AN EPIDEMIOLOGICAL STUDY OF POSSIBLE ADVERSE HEALTH EFFECTS OF SWIMMING IN SANTA MONICA BAY

Final Report

May 7, 1996

Santa Monica
BAY
Restoration
PROJECT

101 Centre Plaza Drive
Monterey Park, CA 91754
213 266 7516
Fax 213 266 7600

A Partnership To
Restore And Protect
Santa Monica Bay

Funded by US EPA
and the State Water Resources
Control Board in cooperation
with the public, local agencies,
and industry.

A Health Effects Study of Swimmers in Santa Monica Bay[1]

Summary

In the summer of 1995, the Santa Monica Bay Restoration Project (SMBRP) conducted the first large-scale epidemiologic study in the nation to investigate possible adverse health effects associated with swimming in ocean waters contaminated by urban runoff. The overall objective of this study was to answer the public's most frequently asked question, *"How safe is it to swim in Santa Monica Bay?"* by investigating swimmers' reports of illness and determining whether the risks of contracting these illnesses were associated with exposure to pathogens in urban runoff.

BACKGROUND

Since the genesis of the Santa Monica Bay Restoration Project (SMBRP), a primary focus of energy has been to find the answer to a fundamental human health question: *"How safe is it to swim in Santa Monica Bay?"* Nearly fifty million tourists and local residents come to Santa Monica Bay's public beaches each year to enjoy its recreational resources, but there has been wide public perception and some scientific evidence that there may be health risks associated with swimming in beach areas contaminated by runoff.

In previous investigations conducted by the SMBRP, human pathogens were detected in summer runoff, an unexpected result since sewer and storm drain systems in Los Angeles are completely separate. Possible sources of pathogen contamination into the storm drain system include illegal sewer connections, leaking sewer lines, malfunctioning septic systems, illegal dumping from recreational vehicles, or direct human sources such as campers or transients. Other potential sources of human pathogens in near shore areas include sewage spills into storm drains, small boat waste discharges and swimmers themselves.

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[1]"An Epidemiological Study of Possible Adverse Health Effects of Swimming in Santa Monica Bay."

The members of the SMBRP therefore decided that the definitive step necessary to answer this question of swimming-related health risks was an epidemiological study. Through this study, we would finally know if risks exist and whether they differ according to where one swims, and we would have the basis for revising recreational water quality standards and monitoring programs so that they are based on risks to human health.

STUDY OVERVIEW

During the course of the study (June to September 1995), 15,492 beachgoers who swam at three Santa Monica Bay beaches located near flowing storm drain outlets (Santa Monica Beach near Ashland Avenue, Will Rogers Beach at Santa Monica Canyon, and Surfrider Beach near Malibu Creek), were interviewed. Nine to 14 days after the beach interviews, 13,278 follow-up telephone interviews were conducted to ascertain the occurrence of symptoms--fever, chills, eye discharge, earache, ear discharge, skin rash, infected cut, nausea, vomiting, diarrhea, diarrhea with blood, stomach pain, coughing, coughing with phlegm, nasal congestion, sore throat and a group of symptoms indicative of "highly credible gastrointestinal illness" (HCGI)[2] and "significant respiratory disease" (SRD)[3].

Water samples were collected daily in ankle depth water at various distances from the drains (0, 100 yards north and south, and at 400 yards) (Figure 1) and analyzed for total and

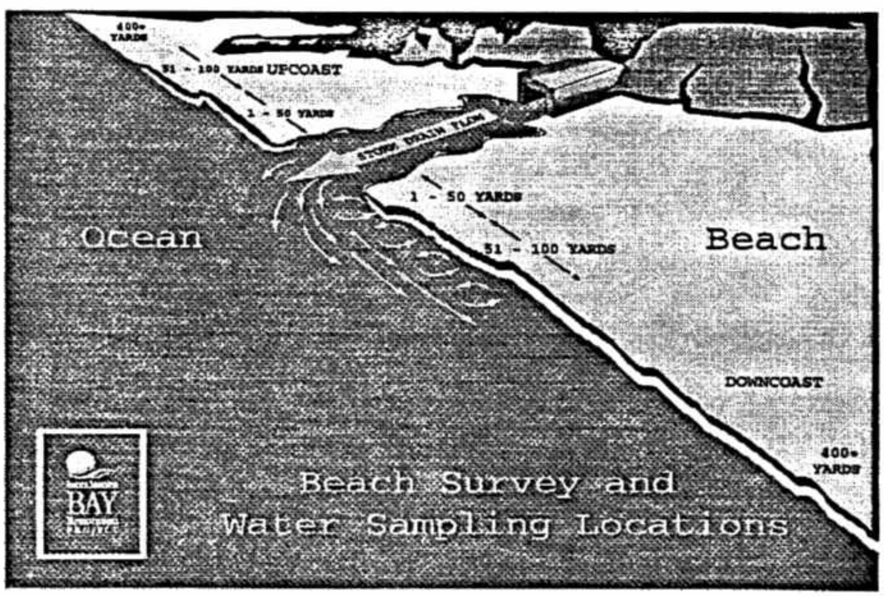

Figure 1. Beach survey and water sampling locations.

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[2] Two definitions of HCGI were used in this study and grouped as HCGI-1 (vomiting, diarrhea and fever, stomach pain and fever) or HCGI-2 (vomiting and fever).
[3] Symptoms including fever and nasal congestion, fever and sore throat, and cough with sputum.

fecal coliforms, enterococci, and *E. coli*. In addition, water samples were collected at storm drain sites every Friday, Saturday and Sunday and analyzed for enteric viruses.

SUMMARY OF FINDINGS

The analyses conducted in this study addressed two questions: a) What are the risks of illness relative to the distance one swims from a flowing storm drain?; and b) Are the risks of illness associated with measures of water quality? The major findings resulting from these analyses are as follows:

1. **There is an increased risk of illness associated with swimming near flowing storm drain outlets in Santa Monica Bay.** Statistically significant increases in risks for a broad range of adverse health effects (fever, chills, ear discharge, vomiting, coughing with phlegm, HCGI-2[4] and SRD) were found for subjects that swam in front of storm drains (at 0 yards) in comparison to those who swam over 400 yards away[5] (Table 1). For example, there was a 57 percent greater incidence of fever for swimmers at the drain than at 400 yards away. These increases in risk appeared to be limited to the 0 yards distance, as a significant drop-off in effects were observed at other distances upcoast or downcoast from the drain (Figure 2).

Table 1. Comparative health outcomes for swimming in front of drains versus 400+ yards away.

