-92	1205								4	
140.6	14-Sep-92	1030	18.2	9.7	102.2	7.9	125	29.90		3	2
140.6	14-Sep-92	1035								1 U	4
140.6	14-Sep-92	1040								1 U	5
140.6	21-Sep-92	1240	18.9	9.7	102.9	8.1	130	30.09		1 U	4
140.6	21-Sep-92	1245								1	2
140.6	21-Sep-92	1248								1 U	5
140.6	28-Sep-92	1210	17.3	9.8	100.3	8.5	128	30.20		1	1 U
140.6	28-Sep-92	1215								3	1 U
140.6	28-Sep-92	1218								1	3
140.6	05-Oct-92	1115	17.0	9.5	95.6	8.6	138	30.52		1 U	2
140.6	05-Oct-92	1118								1 U	1 U
140.6	05-Oct-92	1125								3	2
140.6	12-Oct-92	1200	16.4	9.8	98.3	8.1	143	30.26			1 U
140.6	12-Oct-92	1205									2
140.6	12-Oct-92	1210									1 U
Bridge of the Gods (RM 148.5)											
148.5	02-Sep-92	1010	20.7	8.8	97.0	8.2	153	29.98		1 U	
148.5	02-Sep-92	1015	20.6	8.9	98.0	8.1	150	29.98		1 U	
148.5	02-Sep-92	1020	20.5	8.8	96.7	8.2	148	29.98		1 U	
148.5	14-Sep-92	805	18.3	9.3	98.2		125	29.87		1 U	1 U
148.5	14-Sep-92	850	18.4	9.3	98.5	7.6	220	29.87		2	1 U
148.5	14-Sep-92	855	18.5	9.4	99.7	7.9	139	29.87		1 U	1 U
148.5	21-Sep-92	845	18.5	8.8	92.4	8.0	145	30.17		1	1 U
148.5	21-Sep-92	900	18.5	8.8	92.4	8.0	132	30.17		4	1 U
148.5	21-Sep-92	910	18.5	8.9	93.4	8.1	131	30.17		1 U	1
148.5	28-Sep-92	845	16.7	9.1	92.0	8.2	132	30.22		2	1
148.5	28-Sep-92	900	16.4	9.2	92.4	8.2	142	30.22		1	1 U
148.5	28-Sep-92	905	16.5	9.1	91.6	8.2	130	30.22		3	4
148.5	05-Oct-92	805	16.8	9.1	91.3	8.2	140	30.51		1	1
148.5	05-Oct-92	815	16.9	9.0	90.5	8.3	135	30.51		1	2
148.5	05-Oct-92	820	16.9	9.1	91.5	8.3	137	30.51		3	1
148.5	12-Oct-92	810	16.3	9.2	92.0	8.0	176	30.29			1
148.5	12-Oct-92	815	16.3	9.2	92.0	8.1	149	30.29			1
148.5	12-Oct-92	825	16.3	9.2	92.0	8.1	148	30.29			1 U
Bridge of the Gods (Hydrolab results)											
148.5	14-Sep-92		18.1	9.2		7.7	134				
148.5	14-Sep-92		18.2	9.0		7.8	130				
148.5	14-Sep-92		18.2	9.1		7.8	133				
148.5	21-Sep-92	910	18.6	9.1		7.2	136				
148.5	21-Sep-92		18.5	9.0		7.6	138				
148.5	21-Sep-92		18.5	9.0		7.8	138				

Appendix B. Continued.

River Mile	Date	Time	Temp (C°)	Oxygen (mg/L)	Pct Sat (%)	pH (S.U.)	Cond (µmhos)	Pressure (in Hg)	Salinity (ppt)	Fecal (#/100mL)	Enterococcus (#/100mL)
Bridge of the Gods (Hydrolab results)											
148.5	28-Sep-92	935	17.2	9.2		7.8	138				
148.5	28-Sep-92	925	17.1	9.2		7.7	139				
148.5	28-Sep-92	910	17.0	9.2		7.5	140				
148.5	05-Oct-92		16.6	9.6		8.1	145				
148.5	05-Oct-92		16.7	9.3		7.9	145				
148.5	05-Oct-92		16.7	9.5		7.9	144				
148.5	12-Oct-92	835	16.2	9.5		8.0	150				
148.5	12-Oct-92	850	16.3	9.3		7.8	150				
148.5	12-Oct-92	905	16.4	9.5		7.9	150				
Hood River (RM 169.3)											
169.3	02-Sep-92	845	20.5	9.1	99.8	8.2	137	30.03		9	
169.3	02-Sep-92	850								4	
169.3	02-Sep-92	855								3	
169.3	14-Sep-92	1015	18.9	9.6	102.6	7.9	130	29.87		70	4
169.3	14-Sep-92									52	9
169.3	14-Sep-92									41	4
169.3	14-Sep-92	1040	18.9	9.6	102.6	7.6	129	29.87		36	1
169.3	14-Sep-92	1045								43	5
169.3	14-Sep-92	1050								43	4
169.3	21-Sep-92	1135	18.9	9.1	96.6	8.1	135	30.08		2	2
169.3	21-Sep-92	1137								4	5
169.3	21-Sep-92	1140								7	5
169.3	28-Sep-92	1100	17.7	9.6	99.0	8.1	135	30.23		58 X	3
169.3	28-Sep-92	1105								61 X	1 U
169.3	28-Sep-92	1110								95 X	1 U
169.3	05-Oct-92	1015	16.9	9.4	94.5	8.2	143	30.50		5	4
169.3	05-Oct-92	1020								1	1 U
169.3	05-Oct-92	1025								14	45
169.3	12-Oct-92	1040	16.2	9.8	98.1	8.2	167	30.22			6
169.3	12-Oct-92	1045									11
169.3	12-Oct-92	1050									20

Lower Columbia River Bi-State Water Quality Program: Bacteria Study November-December 1992

by
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March 1993

ABSTRACT

The geometric mean of fecal coliform counts collected between November 22 and December 28, 1992, exceeded water quality standards at two sites on the lower Columbia River: Ilwaco Marina (Washington State marine standard) and near Longview, Washington (Washington State freshwater standard). Fecal coliform counts were also high at Sauvie Island, Oregon, but did not exceed Oregon State freshwater standards (Oregon fecal coliform standards are higher than Washington standards). The geometric mean of enterococcus bacteria counts exceeded freshwater standards at Sauvie Island and were high at Longview, Washington. One enterococcus bacteria sample at Sauvie Island exceeded the federal 'single sample not to exceed' standard during this study.

INTRODUCTION

A reconnaissance survey of eight sites on the lower Columbia River was conducted in autumn 1991 which detected enterococcus bacteria counts which exceeded federal water quality standards (Tetra Tech, 1991). A subsequent study in September through October 1992, conducted by the Washington State Department of Ecology (Ecology), monitored fecal coliform and enterococcus bacteria, temperature, pH, dissolved oxygen, and conductivity (or salinity) at 12 sites from river mile (RM) 1.8 to RM 169 (Hallock, 1993). Violations of water quality standards were detected for fecal coliform, temperature, pH, and dissolved oxygen percent saturation. Concerns that the bacterial problems may become worse with runoff from autumn rains prompted Ecology to follow up with continued monitoring through December 1992. This report presents the results of that monitoring program along with a review of the previous two studies.

METHODS

The same 12 sites on the lower Columbia which were selected by Hallock (1993), were sampled from November 22 to December 28, 1992, at weekly intervals (Table 1). However, Stations 5 and 11, which were sampled by boat in a transect across the river (Hallock, 1993) in the fall, were sampled from the shore in this study. Six of these sites coincided with the sites monitored by Tetra Tech (1991) for bacteria, while the other six sites were selected on the basis of logistics, potential sources of bacteria, proximity of contact recreation areas, the Task Order Statement of Work, and discussions with the Bi-State Program (Hallock, 1993). Water for bacteria analysis was collected from 0.6- to 0.9-meter deep sites by wading out from shore, submerging an inverted, sterilized, 500 mL glass bottle, and then collecting a sub-surface water sample. Three replicate samples were collected by repeating this procedure at 10- to 50-meter intervals while moving upstream, parallel to the shore to avoid sediment stirred up by the sampler. These water samples were placed on ice, shipped the same day to the Manchester Environmental Laboratory, and analyzed within one day.

Temperature was measured *in situ* with a thermistor. Aliquots of water were collected in a stainless steel bucket (APHA *et al.*, 1989) for the determination of dissolved oxygen concentration, pH, conductivity, and salinity (Table 2). All statistical analyses were done with SYSTAT statistics and graphics software (Wilkinson, 1990).

Quality Assurance

All meters are maintained in accordance with the user manuals. The pH meter was calibrated each day and the calibration was checked at mid-day and that evening.

The variability of the bacteria data was assessed by calculating the coefficient of variation (CV) of each set of three replicate samples (Table 3). The CV is calculated by dividing the standard deviation by the mean, so that as the bacteria density approaches the limits of detection, the CV will usually increase (Figure 1). Although the mean CV of all sets of fecal coliform and enterococcus replicates was 28% and 35%, respectively, when the data are grouped by mean value $\leq$35/100 mL and >35/100 mL, the results are 38% and 4% for fecal coliform and 41% and 4% for enterococcus. The variability of the bacteria data is acceptable, especially for densities near and above federal and state standards.

Table 1. Stations on the lower Columbia River monitored during this study.

Station No.	Recon[a] Survey No. (RM)	Name	Latitude	Longitude	River Mile	Comments
1	W2 (1.8)	Ilwaco, WA	46 16.86	124 03.55	1.5	Fort Canby State Park
2	W3 (3)	Ilwaco Marina, WA	46 18.15	124 02.11	3.0	Near boat hoist/wash station
3	W13 (32.5)[b]	Skamakowa Park, WA	46 16.13	123 27.67	32.9	
4	W16 (46.5)	Jones Beach, OR	46 08.35	123 19.07	46.1	Left on Riverfront to 100 yds from end
5	W22 (61.5)[b]	Downstream Weyerhaeuser Longview Plant, WA	46 08.55	123 01.79	61.3	Right bank; Barlow Pt.
--					68.0	Cowlitz River
6	W35 (98)	Sauvie Island, OR	45 43.85	122 45.93	95.9	Rt on gravel road at Columbia Co. line
--					101.5	Willamette River
7	W38 (104)	Kelly Point Park, OR	45 38.92	122 45.53	102.0	
--					~101.5 - 115.0	Vancouver, Portland
8	W40 (115)	148th and Marine, OR	45 33.84	122 30.53	115.0	
9	—[b]	Rooster Rock S.P., OR	45 32.88	122 14.25	128.0	Downstream end of park
10	—[b]	"The Fishery" Resort, OR	45 36.49	122 02.40	140.6	Downstream side of boat launch
--					146.1	Bonneville Dam
11	—[b]	Bridge of the Gods, OR	45 39.81	121 54.03	148.4	100 yds upstream of bridge
12	—[b]	Hood River, OR	45 42.92	121 30.32	169.3	Columbia Sailpark Marina
--					169.4	Hood River

[a]Tetra Tech, 1992.
[b]The original reconnaissance survey did not monitor bacteria at these stations.

Table 2. Parameters measured at bacteria monitoring sites.

Parameter	Method	Units
Fecal Coliform Bacteria	Membrane Filter	colonies/100 mL
Enterococcus Bacteria	Membrane Filter	colonies/100 mL
Temperature	Mercury or Elec. Thermometer	°C
Dissolved Oxygen	Modified Winkler	mg/L
pH	Orion Model 250A	Std Units
Conductivity[a]	Beckman Model RB5	μmhos/cm
Salinity[a]	Refractometer	ppth
Barometric Pressure	Aneroid Barometer	inches Hg

Table 3. Comparison of coefficients of variation calculated from replicate samples.

	Coefficient of Variation	
	Fecal coliform	Enterococcus
>35/100 mL	4%(n=28)	4%(n=15)
<35/100 mL	42%(n=49)	41%(n=54)
All	28%(n=77)	35%(n=69)

RESULTS AND DISCUSSION

Water quality standards for bacteria are not identical for Oregon, Washington, and the federal government (Table 4). State standards consist of two criteria: 1) the geometric mean of samples collected over time at a site must not exceed a specified number, and 2) not more than 10% of samples collected over time at a site may exceed a specified higher number. The EPA (1986) recommends that the geometric mean standard should be applied only to a minimum of five samples equally spaced over 30 days. Geometric means calculated from all six samples are used in this report Because of the low sample size (six samples) in this study, it is difficult to assess the "less than 10% of samples to exceed" rule and this probability was not calculated.

Table 4. Water quality standards for bacteria in the Lower Columbia River (organisms/100 mL).

	Fecal Coliform Bacteria Maximum Geometric Mean	Fecal Coliform Bacteria <10% sample over	Enterococcus Bacteria Maximum Geometric Mean
Washington[a]			
Freshwater	100	200	None
Marine Water	14	43	
Oregon[b]			
Freshwater	200	400	None[d]
Marine Shellfish	14 (median)	43	
Marine Non-shellfish	200	400	
Federal Guidance[c]			
Freshwater			33
Marine	14 (shellfish)	43 (shellfish)	35 (bathing)

[a] Washington Administrative Code 173-201.

[b] Oregon Administrative Rules Chapter 340 Division 41 Section 202; Oregon uses the MPN method for fecal coliform bacteria.

[c] EPA (1986).

[d] Oregon's enterococcus standard was recently suspended.

The federal government has an additional criterion that no single enterococcus bacteria sample may exceed. This number is based on the use of the site for bathing (*i.e.*, infrequent use for bathing, frequent use, or a designated bathing beach), and the variability of the bacteria data collected there over time (EPA, 1986). This number is calculated by constructing a one-sided statistical confidence limit above the federal standard, using site specific bacteria data. The purpose is to protect public health while accounting for the intensity of site use and both the temporal and analytical variability of bacteria data. Marine water quality standards were applied to Stations 1 and 2, and freshwater standards were applied to all others.

Water Quality Standards Violations

The geometric mean of fecal coliform bacteria exceeded standards at Station 2 (Ilwaco Marina) and at Station 5 (near Longview) (Figure 2a; Tables 4 and 5). Fecal coliform counts (geometric mean) at Station 6 (Sauvie Island) were also high (>100/100 mL), but did not exceed the Oregon standard (200/100 mL; Table 4). The fecal coliform data from Station 5 may be complicated by the presence of a pulp mill upstream. *Klebsiella* bacteria are members of the fecal coliform group, and are included in the fecal coliform counts. However, unlike other

Table 5. Geometric means of bacteria calculated from all six sample dates (#/100 mL).

Station	Fecal coliform	Enterococcus
1	11	16
2	18	6
3	66	23
4	43	24
5	282	33
6	157	66
7	28	27
8	16	7
9	4	4
10	2	3
11	6	5
12	4	2

members of this group, *Klebsiella* can be present in certain industrial wastes including pulp mill effluent (APHA, 1989). In these instances high fecal coliform counts may not represent fecal waste contamination. In addition, cattle were observed to have access to the river at this station and may account for the high bacterial densities (L. Lake, personal comm.). Fecal coliform counts were also elevated, relative to the other stations, at Stations 5 and 6) during September-October 1992, although no violations of the geometric mean standard occurred (Hallock, 1993) (Figure 3a). In the fall 1991, fecal coliform counts were much lower at the six stations monitored, but a violation of the marine water quality standard occurred at Station 2, Ilwaco Marina (Figure 4a) (Tetra Tech, 1991).

Enterococcus bacteria exceeded the federal standard for freshwater (33/100 mL) only at Station 6 (Sauvie Island), but values also were high at Stations 5 (near Longview) and 7 (Kelly Point Park) (Figure 2b). Hallock (1993) found relatively high enterococcus counts at Stations 6 and 7, but no violation was noted (Figure 3b). Enterococcus counts exceeded standards at all six stations sampled in fall 1991 (Tetra Tech, 1991) (Figure 4b).

To protect against occasional, extremely high bacteria counts, EPA (1986) defines an upper limit which single enterococcus bacteria sample counts may not exceed. This limit is site specific and is based on the variability of the bacteria data and the use designation of the site. Based on the samples collected in this study and on an "infrequent use for bathing" site use designation (EPA, 1986), enterococci counts at Station 6 exceeded this value one time during this study (Figure 5).

No other measured parameters violated standards.

Spatial and Temporal Patterns

As noted in Hallock (1993), fecal coliform counts tended to be highest in the middle reaches (Stations 5 through 8) of the study area (Figure 6a), similar to the fall 1992 study (Hallock, 1993) (Figure 7a). While enterococcus showed a similar pattern in this study, this pattern was less obvious in the fall 1992 and fall 1991 studies (Figures 6b, 7b, 8b). Counts were usually low at Stations 9 through 12.

Seasonal differences were assessed by constructing 95% confidence intervals (of $\log_{10}$-transformed data) about the median value at each site for fall 1991 (Tetra Tech, 1991), fall 1992 (Hallock, 1993), and winter 1992 (this study) (Table 6). Site specific comparisons and the data collected for this study are included in Appendices A and B, respectively. Median fecal coliform count at Stations 2 and 4, and enterococcus counts at Stations 1, 2, 7, and 8 were higher in fall 1991 than in fall 1992. Fall 1991 enterococcus counts at Stations 2, 7, and 8 were higher than in winter 1992. Winter 1992 fecal coliform counts at Station 3, 4, 5, 6, and 11, and enterococcus counts at Stations 3, 4, 5, and 9 were higher than in fall 1992, while enterococcus counts were lower at Station 12. As suggested by Hallock (1993), both fecal coliform and enterococci counts tended to be higher after the fall rains began. Although contact recreation is much less common in the Columbia River late in the year, heavy rains at other times could presumably cause a more serious problem.

CONCLUSIONS

The results of these studies emphasizes the inherent variability of bacteria density data. However, it is clear that statutory standards for bacteria were violated at Stations 2 (Ilwaco Marina) and 5 (near Longview), and enterococcus bacteria standards were violated at Station 6 (Sauvie Island, Oregon) during this study. Fecal coliform counts were high at Station 6, but were not in violation of Oregon standards. The high bacterial densities observed at Stations 5 and 6 may require further investigation to determine the source of contamination and the potential human health risks. For example, are *Klebsiella* sp. bacteria responsible for a significant proportions of the high fecal coliform densities and, if so, what is the source (fecal contamination or industrial wastes)? The violation at Ilwaco Marina may be important from a public health perspective, if this is a shellfish harvesting area.

Table 6. Stations at which a significant ($P < 0.05$) difference was detected between studies in median fecal coliform or enterococcus count. (+)-median of study in left column was greater than that of the study at the top of the column, (-)-median of study in left column was less than that of the study at the top of the column. Fall 1991-(Tetra Tech, 1991), Fall 1992-(Hallock, 1993), Winter 1992-(this study)

Fecal Coliform	Fall 1992	Winter 1992
Fall 1991	$2^+,4^+$	
Fall 1992		$3^-,4^-,5^-,6^-,11^-$
Enterococcus	Fall 1992	Winter 1992
Fall 91	$1^+,2^+,7^+,8$	$^+2^+,7^+,8^+$
Fall 92		$3^-,4^-,5^-,9^-;12^+$

ACKNOWLEDGEMENTS

I would like to thank Larry Lake for his effort in completing the field work, and Kim Douglas for typing and formatting this report.

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FIGURES

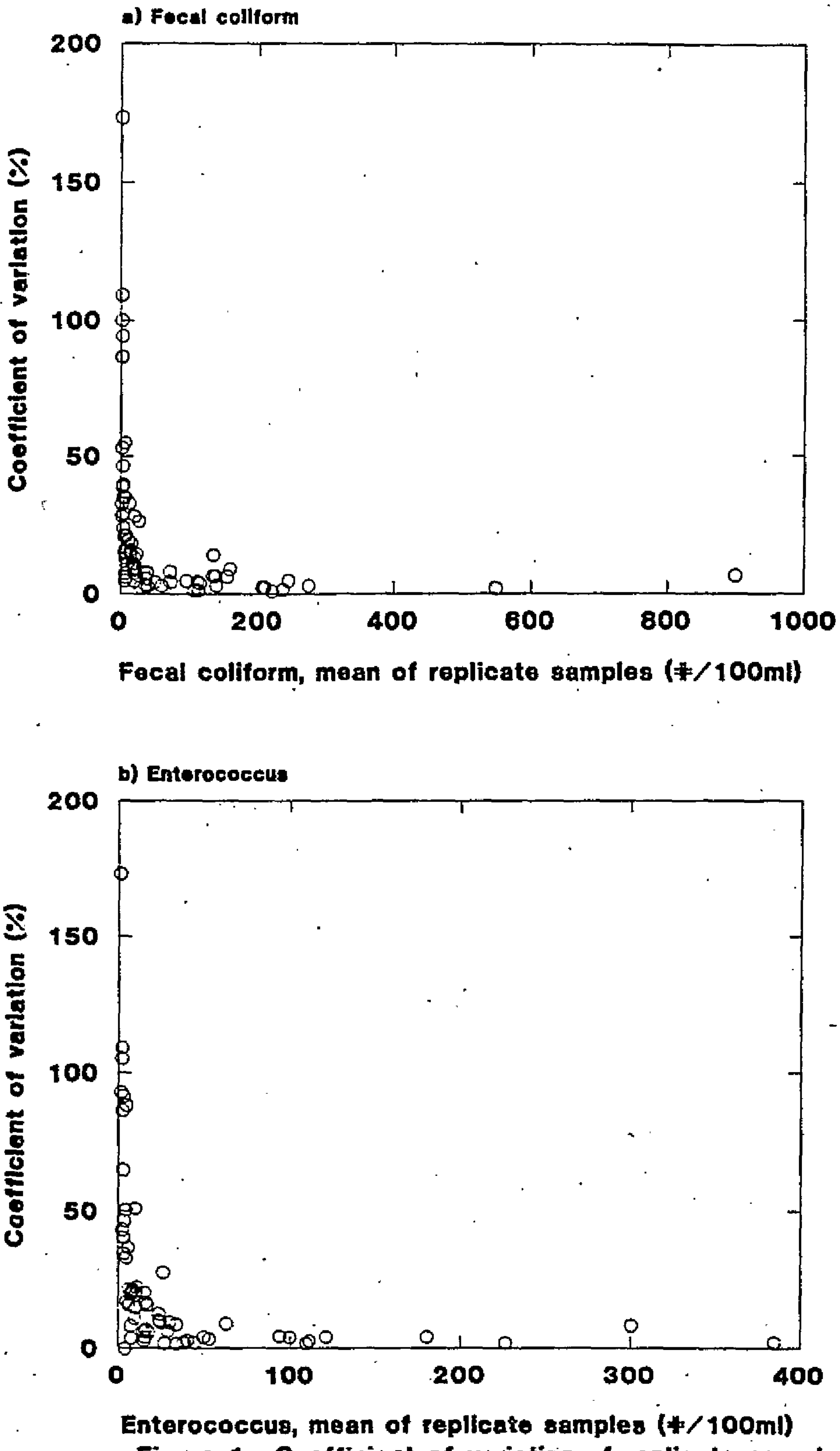
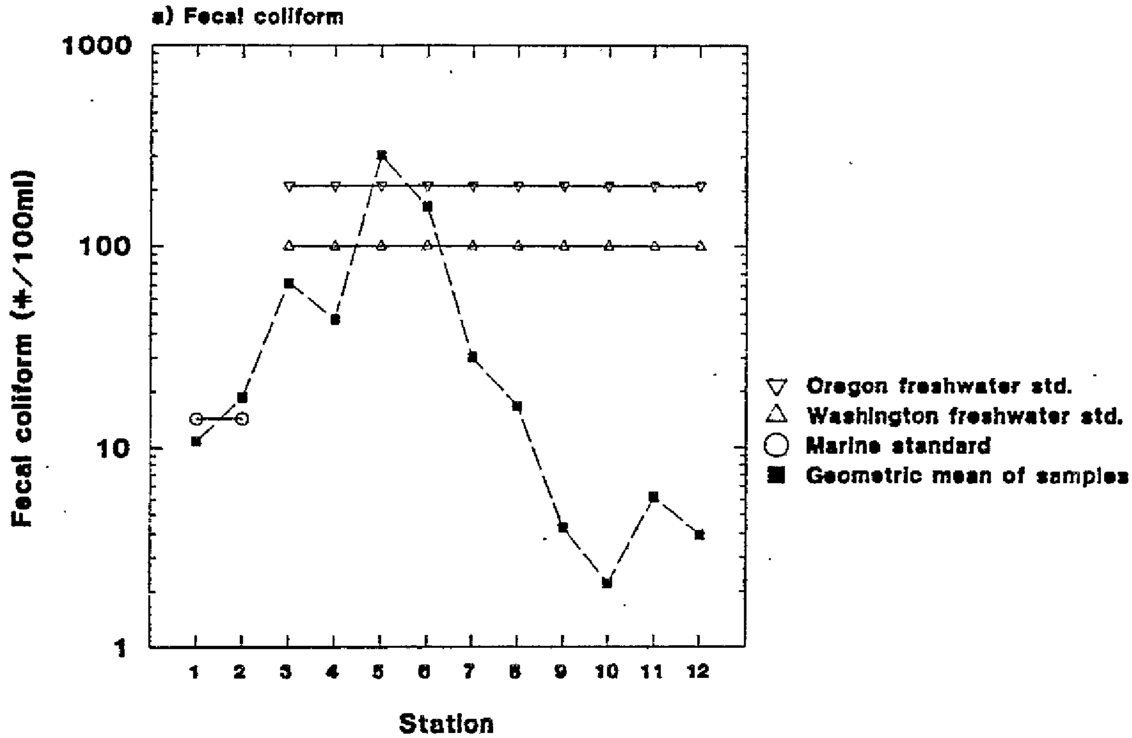


Figure 1. Coefficient of variation of replicate samples as a function of mean of the replicates.