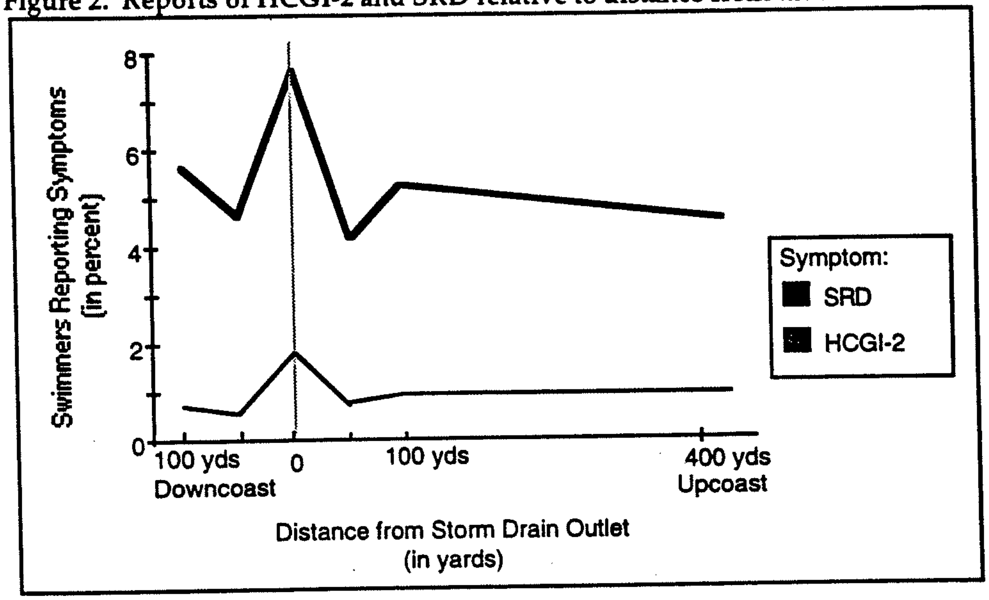
Health Outcome	Relative Risk (0 vs. 400+ Yds.)	Estimated No. of Excess Cases per 10,000 Persons
Fever	57%	259
Chills	58%	138
Ear Discharge	127%	88
Vomiting	61%	115
Coughing with phlegm	59%	175
Any of the above symptoms	44%	373
HCGI-2	111%	95
SRD	66%	303
HCGI-2 or SRD	53%	314

4 See footnote 2.

5 Indicator bacteria levels at 400 yards are low, therefore comparisons could be made between rates of illness in swimmers at this distance and at 0 yards.

The estimated number of excess cases of illness attributable to swimming at the drain reached into the 100's per 10,000 exposed subjects (greater than 1 percent) suggesting that significant numbers of beachgoers swimming near storm drain outlets are subject to increased health risks.

Figure 2. Reports of HCGI-2 and SRD relative to distance from drains.



The results did not change when adjusted for age, beach, gender, race, California versus out-of-state resident, socioeconomic status, or worry about potential health hazards at the beach. Distance results also did not change substantially when controlled for each bacterial indicator.

2. **There is an increased risk of illness associated with swimming in areas with high densities of bacterial indicators.** Researchers used "cutoff points" to determine whether there were differences in the incidence of illness for those who swam in waters with bacterial densities "greater than" versus "less than" certain cutoff levels. Symptoms were found to be associated with swimming in areas where bacterial indicator counts were "greater than" the cutoff points that are used as part of federal and state water quality standards. (Cutoffs vary by type of bacterial indicator.)

Table 2 shows the various outcomes that were found to be associated with these high densities of indicator bacteria. For *E. coli*, associations were seen for earache and nasal congestion. Only skin rash was associated with total coliforms and fecal coliforms. For enterococci, effects were noted for diarrhea with blood and HCGI-1.

Table 2. **Health outcomes associated with swimming in areas with high bacterial indicator counts.**

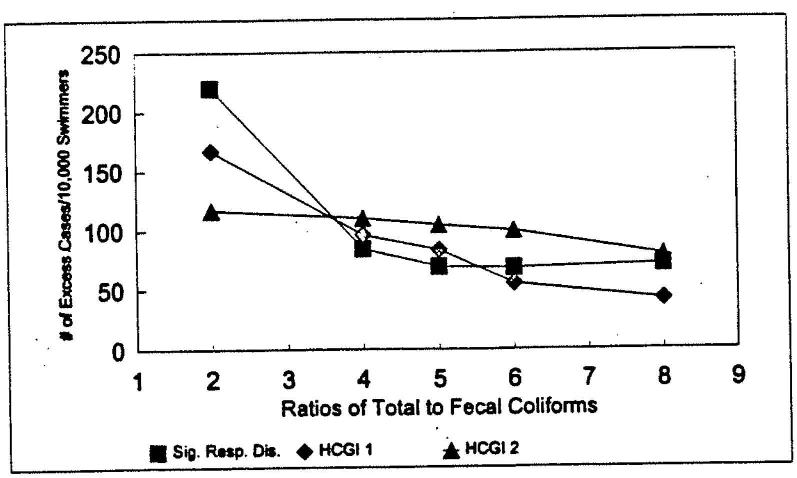
Indicator (cutoff)	Health Outcomes	Increased Risk	Excess Cases per 10,000 Persons
E. coli (> 320 cfu*)	Earache Nasal Congestion	46% 24%	149 211
Enterococcus (>106 cfu)	Diarrhea w/ blood HCGI-1	323% 44%	27 130
Total coliform (>10,000 cfu)	Skin rash	200%	165
Fecal coliform (>400 cfu)	Skin rash	88%	74

*colony forming units

3. **The total coliform to fecal coliform ratio was found to be one of the better indicators for predicting health risks.** In addition to investigating single bacterial indicators, associations between adverse health effects and the ratio of total to fecal coliforms were investigated. Significant associations were observed, with incidence of illness generally increasing as the ratio of densities of total coliforms to fecal coliforms decreased (Figure 3). When analyses were restricted to times when total coliforms exceeded 1,000 cfu, the strongest effects were generally observed when the ratio of 2:1 was used for comparison.

None of the bacterial results changed when adjusted for age, beach, gender, race, California vs. out-of-state resident, socioeconomic status or worry about potential health hazards at the beach.

Figure 3. Relationship of excess cases of illness and total-to-fecal coliform ratios.



4. **Illnesses were reported more often on days when the samples were positive for enteric viruses.** Seventeen water samples (taken in the storm drain) were positive for enteric viruses. Although based on small numbers, a comparison of subjects who were swimming within 50 yards of the drain on days when samples were tested for viruses indicates that a number of outcomes were reported more often on days when the samples were positive for viruses versus days when samples were negative. Symptoms for which increased risks were noted include: fever (53 percent increase), vomiting (89 percent increase), HCGI-1 (74 percent increase) and HCGI-2 (126 percent increase). Results remained essentially unchanged when adjusted for covariates or for each bacterial indicator. Research with gene probes is ongoing and will be presented in a future addendum to this report.

5. **High densities of bacterial indicators were measured on a significant number of survey days, particularly in front of drains.** A great deal of day-to-day variability in bacterial indicator counts was recorded, however high bacterial densities in water samples were detected most frequently directly in front of drains (at 0 yards) (see Table 4). High densities of *E. coli*, fecal coliforms, and enterococcus occurred on over 25 percent of survey days. Total coliform levels were exceeded less frequently (8.6 percent of days). Total-to-fecal coliform ratios of less than 5 occurred on 12 percent of survey days.

Table 4. **Percentage of survey days when bacterial indicator cutoff levels were exceeded in Santa Monica Bay.**

Bacterial Indicator (cutoffs)	Percent of Survey Days Bacterial Cutoffs Exceeded			
	0 yards	Distance from Drain Outlets 1-100 yards upcoast	1-100 yards downcoast	400+ yards upcoast
E. coli (>320 cfu)	25.0%	3.5%	6.7%	0.6%
Total coliforms (>10,000 cfu)	8.6%	0.4%	0.9%	0.0%
Fecal coliforms (>400 cfu)	29.7%	3.0%	8.6%	0.9%
Enterococcus (>106 cfu)	28.7%	6.0%	9.6%	1.3%
Total/fecal ratio ≤5 (total coliforms>1000 cfu)	12.0%	0.5%	3.9%	0.4%

High counts were recorded more frequently downcoast (versus upcoast) from storm drain outlets due to the general pattern of water flow along the Bay's shoreline. At 400 yards away, high counts occurred on generally less than one percent of days.

5. **Characteristics of the survey population.** Persons who bathed and immersed their heads in the ocean water were potential subjects for this study. There were no restrictions based on age, sex or race. Persons who had bathed at the study beaches within seven days of the survey date (before and after) were excluded, as were subjects who bathed on multiple days. Since a primary research question was whether the risk of illness was associated with levels of particular indicator organisms in the water, it would have been impossible to link subjects' experiences with specific counts on a given day if they were in the water on numerous days.

Fifty-five percent of the subjects surveyed were male, 45 percent female. Forty-eight percent of the subjects were children (under 12 years of age); 13-to-25 year-olds comprised 26 percent of the survey population and the remaining 26 percent were aged 26 and over. The ethnicity of the survey population was 45 percent white, 43 percent Latino, 3 percent black, 3 percent Asian, 3 percent multi-ethnic, and 2 percent "other." Children and Latino subjects tended to swim closer to the drain. Sixty-three percent of subjects swimming at the drain were children under 12. Eighty-eight percent of the surveyed subjects were residents of California.

THE EPI STUDY ACTION AGENDA

The results of this health risk investigation provide both good new and cause for concern. *The good news is that, of the Bay's 50-plus mile coastline, less than 2 miles are problematic.* However, the study has also confirmed that there is some risk of illness associated with swimming immediately adjacent to flowing storm drains. Although it is not yet known what specific pathogens cause illness, the study confirms that the bacterial indicators that are being monitored *do help* to predict risk. In addition, a new tool, the total-to-fecal coliform ratio, has been found to be a useful predictor of illness. With the scientific findings now documented through this study, we have laid the foundation to develop new policies and actions that will improve our ability to protect the public's health.

As a first step, the members of the Santa Monica Bay Restoration Project have identified an "Epi Study Action Agenda" to respond to the findings of this study and because of the need to "act now." Some of these actions have already begun, but many more steps are yet to be taken. Like the broader issue of urban runoff and storm water pollution, however, prevention and elimination of pathogen contamination in recreational waters requires a long-term, comprehensive approach. There is, however, much that can begin immediately.

Educating and advising the public about the health risks of swimming near storm drain outlets, ensuring that pathogen sources are identified and controlled, and preventing contamination of runoff into the drainage system are among the governmental actions that have been initiated. The general public also has a role to play -- taking action to prevent urban runoff pollution at home, at the work site and at play.

(This "Action Agenda" will be refined and considered for adoption by the SMBRP Watershed Council at its June meeting.)

EDUCATE AND ADVISE THE PUBLIC

1. **Improve warnings to swimmers by posting new signs and flags near flowing storm drains.** The Los Angeles County Department of Health Services (LACDHS) will revise the Beach Regulatory Protocol to ensure that beaches are well posted and/or closed as necessary. These revisions include:

   a. Strengthen the wording on warning signs posted near flowing storm drain outlets to read as follows: "WARNING! STORM DRAIN WATER MAY CAUSE ILLNESS. NO SWIMMING." This warning will be posted in both English and Spanish.

   b. Post warning signs on both sides of all flowing storm drains in Los Angeles County and place crossed flags adjacent to the signs.

   The remaining procedures contained in the Protocol (regarding incidents such as beach closure requirements in cases of sewage spills, etc.) will continue to be implemented as appropriate.

2. **Warn swimmers to stay away from storm drain outlets.** Los Angeles County Lifeguards will advise beachgoers to stay away from areas directly in front of storm drain outlets when swimming.

3. **Integrate messages about human health risks associated with contaminated urban runoff into storm water education campaigns.**

IMPLEMENT SOURCE CONTROL MEASURES

4. **Prevent and control sources of pathogens to urban runoff.** Controlling pathogen sources is but one part of a comprehensive strategy to address the problem of urban runoff pollution. The Los Angeles County Department of Public Works (LAC-DPW) and the cities in the Santa Monica Bay watershed will therefore continue to implement urban runoff source control measures (including Best Management Practices such as storm drain stenciling, street sweeping, and used oil recycling programs), and where needed, will expand or accelerate these programs.

5. **Divert dry-weather flows from problem storm drains.** The LAC-DPW and cities will continue to work with municipal wastewater agencies and the Los Angeles Regional Water Quality Control Board (LARWQCB) to complete the assessments of projects to divert dry-weather flows from problem storm drains to sewage treatment facilities. Projects that are feasible and cost-effective will be implemented in a timely manner.

6. **Construct a pilot dry-weather flow treatment facility at the Pico-Kenter drain.** The cities of Los Angeles and Santa Monica have been investigating construction of a pilot ozonation facility to treat dry-weather flows from the Pico-Kenter drainage area.

7. **Investigate and correct malfunctioning septic systems.** Cities and the Los Angeles County Department of Health Services will enhance programs to investigate and correct malfunctioning septic systems, especially in the watersheds along the northern Santa Monica Bay coastline;

8. **Maximize the ability to respond to and control sewage spills.** Municipal wastewater treatment facility operators will review sewage spill reporting and response procedures and develop/modify procedures where necessary to block, capture and re-direct spills to storm drains back into the sewer system.

IDENTIFY AND PREVENT PATHOGEN SOURCES

9. **Identify and eliminate illicit connections and illicit discharges to the storm drain system.** The municipal storm water/urban runoff pollution control permit issued by Los Angeles Regional Water Quality Control Board (LARWQCB) requires

implementation of programs to identify and eliminate illicit connections and discharges to the storm drain system. To accelerate the implementation of these programs, the LAC-DPW will develop a model program which includes standardized storm drain inspection procedures, illicit connection and discharge identification and elimination procedures, and enforcement procedures to terminate illicit connections and discharges.