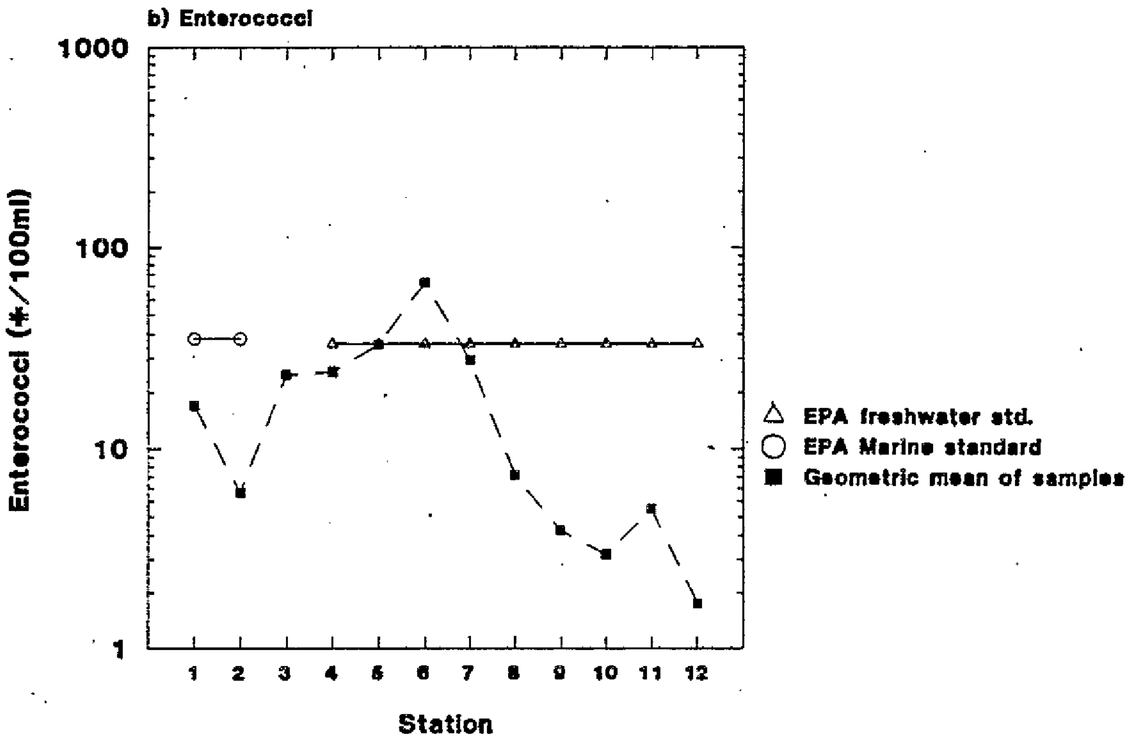


Figure 2. Geometric means of the six samples collected between 22 Nov. and 28 Dec., 1992. Fecal coliform violations occurred at Stations 2, and 5, and an enterococci violation occurred at Station 6.

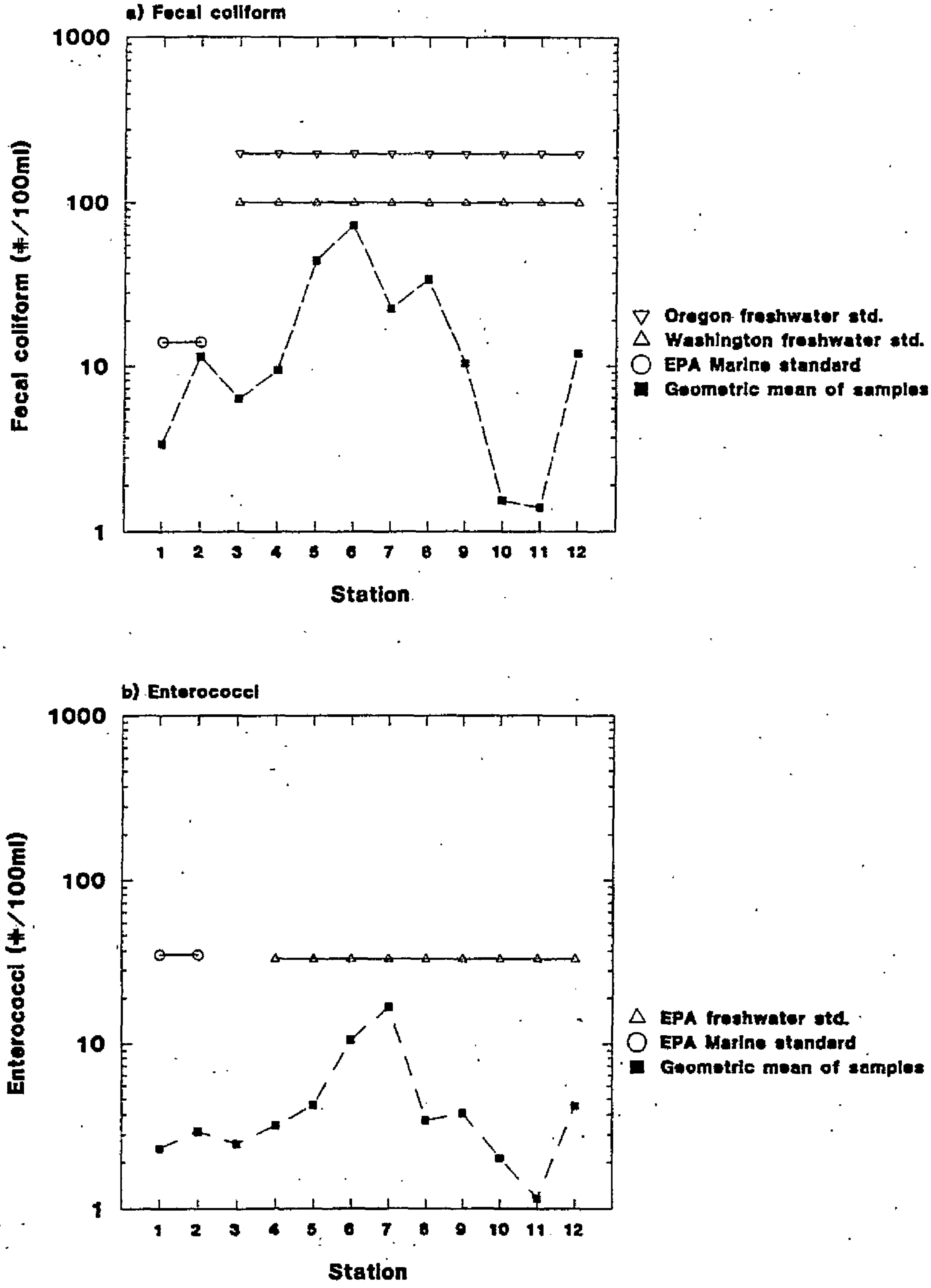


Figure 3. Geometric means of the six samples collected between 1 Sept. and 12 Oct., 1992 (Hallock, 1992). Standards are indicated.

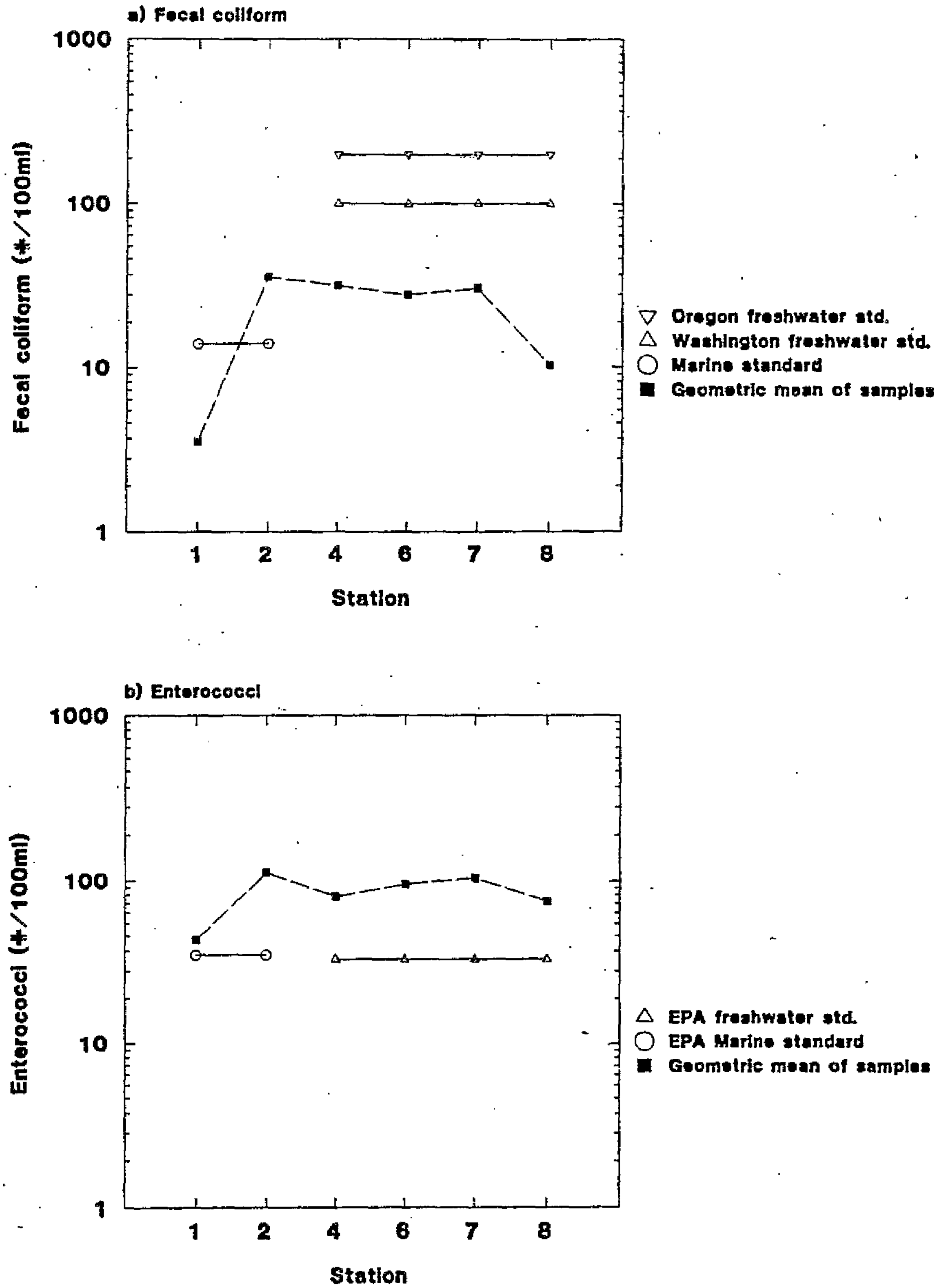


Figure 4. Geometric means of the six samples collected between 15 Oct. and 13 Nov., 1991 (Tetra Tech, 1991). Standards are indicated.

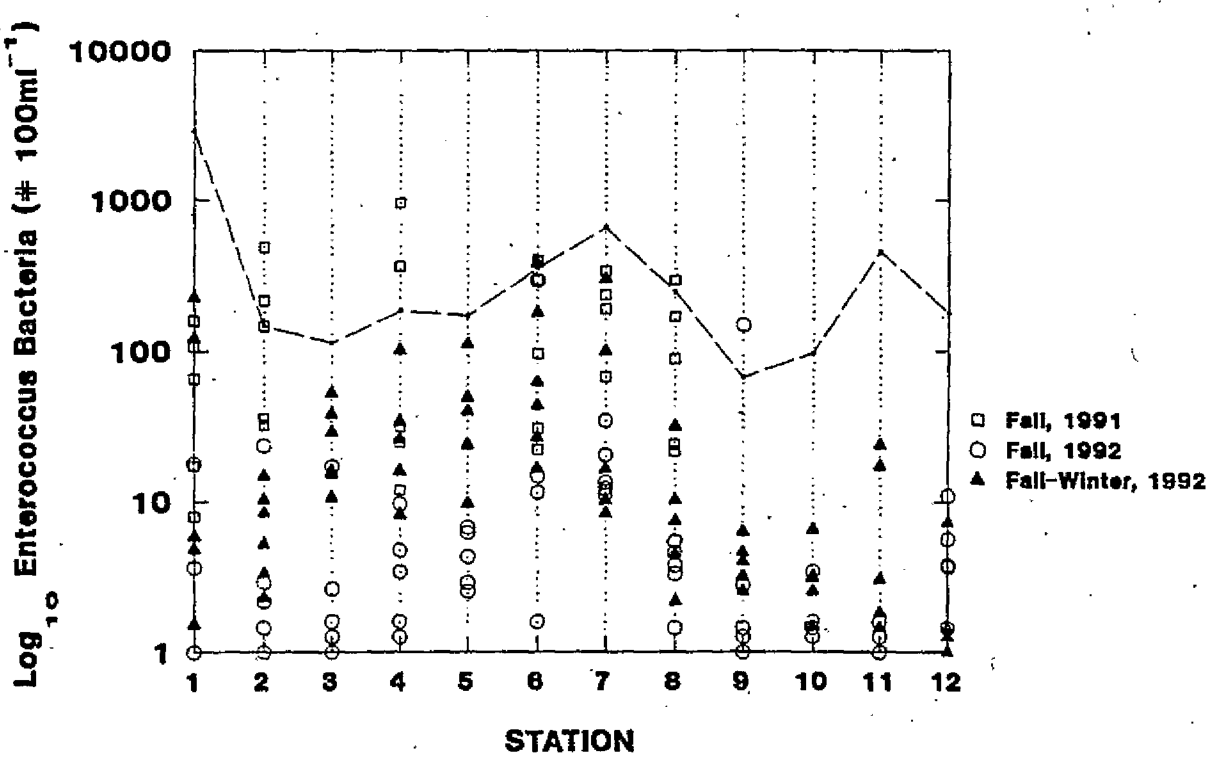


Figure 5. Individual sample values with single sample 'not to exceed' enterococcus standard was calculated from the November 11 to December 28, 1992 data and is based on 'infrequent use for bathing' (EPA, 1986). Values from previous studies are shown for comparison only.