10. **Investigate adverse impacts of street and sidewalk washing and develop methods to eliminate or minimize impacts.** The City of Los Angeles will, in the next year, investigate the impact of street and sidewalk washing on pathogen loadings to storm drain systems and will develop appropriate Best Management Practices to minimize the adverse impacts.

11. **Develop standardized procedures for locating sources of pathogens.** The LAC-DPW will lead efforts to develop a standardized sanitary survey protocol (procedures) for locating sources of pathogens and based in the results of this study, develop criteria for initiation of a sanitary survey;

INCORPORATE FINDINGS INTO STANDARDS AND MONITORING PROGRAMS

12. **Provide periodic reports to the public on beach water quality.** Shoreline bacterial monitoring programs are currently conducted by the City of Los Angeles, the County Sanitation Districts of Los Angeles County and the Los Angeles County Department of Health Services. These programs currently report individual bacterial indicator counts and it is recommended that the total-to-fecal coliform ratio also be added and incorporated into the regional water quality data base maintained by the LARWQCB. Both the individual indicator counts and total/fecal ratio should be used as the basis for development of periodic reports to the public on beach water quality prepared by the LARWQCB, SMBRP, Heal the Bay or other organizations.

13. **Review and revise recreational water quality standards or criteria.** Recreational use of coastal waters occurs near urbanized regions throughout California and the U.S. Current standards/criteria for bacterial indicators are not based on epidemiological studies of swimmers in marine waters contaminated by urban runoff. Given the results of this study, it is recommended that the U.S. Environmental Protection Agency, the California State Department of Health Services and the State Water

Resources Control Board review existing recreational water quality standards/criteria for marine waters and revise them as appropriate.

14. **Review water quality data trends in Santa Monica Bay.** The SMBRP will spearhead a team to review existing water quality data utilizing analytical methodologies identified through this study, so that additional results can be incorporated into modifications of the beach warning protocol and water quality monitoring and reporting activities.

15. **Support additional research projects that help answer additional questions about potential health risks.** Examples of such studies may include an assessment of health risks to persons who frequently swim in the Bay (e.g. surfers and lifeguards) or research efforts necessary to improve our ability to more quickly detect human pathogens in urban runoff.

FINANCE SOURCE CONTROL MEASURES

16. **Seek financing at local, state and federal levels for implementation of source control measures.** The members of the SMBRP will investigate financing mechanisms to support implementation of local efforts to control storm water and urban runoff pollution.

ACTIONS THE PUBLIC CAN TAKE

In addition to governmental action, the general public can take steps to help reduce urban runoff pollution. Urban runoff pollution includes bacteria, trash and chemicals which are washed into the storm drain system from streets, neighborhoods, business locations, parking lots, construction sites, etc. This type of pollution is a problem because, unlike the sewer system, which includes treatment plants, the storm drain system carries water and whever else is put into it--without treatment--to our streams and the ocean. Urban runoff pollution can be minimized by following these suggestions:

1. **Practice "good housekeeping " in and around the home.**
   - Clean up after your pet. Dispose of wastes in trash cans.
   - Make sure that septic tanks are properly maintained.
   - Properly dispose of disposable diapers.
   - Use a broom rather than a hose to clean up garden clippings. Deposit leaves and grass clippings in a trash can or start a compost pile.

- Take leftover household hazardous materials to a Countywide Household Hazardous Waste collection event or other local collection program.
- Take used motor oil and antifreeze to a participating gas station or other recycling center.
- Have your car inspected and maintained regularly to reduce leakage of oil, antifreeze and other fluids.
- Recycle reuseable materials.

2. **Practice "good housekeeping" at your worksite and where you play.**
   - Clean up spills of materials such as vehicle fluids, paints and solvents properly.
   - Control runoff and prevent erosion at construction sites.
   - Cover and maintain dumpsters.
   - Properly dispose of kitchen wastes. Wash down floor mats in areas that drain to the sewer system.
   - Compost or haul away manure from horses or other livestock.
   - Use pumpout and dump stations to dispose of sewage from boats and recreational vehicles.

3. **Promote pollution prevention and awareness in your community.**
   - Participate in programs such as storm drain stenciling and Coastal Cleanup Day.
   - Support your municipality by reporting any dumping of inappropriate materials into storm drains (such as oil and antifreeze) to 1-800-303-0003.

STUDY PARTICIPANTS

A unique team was assembled to carry out the various elements of this study. Dr. Robert Haile, USC School of Medicine, Department of Preventive Medicine, served as Principal Investigator. Dr. Haile led the research team that conducted the beach and follow-up telephone interviews and conducted the health risk analyses utilizing water quality and survey data. The City of Los Angeles Environmental Monitoring Division (LA-EMD) analyzed daily water samples for total coliform, fecal coliform and enterococcus. Heal the Bay volunteers collected the daily bacterial indicator samples and their Executive Director, Dr. Mark Gold served as a principal study advisor. The County Sanitation District of Orange County (CSDOC) collected and analyzed water samples for enteric viruses. The University of Southern California, Department of Biology conducted enteric virus analysis utilizing polymerase chain reaction (PCR)/gene probe technique. The Santa Monica Bay Restoration Project and Foundation served as principal project organizer and was responsible for project management, coordination of financing and contracts, and for providing technical and policy oversight.

FUNDING FOR THIS STUDY

The financial and human resources for this study were provided by many public and private entities. The Santa Monica Bay Restoration Project and Foundation thanks the following organizations for their support and commitment to this important scientific undertaking: the State Water Resources Control Board, City of Los Angeles, Beach Cities Health District, City of Santa Monica, Los Angeles County Department of Public Works, Los Angeles Regional Water Quality Control Board, Chevron Companies, Las Virgenes Municipal Water District, Milken Families Foundation, Heal the Bay, and the U.S. Environmental Protection Agency.

ABOUT THE SANTA MONICA BAY RESTORATION PROJECT AND FOUNDATION

The Santa Monica Bay Restoration Project (SMBRP) is a coalition of government, environmentalists, scientists, industry and the public charged with finding solutions to the Bay's problems. The SMBRP, established in 1988 as part of the Clean Water Act National Estuary Program, completed a comprehensive "Bay Restoration Plan" in 1994 that outlines a wide range of actions necessary to restore and protect the Bay. Implementing this health effects study was one of the Plan's highest priorities.

The Santa Monica Bay Restoration Foundation is a non-profit, 501(c)(3) community foundation of the SMBRP. The Foundation is an independent fundraising vehicle created to attract research, planning and implementation funds for activities, such as this epidemiological study, that lead to the restoration and enhancement of Santa Monica Bay.

AN EPIDEMIOLOGICAL STUDY OF POSSIBLE ADVERSE HEALTH EFFECTS OF SWIMMING IN SANTA MONICA BAY

Final Report

Submitted by: Robert W. Haile and, in alphabetical order, James Alamillo, Kevin Barrett, Ron Cressey, John Dermond, Carolyn Ervin, Alice Glasser, Nina Harawa, Patricia Harmon, Janice Harper, Charles McGee, Robert C. Millikan, Mitchell Nides, John S. Witte

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GLOSSARY

Bacterial Indicator Counts - one way of estimating the amount of untreated sewage in contaminated water is to test it for bacteria that are commonly found in human waste. The amount of these bacteria found can then "indicate" the amount of contamination even if they themselves are not pathogenic.

Bathing (or swimming) - by bathing, subjects had to immerse their faces in the water; incidental splashing of the face would not qualify as "bathing" for purposes of this study.

"Cabelli-type" -refers to the Victor Cabelli's classic studies comparing health outcomes in swimmers versus non-swimmers while monitoring marine water quality. His studies were sponsored by the Environmental Protection Agency in the late seventies and early eighties.

Cohort - the study group being followed over a defined period of time.

Colony forming units (cfu) - the unit of measure used to evaluate the bacterial indicator counts. It refers to the density of the bacterial colonies grown per 100mL of water sampled.

Confounder - an independent risk for the outcome of interest that is also associated with the exposure of interest so it can distort its apparent effect on disease outcome.

Cytopathic Effect (CPE) - microscopic observations of changes in the morphology and/or growth rate of a cell culture assay system resulting from infection of the cells by virus.

Downcoast - in this study refers to the area south of the storm drain of interest.

Enteric Viruses - refers to a group of viruses transmitted through human waste. Can cause a variety of adverse health effects.

Enterococcus - (formerly known as Streptococcus faecalis). A bacteria that is part of the normal flora found in human and animal waste. Commonly used as a bacterial indicator.

E. coli - another bacteria normally found in human waste. Is sometimes used as a bacterial indicator.

Fecal Coliforms - a group of bacteria from the intestinal tract of humans, mammals and birds, commonly found in urban run-off. Commonly used as a bacterial indicator of the presence of sewage.

HCGI1 - (highly credible gastroenteritis one) - defined for this study as a person having either 1) vomiting 2) diarrhea and fever 3) stomach pain and fever. This is the standard definition for this symptom complex as defined by the EPA and used by many previous studies.

HCGI 2 - (highly credible gastroenteritis two) - defined for this study as a person having vomiting and fever.

Indicator Counts-refers to bacterial indicator counts as defined above.

Odds Ratio - it approximates the risk ratio in this study. (See Risk Ratio below).

Pathogenic - refers to organisms that cause disease.

PEPS - Population Estimation and Projection System from LA County 1993.

Plaque Forming Unit (PFU) - macroscopic hole(s) in the monolayer of a cell culture assay system resulting from localized lysis of the cells in the monolayer that initially

began with infection of one cell by an infectious unit of virus. In the PFU assay technique, agar is incorporated into the medium so that cell lysis resulting in release of additional infectious virus restricts the infection of new cells to only the adjacent healthy cells. Multiple cycles results in a hole in the monolayer.

Plume - refers to the quantity and direction the run-off from the storm drain takes when it enters the ocean. Due to ocean currents, it is generally believed that plumes from the storm drains considered in this study usually go downcoast, but this may not always be the case.

RR (Risk Ratio) - a measure of relative effect comparing the symptom risk of exposed subjects to subjects in a different exposure category.

SRD (significant respiratory disease) - in our study defined as a complex of symptoms that include; 1) fever and nasal congestion; 2) fever and sore throat and 3) cough with sputum.

Study Area 1 - defined as the area within 100 yards upcoast and downcoast of the storm drain of interest, the "exposed area".

Study Area 2 - defined as the area 400+ yards upcoast and downcoast of the storm drain of interest, the "control area".

Total Coliforms - bacteria that can originate from soil, plants, human and animal waste. Commonly used as a bacterial indicator.

Total Coliform/Fecal Coliform Ratio - a ratio used by bacteriologists as an additional bacterial indicator. For those wishing to know more, the baseline ratio is derived from the cut-off points of total and fecal coliforms, 1000(total)/200(fecal)=5. When one is

exposed to sewage contaminated water the fecal coliforms increase thus decreasing the ratio to <5.

Upcoast-refers to the area north of the storm drain of interest.

Water Sampling-In this study refers to taking samples of ocean water in front of the storm drain and at 100 and 400 yards away in order to test for the following indicators, total and fecal coliforms, enterococus, E. coli and enteric viruses.

participate were then interviewed about basic demographic data and about their bathing, including type of bathing activity (particularly immersion of the head into ocean water). Distance from the storm drain, gender, age, and race of the subject were noted by the interviewer.

On the same days that subjects were recruited, morning water samples were collected at ankle depth at 0, 100 yards north and south of the storm drain, and 400 yards north or south (depending on which area was used as a "control" area). Samples were analyzed for total and fecal coliforms, enterococci, and *E. coli*. In addition, one sample each Friday, Saturday, and Sunday of the study was taken in the storm drain (0 yards) at each study beach and analyzed for enteric viruses.

Nine to fourteen days after the interview date, subjects were interviewed by telephone to ascertain the occurrence(s) of fever, chills, eye discharge, earache, ear discharge, skin rash, infected cut, nausea, vomiting, diarrhea, diarrhea with blood, stomach pain, coughing, coughing with phlegm, nasal congestion, sore throat, and a group of symptoms indicative of highly credible gastrointestinal illness (HCGI) and significant respiratory disease (SRD). Of the 15,492 subjects interviewed on the beach, we were able to contact and interview 13,278 (86% follow-up). Of these 13,278, 1,485 were found to be ineligible because they bathed (and immersed their heads) at a study beach between the day of the beach interview and the telephone follow-up. This left 11,793 eligible subjects who provided data that were analyzed for this study. Of these, 107 were excluded because they reported not immersing their faces in the ocean water, leaving 11,686 subjects for analysis.

Analyses addressed the following two questions: 1) What are the relative risks of specific adverse health outcomes in subjects bathing at 0, 1-50, and 51-100 yards from a storm drain compared to subjects bathing at the same beach, but beyond 400 yards from a storm drain? 2) Are risks of specific outcomes (e.g. highly credible gastrointestinal illness; ear, eye and sinus infections; upper respiratory infections; skin rashes and lesions) among subjects associated with levels of the bacterial indicators (or viruses) mentioned above.

EXECUTIVE SUMMARY

A cohort study was conducted to investigate the possible adverse health effects of bathing in Santa Monica Bay and whether the risks of ill health outcomes were associated with urban runoff from storm drains. Exposures of primary interest were pathogens that produced acute illnesses (for reasons discussed in our original proposal, chronic health effects were not studied).

Three beaches with a wide range of indicator counts and high density of bathers were studied. The beaches were Santa Monica Beach (near the Ashland Avenue storm drain), Will Rogers Beach (Santa Monica Canyon Channel or storm drain) and Surfrider Beach (near Malibu Creek).