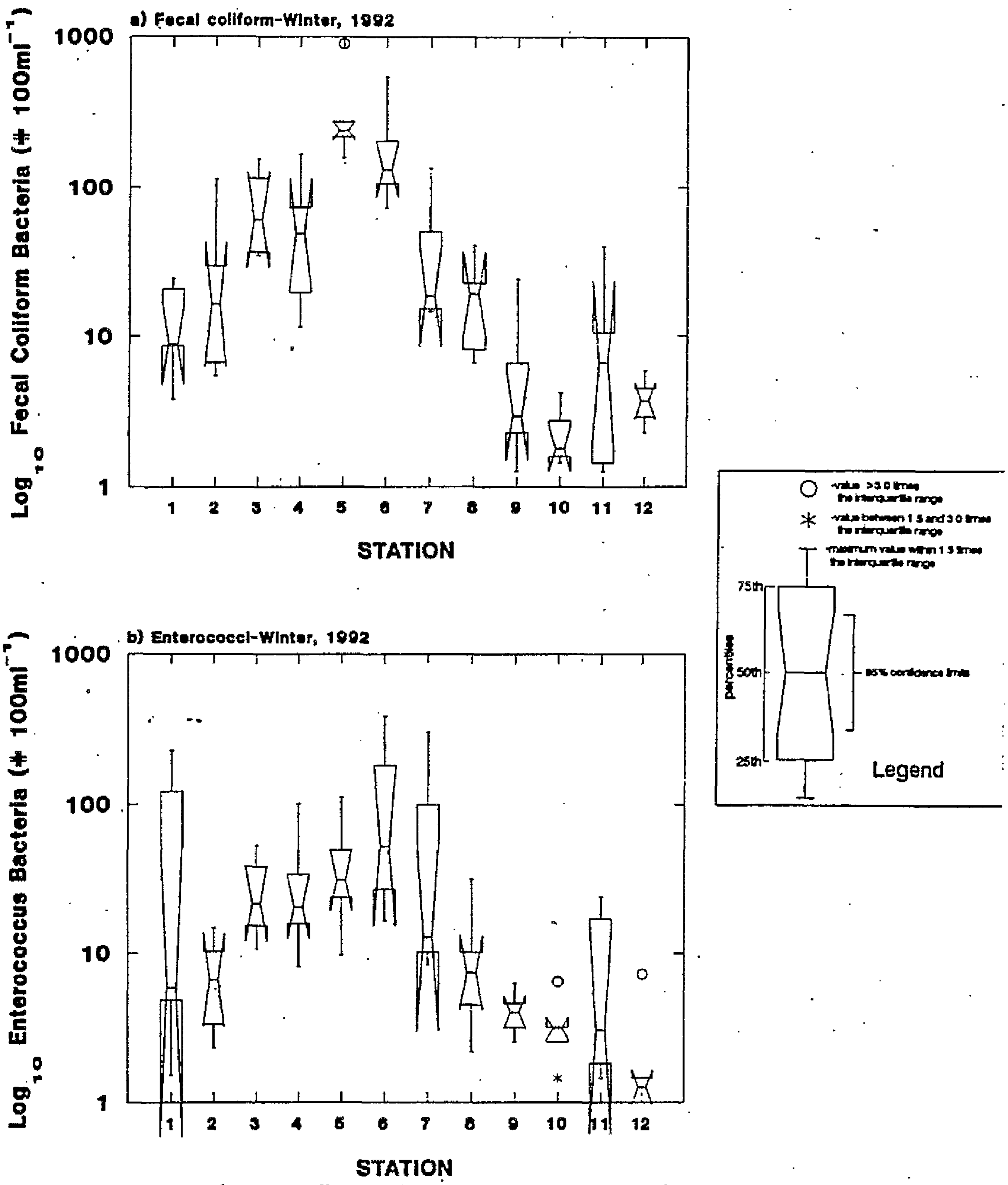
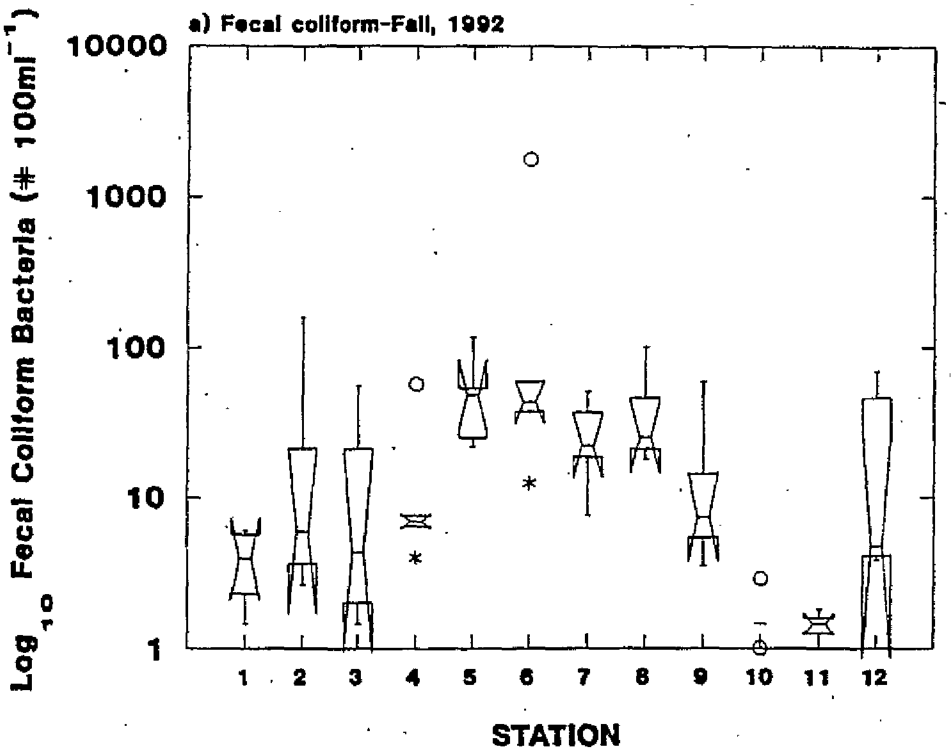


Figure 6. Data distribution by station. Includes data collected 22 November–28 December, 1992. See Figures 7 and 8 for previous studies. Differences between stations can be inferred from non-overlapping 'notches'.



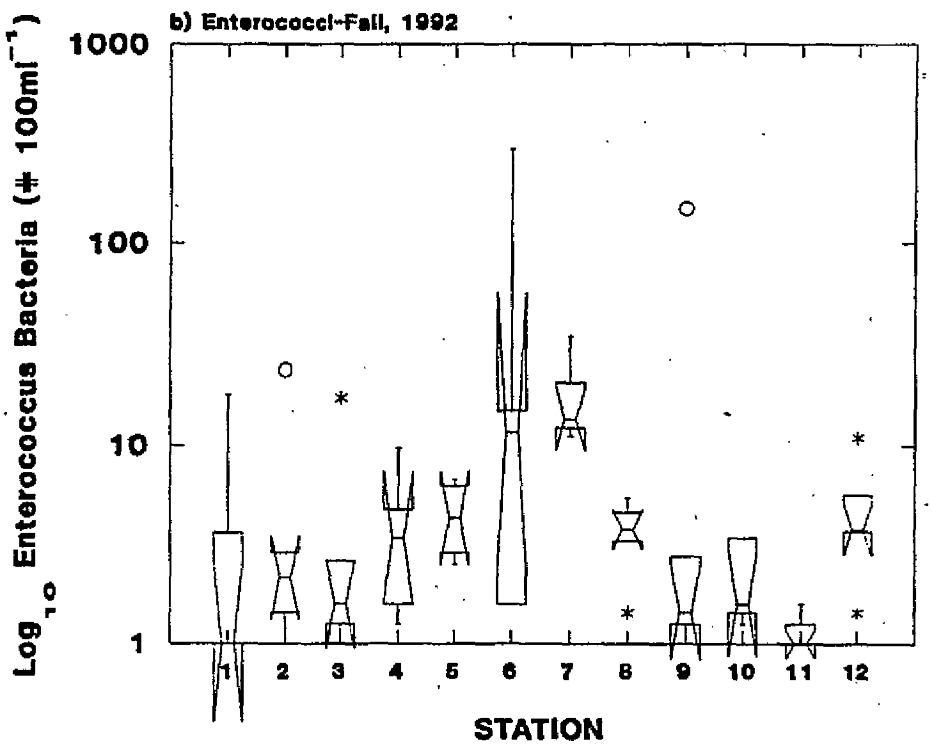


Figure 7. Data distribution by station (Hallock, 1993). Includes data collected 1 September-12 October, 1992. See Figures 6 and 8 for other studies. Differences between stations can be inferred from non-overlapping 'notches'. Legend as in Figure 6.

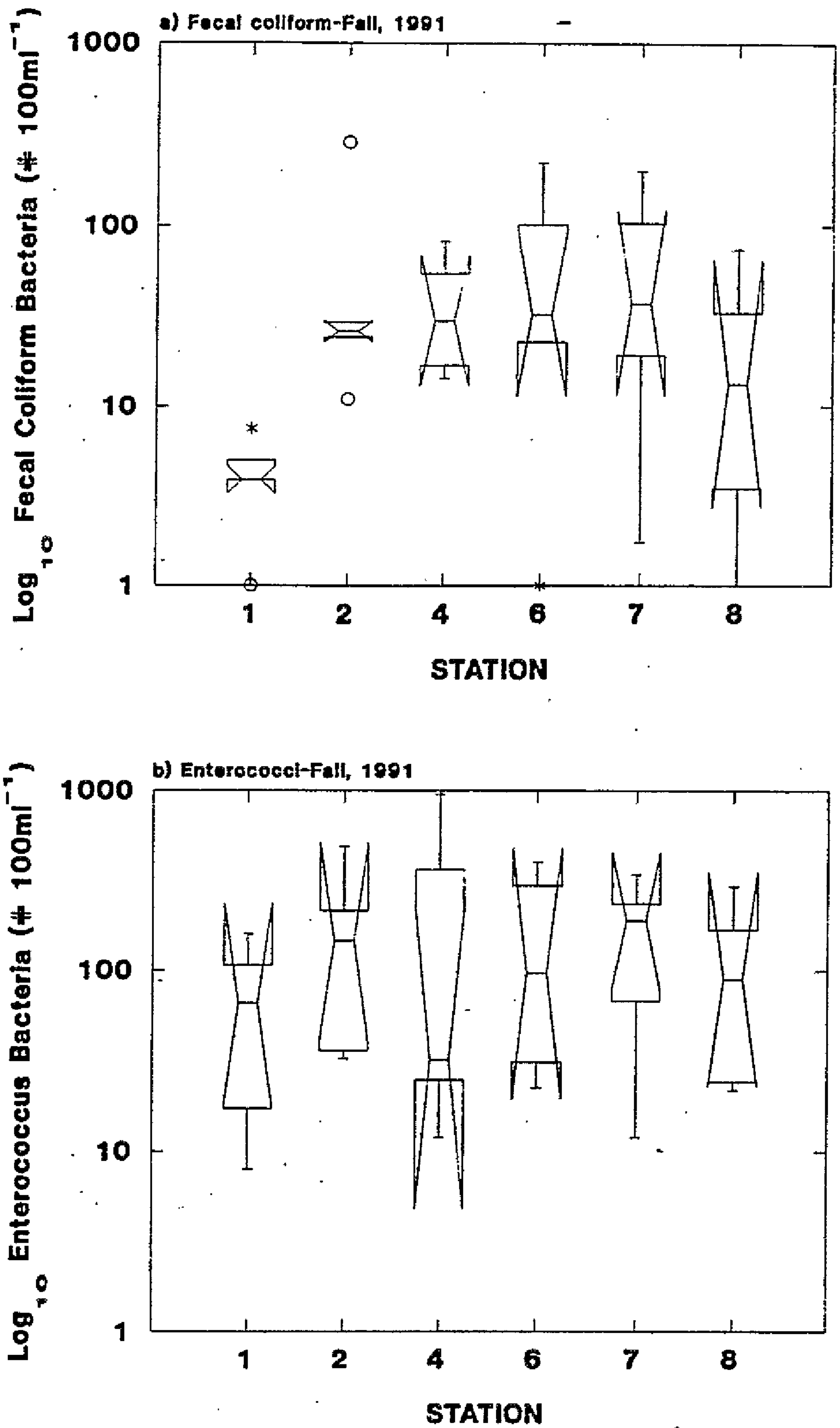


Figure 8. Data distribution by station (Tetra Tech, 1991). Includes data collected 16 October-14 November, 1992. See Figures 6 and 7 for other studies. Differences between stations can be inferred from non-overlapping 'notches'. Legend as in Figure 6.