Persons who bathed and immersed their heads in the ocean water were potential subjects for this study. There were no restrictions based on age, sex, or race. Persons who had bathed at the study beaches, Mothers' Beach in Marina del Rey or near the Santa Monica Pier within seven days of the study date were excluded, as were subjects who bathed at the study beaches (or Mothers Beach or near the Santa Monica Pier) between the date of the beach interview and the telephone follow-up. Subjects who bathed on multiple days had to be excluded since one of our primary research questions was whether risk of health outcomes was associated with levels of specific indicator organisms on the day a subject entered the water. Given the range of incubation periods for the outcomes of interest and that the counts were quite variable from day to day, it would have been impossible to link subjects' experiences with specific counts on a given day if they were in the water on numerous days. Persons bathing within 100 yards upcoast or downcoast of the storm drain and persons bathing greater than 400 yards beyond a storm drain were targeted for this study.

For this study, 22,085 subjects were interviewed on the beach to ascertain eligibility and willingness to participate. Of these, 17,253 subjects were found to be eligible and able to participate (had a telephone and were able to speak English or Spanish). Of these, 15,492 agreed to participate. Eligible subjects who agreed to respectively. Diarrhea with blood RR=4.23 (1.12-15.91) and HCGI 1 RR=1.44 (1.03-2.03) were associated with enterococci, using the higher cutpoint of 106 cfu.

It is conceivable that real increases in risk might have been missed with these cutpoints, particularly since they were not based on data that were generated by previous studies of Santa Monica Bay, so we also calculated odds ratios from categorical models using quintiles (of bacterial indicator levels) and from continuous models. For the continuous linear (on logistic scale) models, the odds ratios correspond to a unit increase equal to the difference between the 90th and 10th percentiles (i.e. the difference between the midpoints of the fifth and first quintiles). In general, results from the categorical models resembled results using the cutpoints (to define dichotomies) described above. The continuous models yielded a number of positive associations. For *E. coli*, small but statistically significant associations were seen for skin rash and stomach pain. Only skin rash was associated with total coliforms. Fever, skin rash, and HCGI 1 and 2 were associated with fecal coliforms. For enterococci, significant positive associations were noted for fever, skin rash, nausea, diarrhea, stomach pain, coughing, runny nose, HCGI 1, HCGI 2, and SRD.

In addition to investigating single bacterial indicators, associations between adverse health effects and the ratio of total to fecal coliforms, and the ratio of total coliforms to enterococci were investigated. For the total to fecal ratio, we initially used a cutpoint of 5.0, assuming the risk may be higher when the ratio is smaller. For the entire data set, significant associations were observed for diarrhea RR=1.28 (1.08-1.51) and HCGI 2 RR=1.87 (1.20-2.90). We then estimated effects of this ratio restricted to subjects in water where the total coliforms exceeded 1,000 cfu. Significant effects were observed for nausea RR=1.48 (1.08-2.04), diarrhea RR=1.40 (1.07-1.85), and HCGI2 RR=3.12 (1.60-6.07). We also conducted a similar analysis restricted to subjects in water where the total coliforms exceeded 5,000 cfu. Significant effects were observed for fever, eye discharge, skin rash, nausea, diarrhea, stomach pain, nasal congestion, HCGI 1, and SRD. Risk ratios ranged from 2-7. We then conducted a similar analysis restricted to subjects in water where the total coliforms exceeded 10,000 cfu. Here we observed significant

As a measure of strength of association, we relied initially on the risk ratio (RR), which expresses the risk (proportion of subjects who report a given symptom) among subjects who bathed, for example, in front of the drain (0 yards) versus the risk among subjects who bathed 400+ yards from the drain. Comparing subjects who swam at 0 versus 400+ yards from the drain for all three beach sites combined, statistically significant increases in risk were observed for fever, where the RR=1.57 (95% C.L. = 1.17-2.10), chills RR=1.58 (1.04-2.39), ear discharge RR=2.27 (1.14-4.51), vomiting RR=1.61 (1.01-2.56), coughing with phlegm RR=1.59 (1.10-2.29), a group of symptoms we labeled highly credible gastrointestinal illness (HCGI 2) RR=2.11 (1.12-3.97), and a group of symptoms indicative of significant respiratory disease (SRD) RR=1.66 (1.25-2.21). These increases in risk were observed predominantly at the distance of 0 yards.

A second set of analyses was completed, restricted to days when the total coliforms to fecal coliforms ratio was greater than 5 for the water samples taken at 400 yards. The rationale was to exclude days when the plume from the drain or some other source of high counts apparently reached the 400 yard area, making this less than an ideal "control" zone. The relative risks for the seven outcomes cited above all increased. In addition, some significant increases in risk were observed for adverse health effects at distances of 1-50 and 51-100 yards from the drain, compared to 400+ yards from the drain.

The results for distance did not change when adjusted for age, beach, gender, race, California versus out-of-state resident, socioeconomic status, and worry about potential health hazards at the beach. Distance results also did not change substantially when controlled for each bacterial indicator.

A number of approaches to analyzing the effects of bacterial indicators were taken. We first calculated risk ratios for the lower and higher cutpoints described in the text (e.g. 200 and 400 colony forming units, or cfu, for fecal coliforms). Very few associations were observed when these cutpoints were used. None were detected for *E. coli* at lower cutpoints (35 or 70 cfu). Earache RR= 1.46(1.06-2.00) and runny nose RR=1.24(1.00-1.53) were associated with *E. coli* at the highest cutpoint of 320 cfu. Only skin rash was associated with total and fecal coliforms using the cutpoints of 10,000 and 400 cfu, indicator) of interest. For a number of outcomes, the attributable number ranged into the 100's of new cases per 10,000 exposed subjects (complete results are presented in Tables 65-70).

In summary, both sets of results (the positive associations between adverse health effects and a) distance from the drain and b) bacterial indicators and presence of enteric viruses) taken together strongly suggest that there is an increased risk of a relatively broad range of symptoms caused by swimming in ocean water at the beach sites included in this study, particularly close to the drains and when indicator densities increase or ratios between selected indicators decrease.

associations with eye discharge, ear discharge, skin rash, nausea, diarrhea, stomach pain, nasal congestion, HCGI 1, and HCGI 2. The significant RR's ranged from 2-39. All the effects noted above became consistently stronger as the analyses were increasingly restricted to occasions with higher counts of total coliforms. Since this ratio appeared to be informative, a range of cutpoints (2, 4, 6, 8) was subsequently investigated. There was a consistent pattern of stronger risk ratios as the cutpoint became lower (when the analyses were restricted to times when total coliforms exceeded 1,000 or 5000 cfu), with the strongest effects generally observed when the cutpoint of 2 was used. The consistency of the results suggests the observed associations are real.

None of the bacterial results changed when adjusted for age, beach, gender, race, California versus out-of-state resident, socioeconomic status, and worry about potential health hazards at the beach. They also did not change when we adjusted the bacterial results for distance from the drain.

The analysis of samples for enteric viruses yielded seventeen samples (taken in the storm drain) that were positive for enteric viruses. This number of positive samples did not enable us to conduct many analyses; however, we were able to compare the frequency of outcomes reported by subjects who were swimming within 50 yards of the drain on days when samples were tested for viruses and found to be negative versus days when the samples were positive for viruses. Results are presented in Table 73. Although based on small numbers, a number of outcomes were reported more often on days when the samples were positive for viruses, including fever (RR=1.53, 95% CI 0.97-2.42, p=value 0.07); vomiting (RR=1.89, 0.94-3.78), HCGI-1 (RR=1.74, 0.99-3.06) and HCGI-2 (RR=2.26, 0.91-5.60). Results remained essentially unchanged when adjusted for covariates or for each bacterial indicator. Research with gene probes is ongoing and will be presented in an addendum at a later date.

The attributable number for noteworthy distance and bacterial indicator results was also calculated. This attributable number is an estimate of the number of new cases of a specific adverse health outcome that is attributable to the exposure (distance or bacterial indicator) of interest. For a number of outcomes, the attributable number ranged into the

Beaches in Santa Monica Bay are heavily used during the summer months. It is estimated that 50-60 million persons visit Santa Monica Bay beaches annually. Concern about adverse health effects due to swimming in the bay has been raised by interested parties (SMBRP, 1995), citing numerous anecdotal reports of illnesses that were perceived to be caused by swimming in the bay. "Is it safe to swim in Santa Monica Bay?" appeared to be a prevalent concern.

These circumstances (high volume of urban runoff in storm drains, numerous days with high levels of bacterial indicators, isolation of pathogenic human enteric viruses even when water quality indicator densities were low, heavily populated beaches, and concern about adverse health effects) provided the motivation to study the possible health effects of swimming in the bay. It was decided by the Technical Committee and the Management Committee of the Santa Monica Bay Restoration Project (SMBRP) that an epidemiological study of bathers in Santa Monica Bay was the most direct and relevant means of addressing the question, "Is it safe to swim in Santa Monica Bay?" A pilot study was conducted in the summer of 1994 to assess the feasibility of a large-scale study. The protocol for the large scale study was revised as a result of this pilot study and was subsequently approved by SMBRP.

II. MATERIALS AND METHODS

Overview:

A cohort study was conducted to investigate the possible adverse health effects of bathing in Santa Monica Bay and whether the risks of ill health outcomes were associated with urban runoff from storm drains. Exposures of primary interest were pathogens that produced acute illnesses (for reasons discussed in our original proposal, chronic health effects were not studied).

Three beaches with a wide range of indicator counts and high density of bathers were studied. The beaches were Santa Monica Beach (near the Ashland Avenue storm drain), Will Rogers Beach (Santa Monica Canyon Channel or storm drain) and Surfrider Beach (near Malibu Creek). Maps indicating beach sites are included in Appendix E.

I. INTRODUCTION

At the time this study began, there had never been an epidemiologic study of persons who swam in marine waters contaminated by heavy urban runoff. Waters adjacent to the County of Los Angeles receive runoff from a system of storm drains year round. Even in the dry months of the summer, an average of 10-25 million gallons of runoff (or non-storm water discharge) per day enter Santa Monica Bay from the storm drain system (this includes, of course, substantial flows from permitted discharges beyond the control of the owner/operator at the facility). These drains are separated completely from the municipal sewage system of pipes and treatment plants; waters collected by the storm drain system are not subject to treatment and are discharged directly into the ocean at a number of sites. Years of monitoring by public agencies and recent surveys by the Santa Monica Bay Restoration Project have demonstrated that total and fecal coliforms as well as enterococci are sometimes elevated in surfzones adjacent to storm drain outlets; pathogenic human enteric viruses have been isolated from storm drain effluents, even when levels of all indicators, including F2 male-specific bacteriophage, were low (SMBRP, 1991). Sewage spills and hydraulic overload following rainstorms occur intermittently and may lead to discharge of primary-treated sewage and floatables such as tampon applicators into storm drains (NRDC, 1991); leaky sewer lines, illegal sewer connections, blocked sewer overflows, leaky septic tanks and local direct human sources (such as the transient population and illegal dumping of recreational vehicles) may also contribute human waste to storm drains emptying into the bay (SMBRP, 1990, 1992). At least 338 beach closures/advisories (many due to high bacteria levels attributable to storm drain runoff) occurred in Los Angeles and San Diego Counties in 1990 (NRDC, 1991). Water sampling at varying depths and distances from storm drains has established that a gradient of water quality (as measured by bacterial indicator densities) exists at Santa Monica Bay beaches receiving storm drain effluent (SMBRP, 1991).

Nine to fourteen days after the interview date, subjects were interviewed by telephone to ascertain the occurrence(s) of fever, chills, eye discharge, earache, ear discharge, skin rash, infected cut, nausea, vomiting, diarrhea, diarrhea with blood, stomach pain, coughing, coughing with phlegm, nasal congestion, sore throat, and a group of symptoms indicative of highly credible gastrointestinal illness (HCGI) and significant respiratory disease (SRD). Of the 15,492 subjects interviewed on the beach, we were able to contact and interview 13,278 (86% follow-up). Of these 13,278, 1,485 were found to be ineligible because they swam (and immersed their heads) at a study beach between the day of the beach interview and the telephone follow-up. This left 11,793 eligible subjects who provided data for this study. We excluded 107 of these subjects because they reported not immersing their faces in ocean water, leaving 11,686 subjects for analysis.

Analyses addressed the following two questions: 1) What are the relative risks of specific outcomes in subjects bathing at 0, 1-50, and 51-100 yards of a storm drain compared to subjects bathing at the same beach, but beyond 400 yards of a storm drain? 2) Are risks of specific outcomes (e.g. highly credible gastrointestinal illness; ear, eye and sinus infections; upper respiratory infections; skin rashes and lesions) among subjects associated with levels of the bacterial indicators (or viruses) mentioned above. Given this design of the study, we are not able to address the effects of repeated exposures or chemical contamination or special at risk populations.

A detailed description of the study follows, including sections on study preparation, data collection (beach and telephone interviews), collection of water samples, laboratory analyses of water samples, and statistical analyses of the data.

Study Preparation:

Staff Recruitment and Selection:

The project coordinating team of the Santa Monica Bay Beach Study consisted of a multi-ethnic group of researchers with extensive experience in the design and conduct of epidemiologic studies. Included in this team were the study's principal investigator, the principal project coordinator, the study physician, and several professionals with

Persons who bathed and immersed their heads in the ocean water were potential subjects for this study. There were no restrictions based on age, sex, or race. Persons who bathed at the study beaches, Mothers' Beach in Marina del Rey or near the Santa Monica Pier within seven days of the study date were excluded, as were subjects who bathed at the study beaches (or Mothers Beach or near Santa Monica Pier) between the date of the beach interview and the telephone follow-up. Subjects who swam on multiple days had to be excluded since one of our primary research questions was whether risk of health outcomes was associated with levels of specific indicator organisms on the day a subject entered the water. Given the range of incubation periods for the outcomes of interest and that the counts were quite variable from day to day, it would have been impossible to link subjects' experiences with specific counts on a given day if they were in the water on numerous days. Persons bathing within 100 yards upcoast or downcoast of the storm drain and persons bathing greater than 400 yards beyond a storm drain were targeted for this study.