APPENDIX A

Site specific comparisons of
fecal coliform and enterococcus bacteria.

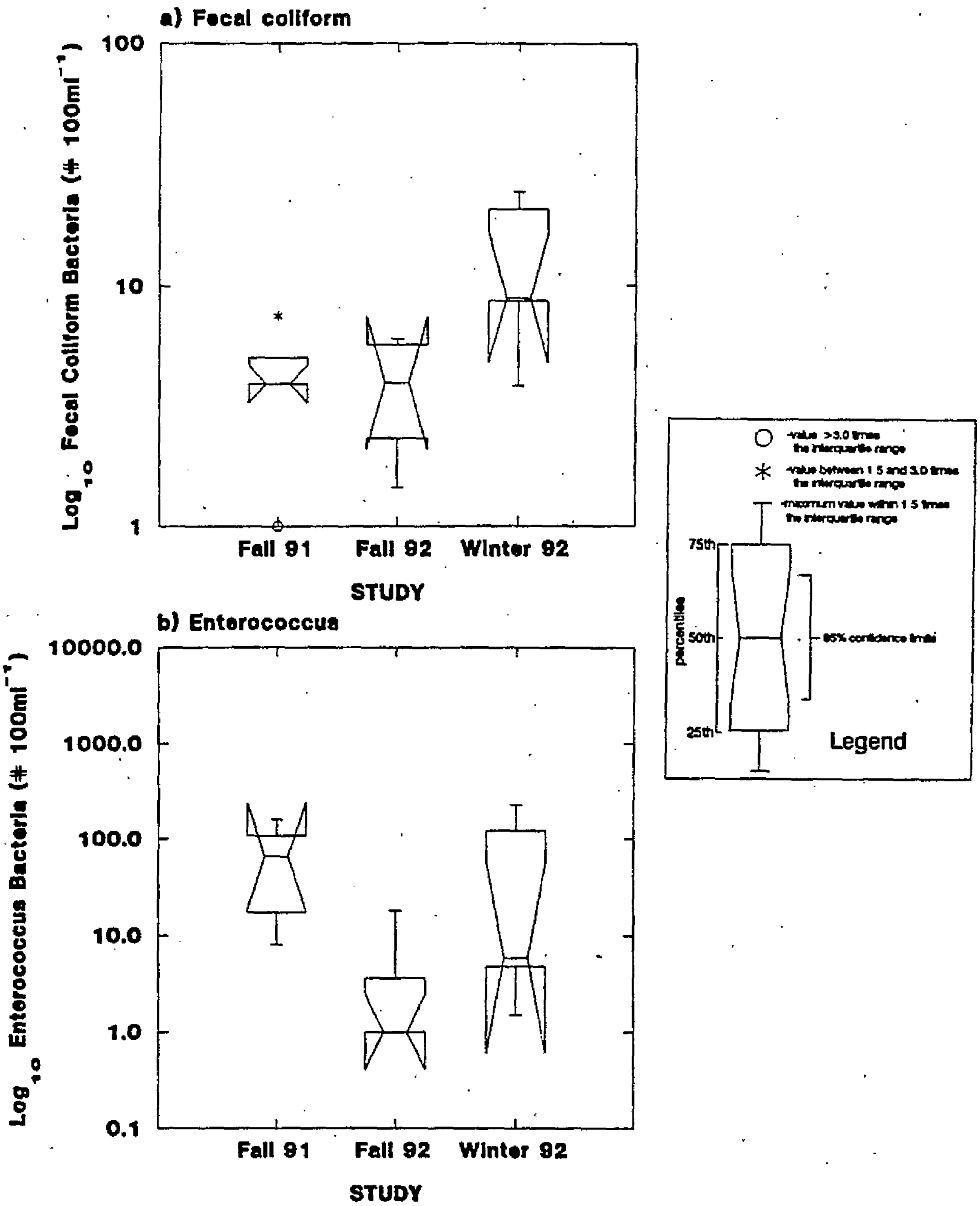


Figure A1. Comparison of bacteria counts collected at Station 1. Fall 1991-(Tetra Tech, 1991), Fall 1992-(Hallock, 1992). Differences of medians between stations can be inferred from non-overlapping 'notches'.

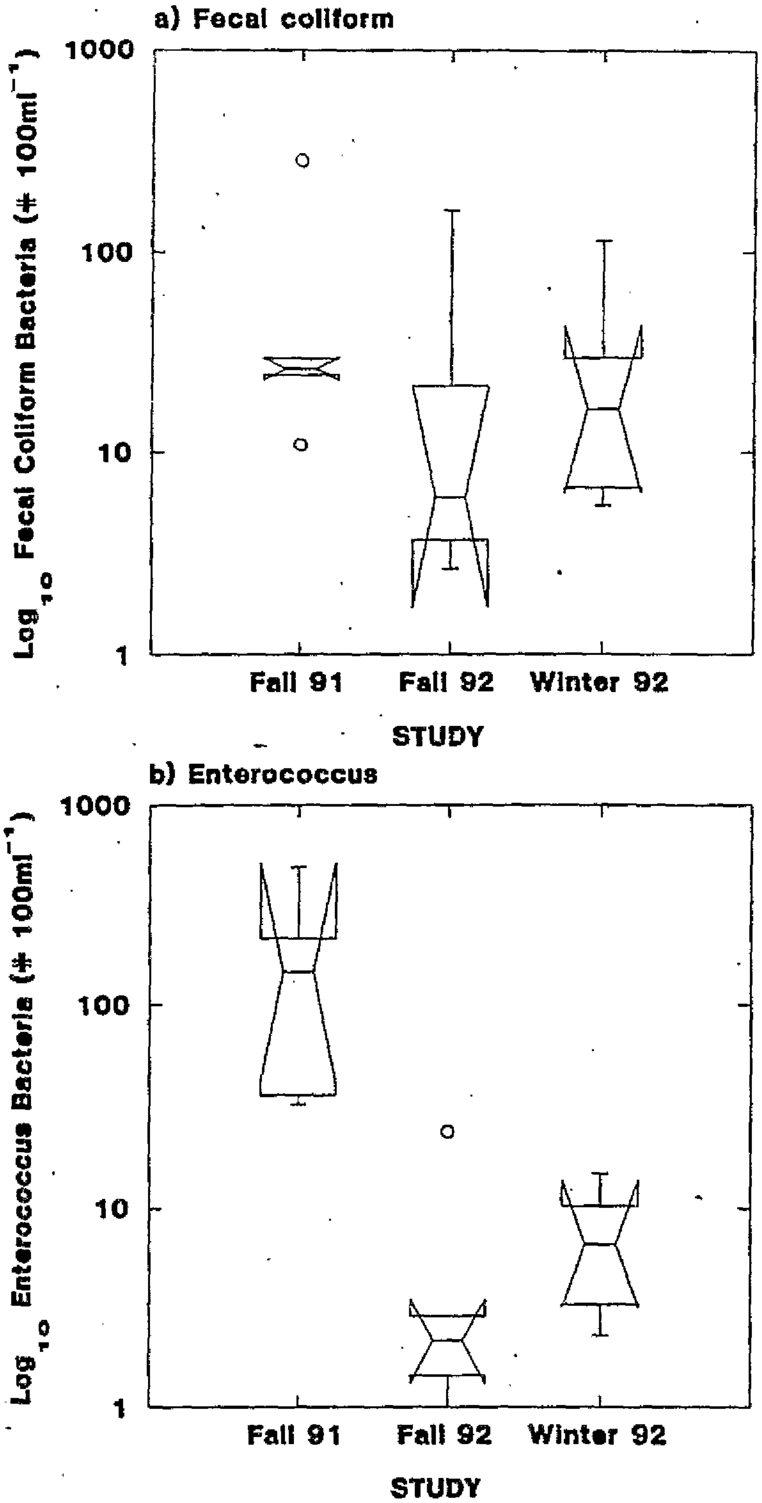


Figure A2. Comparison of bacteria counts collected at Station 2. Fall 1991-(Tetra Tech, 1991), Fall 1992-(Hallock, 1992), Winter 1992- Differences of medians between stations can be inferred from non-overlapping 'notches'. Legend as in Figure A1.

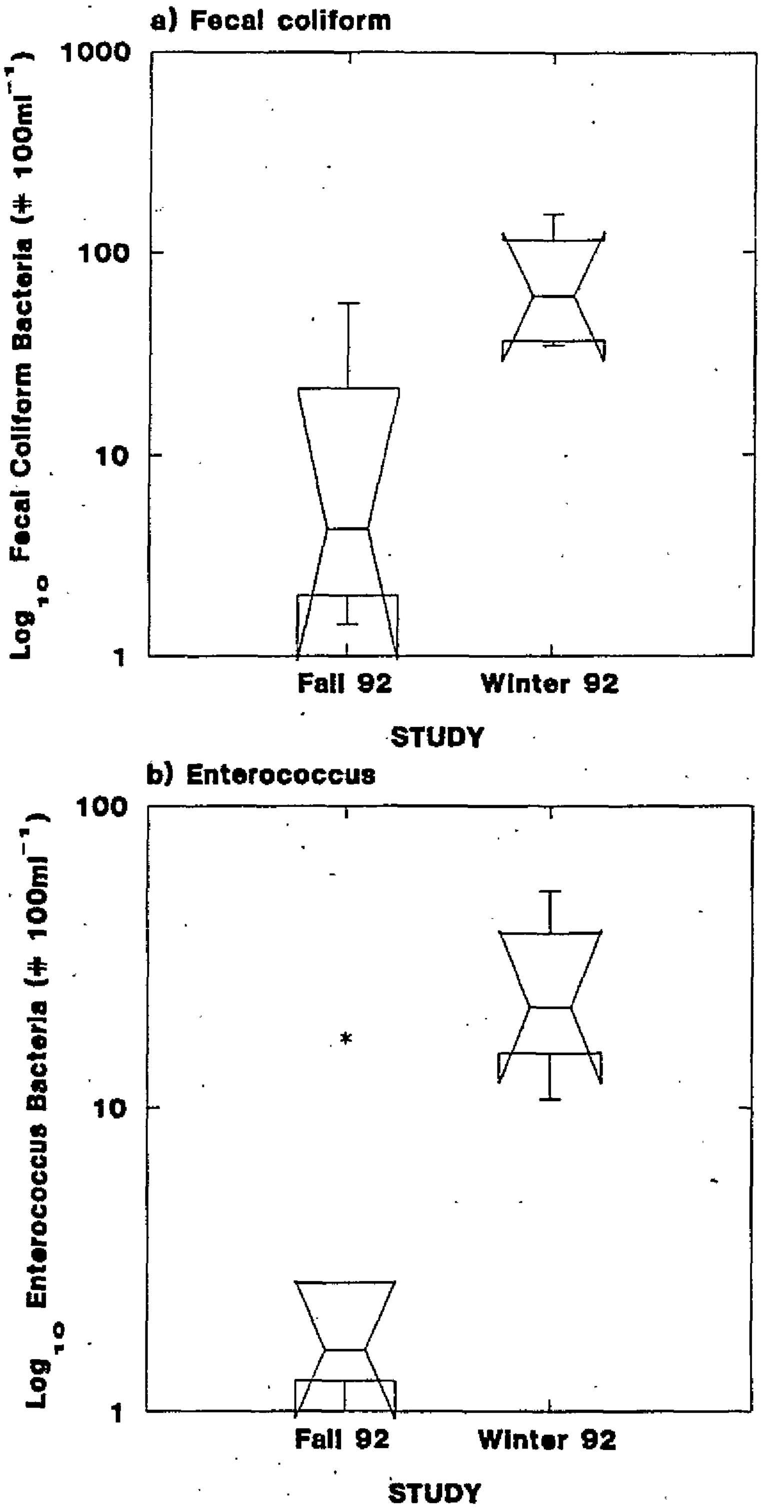


Figure A3. Comparison of bacteria counts collected at Station 3. Fall 1991-(Tetra Tech, 1991), Fall 1992-(Hallock, 1992). Differences of medians can be inferred from non-overlapping 'notches'. Legend as in Figure A1.

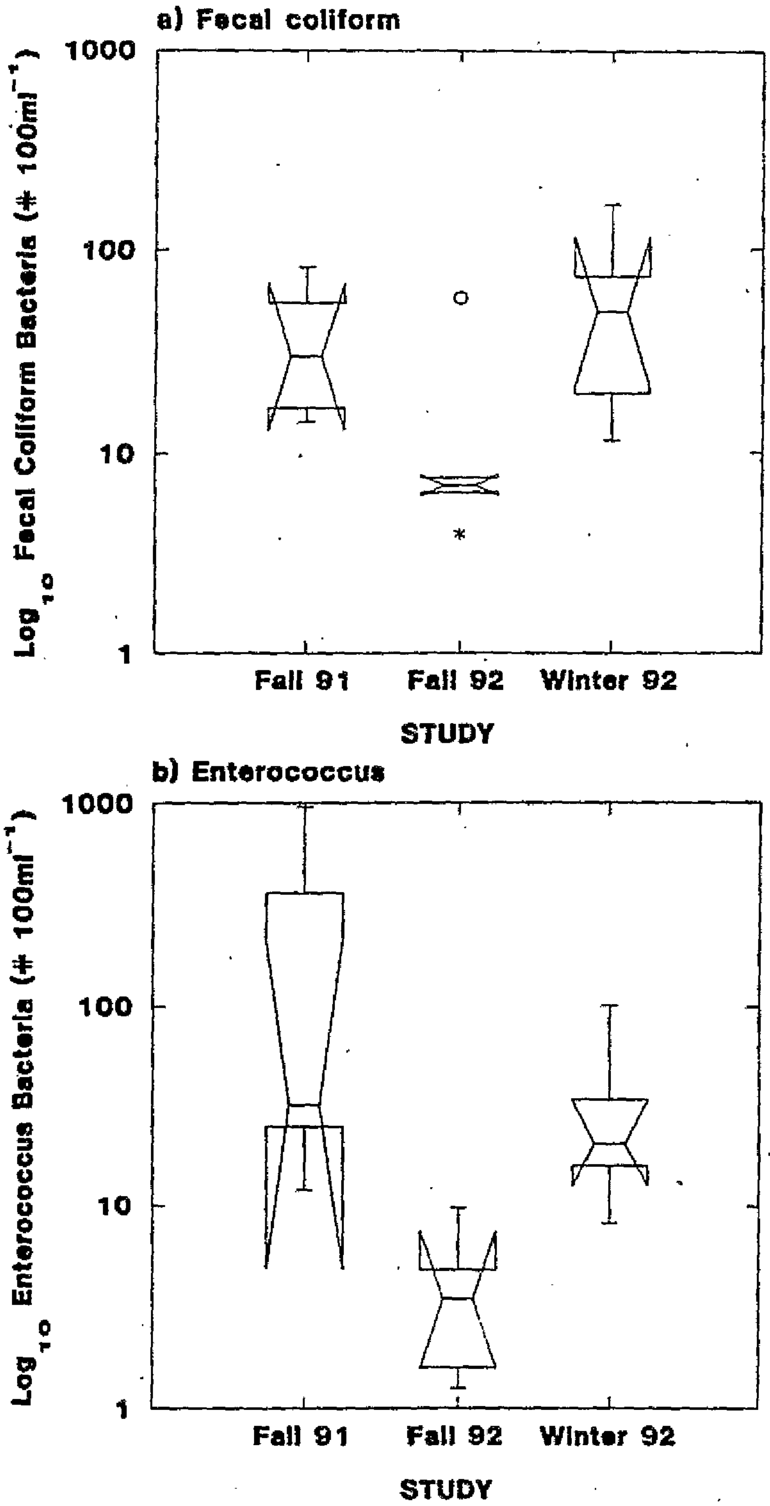


Figure A4. Comparison of bacteria counts collected at Station 4. Fall 1991-(Tetra Tech, 1991), Fall 1992-(Hallock, 1992). Differences of medians can be inferred from non-overlapping 'notches'. Legend as in Figure A1.

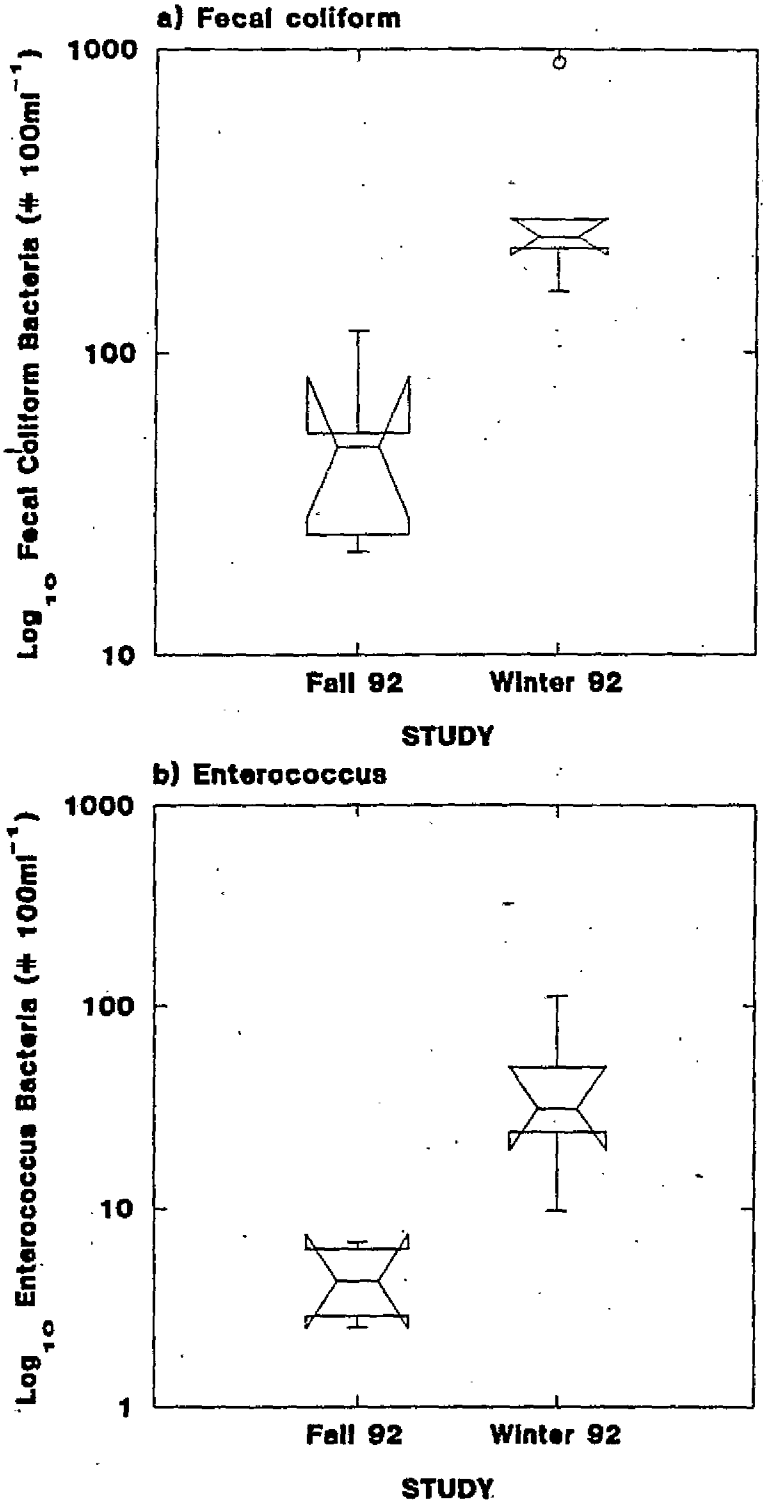


Figure A5. Comparison of bacteria counts collected at Station 5. Fall 1991-(Tetra Tech, 1991), Fall 1992-(Hallock, 1992). Differences of medians can be inferred from non-overlapping 'notches'. Legend as in Figure A1.

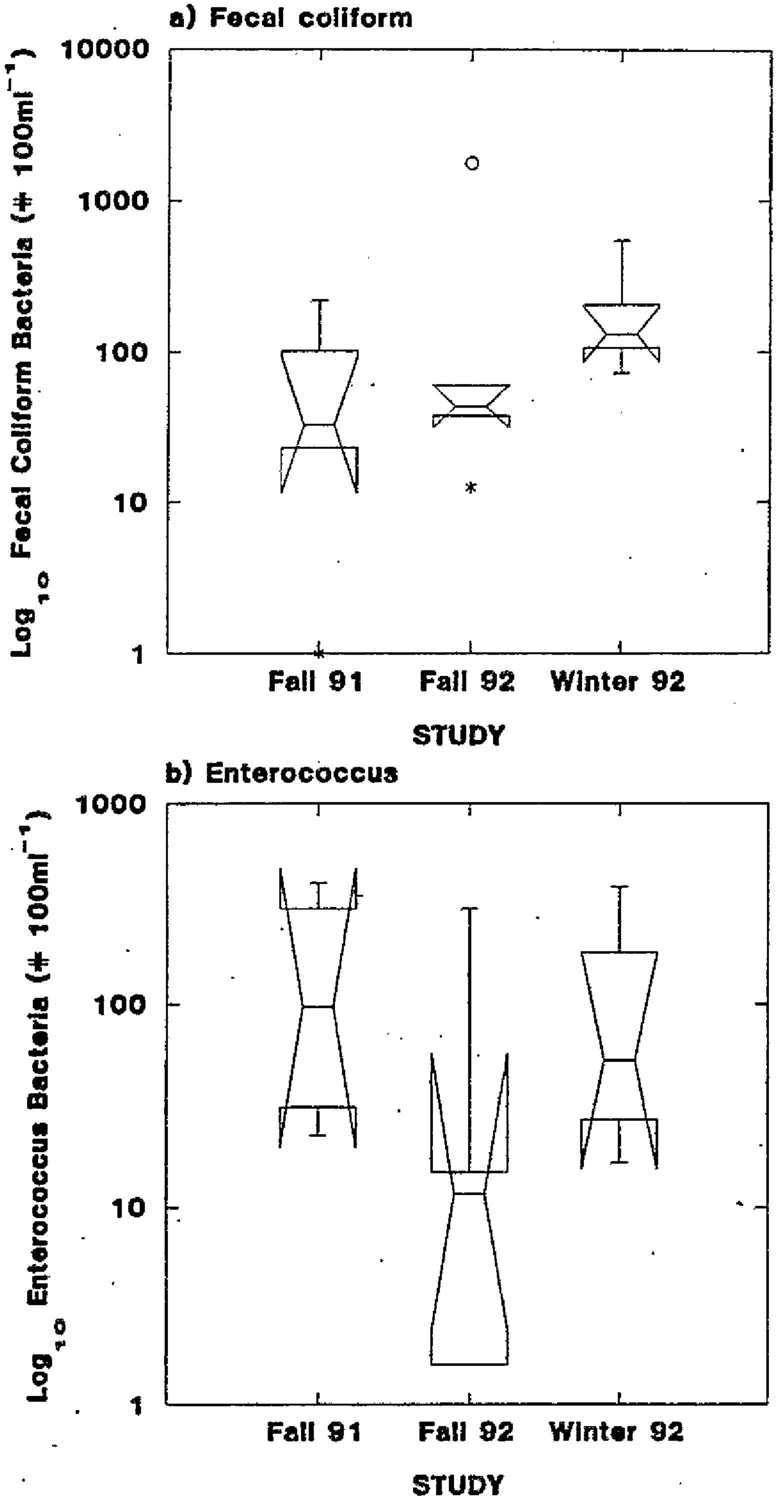
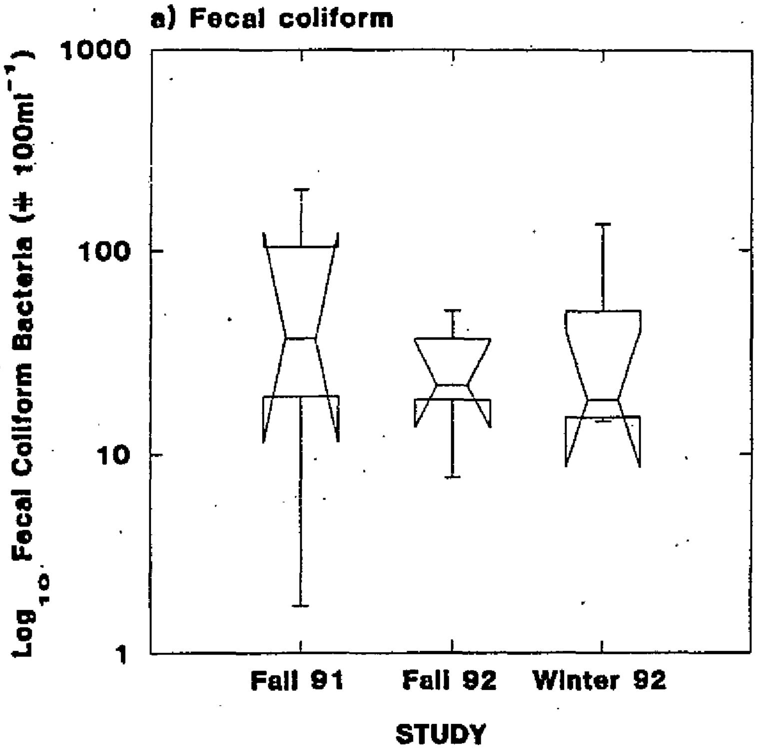


Figure A6. Comparison of bacteria counts collected at Station 6. Fall 1991-(Tetra Tech, 1991), Fall 1992-(Hallock, 1992). Differences of medians can be inferred from non-overlapping 'notches'. Legend as in Figure A1.



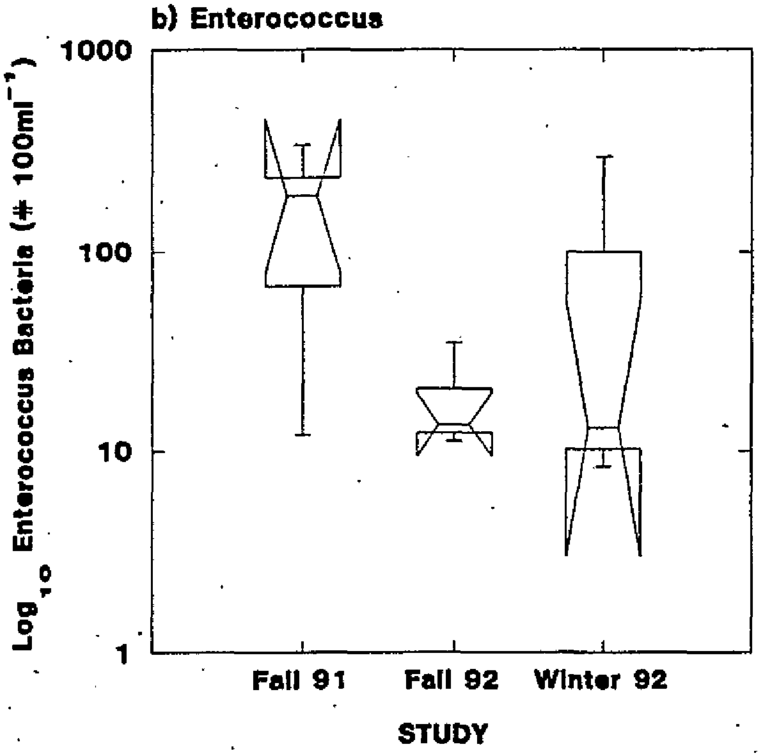
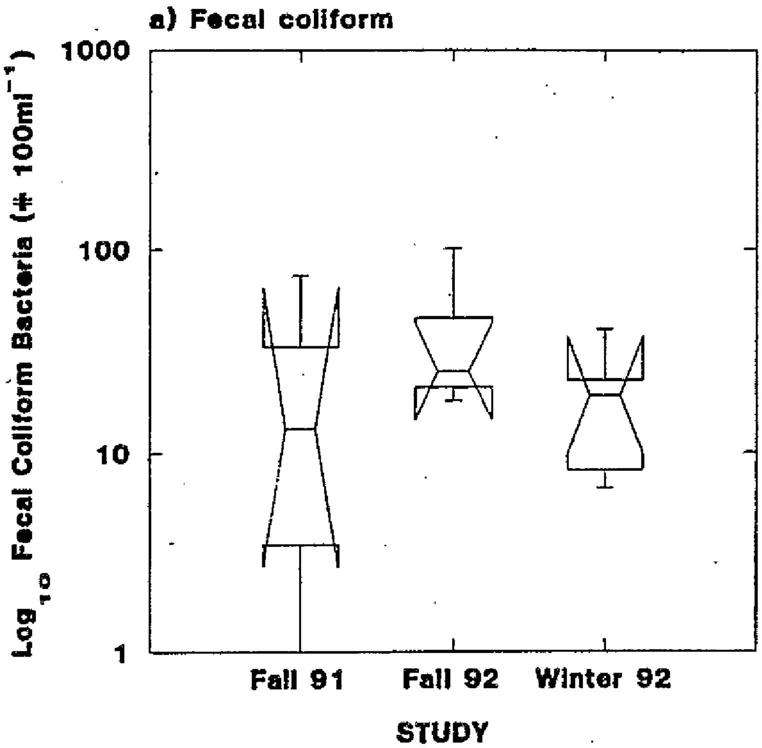


Figure A7. Comparison of bacteria counts collected at Station 7. Fall 1991-(Tetra Tech, 1991), Fall 1992-(Hallock, 1992). Differences of medians can be inferred from non-overlapping 'notches'. Legend as in Figure A1.



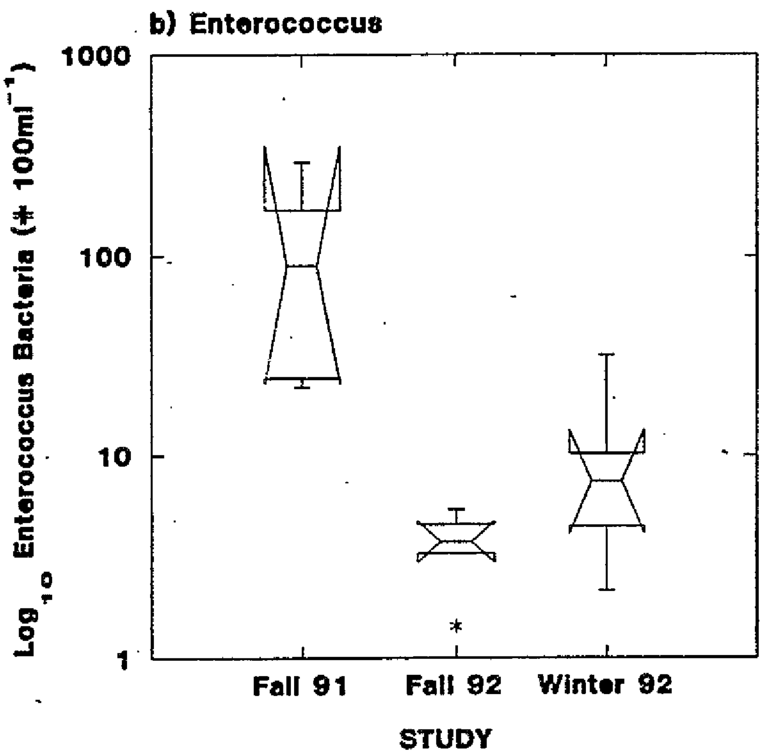


Figure A8. Comparison of bacteria counts collected at Station 8. Fall 1991-(Tetra Tech, 1991), Fall 1992-(Hallock, 1992). Differences of medians can be inferred from non-overlapping 'notches'. Legend as in Figure A1.

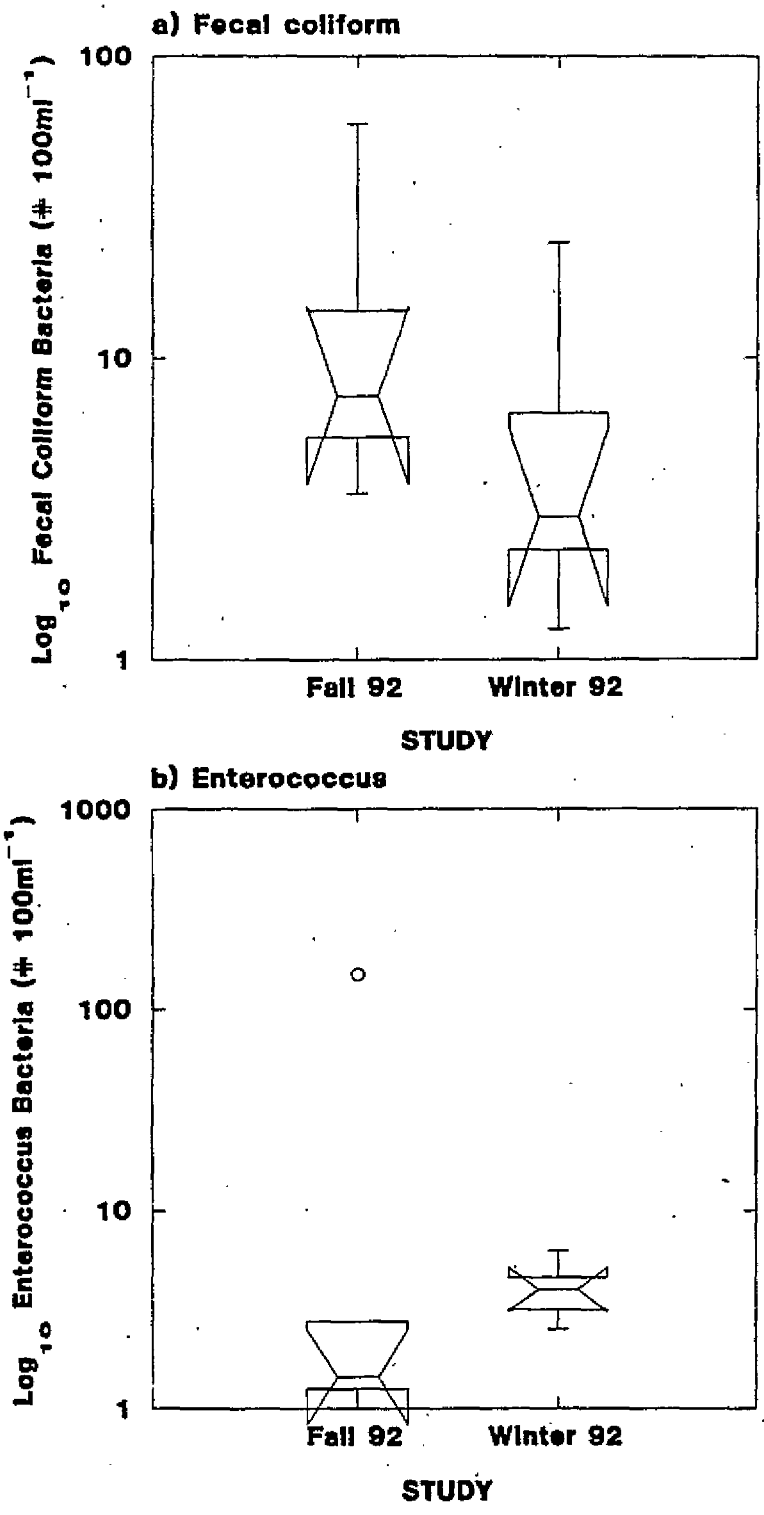
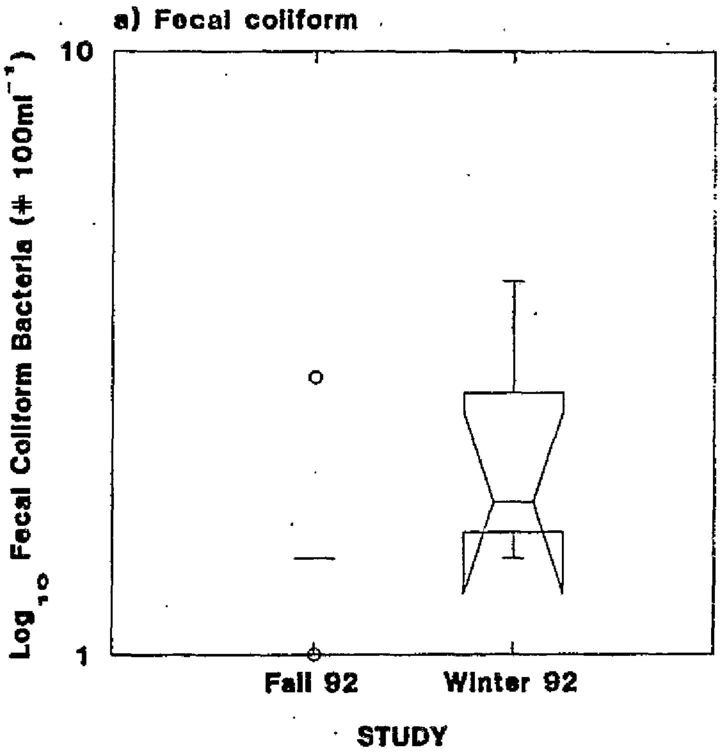


Figure A9. Comparison of bacteria counts collected at Station 9. Fall 1991-(Tetra Tech, 1991), Fall 1992-(Hallock, 1992). Differences of medians can be inferred from non-overlapping 'notches'. Legend as in Figure A1.



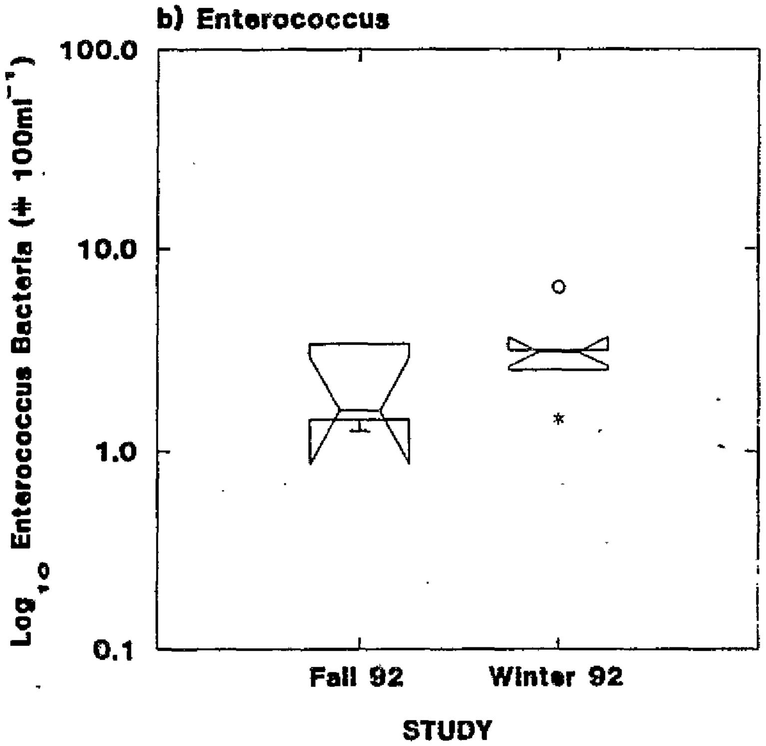


Figure A10. Comparison of bacteria counts collected at Station 10. Fall 1991-(Tetra Tech, 1991), Fall 1992-(Hallock, 1992). Differences of medians can be inferred from non-overlapping 'notches'. Legend as in Figure A1.

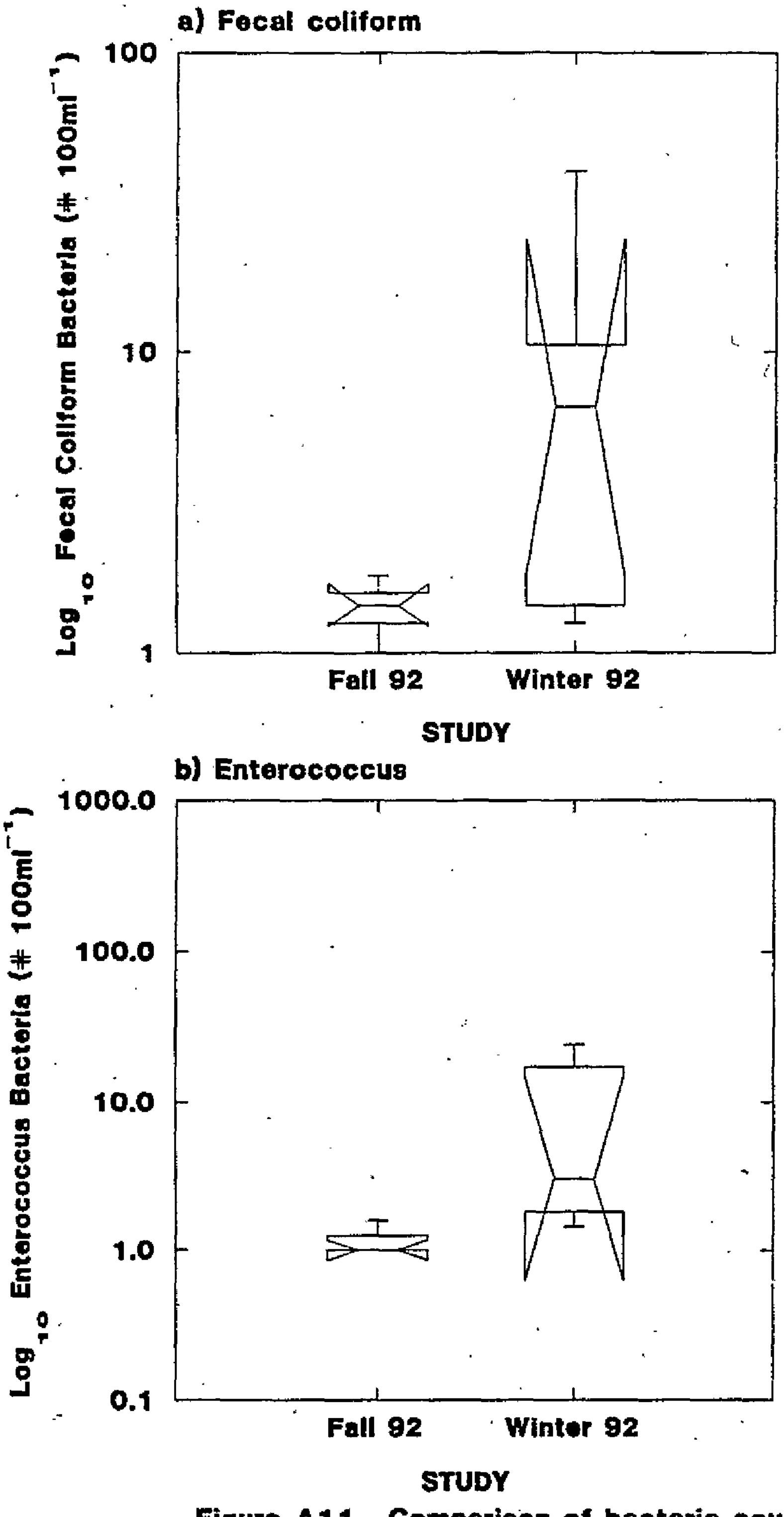
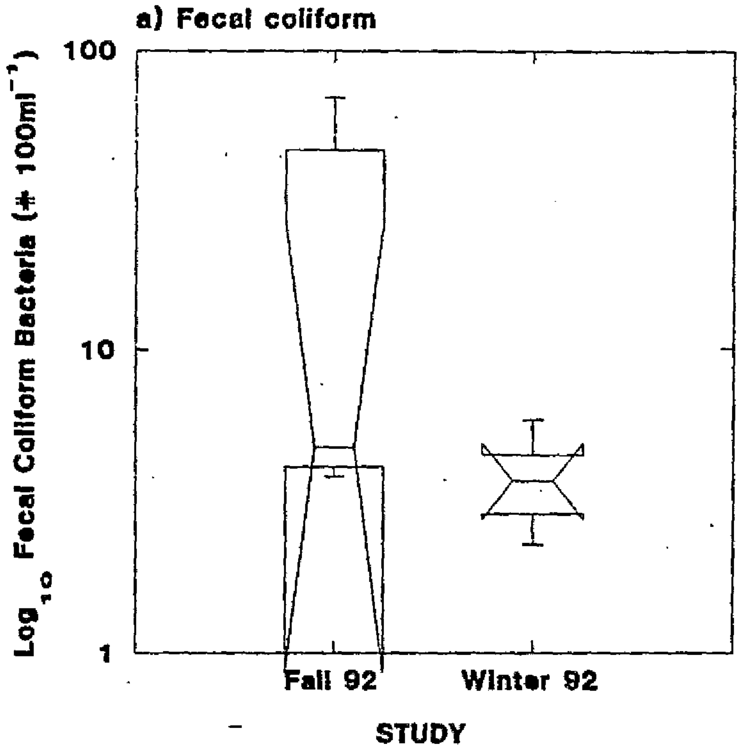


Figure A11. Comparison of bacteria counts collected at Station 11. Fall 1991-(Tetra Tech, 1991), Fall 1992-(Hallock, 1992). Differences of medians can be inferred from non-overlapping 'notches'. Legend as in Figure A1.



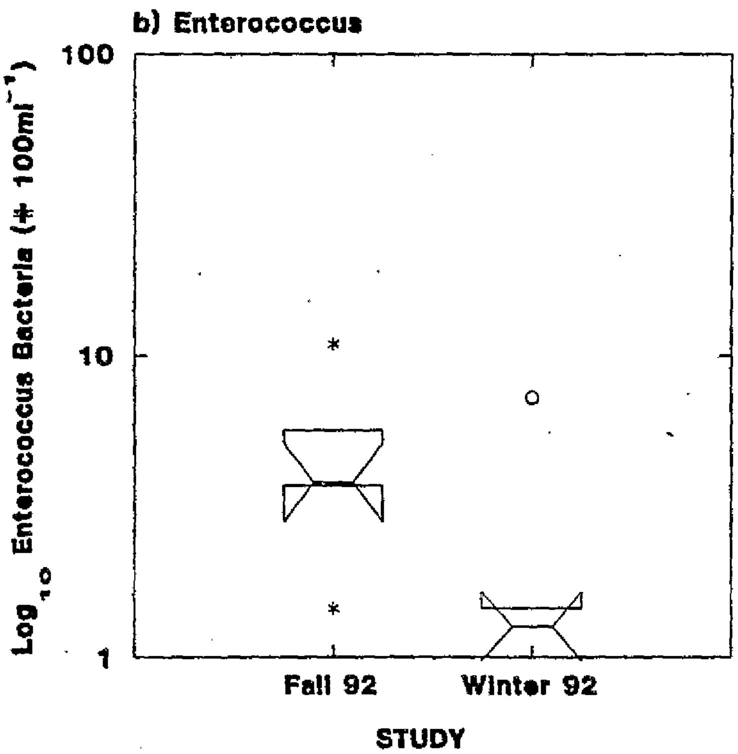


Figure A12. Comparison of bacteria counts collected at Station 12 Fall 1991-(Tetra Tech, 1991), Fall 1992-(Hallock, 1992). Differences of medians can be inferred from non-overlapping 'notches'. Legend as in Figure A1.

APPENDIX B

Data summary of all stations and dates sampled.

APPENDIX B

Data summary of all stations and dates sampled. Bacteria data are the geometric mean of replicate samples.

STATION	RM	DAY	MO	YR	T(°C)	pH	DO (mg/L)	COND (µS)	SAL (ppm)	FECAL (#/100mL)	ENTERO-COCCUS
1	1.5	22	11	92	11.3	8.1			28	25	122
1	1.5	29	11	92	8.2	8.2			16	9	6
1	1.5	6	12	92	7.6	8.0	11.0		17	4	2
1	1.5	13	12	92	7.4	8.0	10.4		12	21	226
1	1.5	20	12	92							
1	1.5	27	12	92	7.3	8.0	10.0		13	9	5
2	3	22	11	92	10.4	8.0			16	5	8
2	3	29	11	92	8.2	8.1			9	13	5
2	3	6	12	92	3.6	7.8	11.1		8	113	10
2	3	13	12	92	6.3	8.0	10.9		6	30	2
2	3	20	12	92	6.4	7.8	10.6		7	20	15
2	3	27	12	92	6.5	8.0	10.5		9	7	3
3	32.9	22	11	92	10.4	7.4		95		155	38
3	32.9	29	11	92	7.6	7.6		129		38	15
3	32.9	6	12	92	6.1	8.0	10.8	143		96	16
3	32.9	13	12	92	6.3	7.6	10.7	133		115	53
3	32.9	20	12	92	5.5	7.8	11.0	152		35	11
3	32.9	27	12	92	6.0	7.9	10.9	135		37	29
4	46.1	22	11	92	10.3	7.8		155		11	26
4	46.1	29	11	92	7.6	7.8		150		40	16
4	46.1	6	12	92	5.8	7.9	11.2	139		60	16
4	46.1	13	12	92	6.2	7.7	11.2	152		172	102
4	46.1	20	12	92	6.7	7.7	11.2	16		73	34
4	46.1	27	12	92	5.9	7.8	11.1	150		20	8
5	61.3	22	11	92	10.4	7.5		97		901	111
5	61.3	29	11	92	7.6	7.7		140		159	24
5	61.3	6	12	92	5.7	7.8	11.0	149		244	24
5	61.3	13	12	92	6.2	7.7	10.7	155		220	50
5	61.3	20	12	92	5.5	7.8	11.0	150		236	10
5	61.3	27	12	92	5.9	7.5	11.0	134		274	40
6	95.9	22	11	92	10.0	7.6		105		138	180
6	95.9	29	11	92	7.7	8.0		118		206	63
6	95.9	6	12	92	5.6	8.0	11.6	123		107	44
6	95.9	13	12	92	6.5	7.7	12.1	102		548	384
6	95.9	20	12	92	5.7	7.7	11.5	150		125	17
6	95.9	27	12	92	6.8	7.7	11.4	128		73	27

Appendix B. Continued.

STATION	RM	DAY	MO	YR	T(°C)	pH	DO (mg/L)	COND (uS)	SAL (ppm)	FECAL (#/100mL)	ENTERO-COCCUS
7	102	22	11	92	10.3			151		134	300
7	102	29	11	92	8.3	1.9		55		15	100
7	102	6	12	92	4.6	7.5	11.4	168		20	8
7	102	13	12	92	6.3	7.8	11.0	175		17	16
7	102	20	12	92	5.5	7.8	11.3	200		51	10
7	102	27	12	92	6.7	8.0	11.2	150		15	10
8	115	23	11	92	8.2	7.4		122		21	
8	115	30	11	92	8.0	7.9		165		17	32
8	115	7	12	92	4.8	7.5	11.4	160		41	2
8	115	13	12	92	6.5	7.6	11.1	165		8	4
8	115	21	12	92	5.6	7.7	11.3	163		7	10
8	115	28	12	92	5.4	7.5	11.3	153		23	7
9	128	23	11	92	7.0	7.3				76	24
9	128	30	11	92	7.8	8.0		165		3	3
9	128	7	12	92	0.9	7.2	12.5	178		7	5
9	128	13	12	92	6.5	7.9	11.0	170		2	6
9	128	21	12	92	5.4	7.7	11.3	167		3	4
9	128	28	12	92	4.2	7.6	11.6	148		1	3
10	140.6	23	11	92	8.5	7.5		160		4	
10	140.6	30	11	92	8.4			170		2	3
10	140.6	7	12	92	5.9	7.4	10.8	168		3	1
10	140.6	13	12	92	6.5	8.0	10.8	175		1	6
10	140.6	21	12	92	5.4	7.7	11.2	169		2	3
10	140.6	28	12	92	5.7	7.6	11.3	168		2	
11	148.5	23	11	92	10.0	7.4		138		7	
11	148.5	30	11	92	8.3	7.9		162		6	17
11	148.5	7	12	92	6.0	7.9	10.7	163		40	1
11	148.5	13	12	92	6.3	8.0	10.7	178		10	24
11	148.5	21	12	92	5.4	7.7	11.0	164		1	2
11	148.5	28	12	92	5.0	7.6	10.7	170		1	3
12	169.3	23	11	92	4.8	7.5		170		6	
12	169.3	30	11	92	8.4	7.9		157		2	1
12	169.3	7	12	92	6.6	8.3	10.2	170		4	1
12	169.3	13	12	92	6.3	7.9	10.5	183		3	1
12	169.3	21	12	92	5.5	7.7	10.4	172		4	1
12	169.3	28	12	92	5.4	7.4	11.1	167		3	7