For this study, 22,085 subjects were interviewed on the beach to ascertain eligibility and willingness to participate. Of these, 17,253 subjects were found to be eligible and able to participate (had a telephone and were able to speak English or Spanish). Of these, 15,492 agreed to participate. Eligible subjects who agreed to participate were then interviewed about basic demographic data and about their bathing, including type of bathing activity (particularly immersion of the head into ocean water). Distance from the storm drain, gender, age, and race of the subject were noted by the interviewer.

On the same days that subjects were recruited, morning water samples were collected at ankle depth at 0, 100 yards north and south of the storm drain, and 400 yards north or south (depending on which area was used as a "control" area). Samples were analyzed for total and fecal coliforms, enterococci, and *E. coli*. In addition, one sample each Friday, Saturday, and Sunday of the study was taken in the storm drain (0 yards) at each study beach and analyzed for enteric viruses.

interview. Interviewing instructions contained in the original version of the beach questionnaire were eliminated after a few days of field-testing, streamlining it from two sheets (3-sides) to one double-sided sheet that could be folded up while remaining attached to a clipboard. Interviewers were able to write down respondents' phone numbers and useful comments on the flip side of the beach questionnaire (field sheet) without worrying about it being lifted and carried away by a sudden gust of wind.

The telephone questionnaire was finalized after consultation with the study physician, the Chief of Infectious Disease at Olive View/UCLA Medical Center, and the California State Department of Health Services. Previous studies have suggested that acute infectious diseases including gastroenteritis, ear and respiratory infections, conjunctivitis, and skin rashes can be transmitted through polluted salt or brackish water. Therefore, sixteen questions representative of easily recognizable symptoms of these illnesses were asked during the telephone interview. The instrument was designed with space available for comments. In addition, the questionnaire contained sections for recording demographic information obtainable from the field sheet or the telephone interview. At the end of the telephone interview, respondents were queried about their levels of concern regarding health hazards at the beach. Interviewers used probing techniques to elicit better information whenever respondents experienced difficulty in answering questions clearly. Questions concerning types and durations of water activities were not included because participants in our pilot study found them annoying and too difficult to answer.

The symptoms and corresponding probes are listed below:

1. **Fever** - defined as a temperature equal to or greater than 100° F or 38° C. If the temperature was not taken, a subjective answer was considered positive if the respondent either volunteered or answered positive to the probes of feeling warm, achy and/or having chills.
2. **Chills** - substantiated by probing for uncontrollable shaking. Not considered "yes" when fever was "no."

diverse research backgrounds and practical expertise in data collection, management and analysis.

Other staff were recruited from several sources (mainly UCLA and Santa Monica City College) by fliers and adds in the UCLA newspaper. Ideal candidates were those who could be trained to interview both at the beach and on the telephone. First, a project coordinator screened each applicant for experience and telephone demeanor, then explained the job requirements. Next, applicants were interviewed by three to four project coordinators. Staff members who had worked on the pilot study two years earlier were contacted and offered positions as experienced interviewers and/or mid-level supervisors.

The mid-level supervisory and interviewing/office staffs were comprised of individuals representing various ethnicities and educational backgrounds. Twenty-four interviewers were undergraduate students, 17 were college graduates and 9 had worked toward or achieved graduate degrees. Thirteen telephone and beach interviewers were bilingual in English and Spanish and several students, although not completely bilingual, could manage the beach interview in Spanish. Other interviewers' language skills allowed for the conduct of interviews in Japanese, French and German. Fifty staff members worked the majority of the summer -- 24 mainly full-time, 26 part-time.

Questionnaire Development:

The beach questionnaire and the follow-up telephone questionnaire were developed by the project coordinating team during a series of meetings. The beach questionnaire was photocopied on colored paper in order to distinguish among the three beaches (Santa Monica/Ashland: yellow; Surfrider/Malibu:pink; Will Rogers/Santa Monica Canyon Channel: blue). The telephone questionnaire was formatted to be scanned by an optical mark reader. Both questionnaires were fully translated into Spanish, with special attention paid to the diversity of Latino/a subgroups living around and within the Los Angeles area. Appendix A contains a copy of each questionnaire.

The coordinating team designed the beach questionnaire to serve as an instrument on which to record subjects' names, telephone numbers and swimming locations, plus as an aid in determining subject eligibility and accessibility for the follow-up telephone

Orientation and Training:

All office and interviewing personnel were introduced to general interviewing techniques, the study background and protocol, and participated in role-playing exercises during an 8-hour orientation and training session. Pertinent information and materials were provided in a "Santa Monica Bay Beach Study Training Manual" (See Appendix D). During the following week, the supervisory staff underwent a day of practice training on the beach, and then worked during the following four days one-on-one practice training with the rest of the beach interviewers. At the beginning of data collection staff meetings were held each day to discuss experiences on the beach and to address questions and problems. Emphasis was placed on ways to observe and approach potential subjects and strategies were standardized for handling answers to their questions. As a result of these early meetings, the field sheet was streamlined and the method of assigning interviewers to designated areas on the beach was developed.

New beach interviewers who joined the project after the onset of the study first trained in the office with experienced interview supervisors, and then were taken to the beaches and allowed to practice the interview by interacting with beach patrons in non-study areas. This protocol was used for training beach interviewers throughout the summer.

A separate 8-hour training session was later held for telephone interviewers in which telephone interviewing techniques and the telephone questionnaire were emphasized. Interviewers were instructed on the use of standardized probes to clarify symptom events and to document answers to probes as well as comments voluntarily offered by subjects.

Telephone interviewers continued their training by conducting interviews under the direction and observation of a trained supervisor. These interviewers and their supervisors became adept at handling numerous scenarios by sharing experiences during the first few days of telephone interviews. Phone supervisors provided suggestions to beach interviewers about the types of comments on the field sheet (i.e., respondent's demeanor, swimming behavior, etc.) most useful in expediting the phone interview. The

3. **Redness and discharge from eyes** - used to evaluate the diagnosis of conjunctivitis. Both redness and discharge were documented because BOTH had to be positive for a "yes" answer. Standard probes to "don't know" responses were "Did you have pink eye?...Did you have yellow discharge?" This was done to exclude irritation from salt water, smog and other sources.
4. **Earache** - To substantiate a positive response, the respondent was also asked if he/she had an ear infection.
5. **Discharge/draining from ear** - used to assess swimmer's ear.
6. **Skin rash** - The respondent was asked the location of the rash. Only rashes covering the body (as opposed to small patches, for example, on the foot or arm) were marked positive on the questionnaire. This was done to increase the chances that the observed rash was a generalized viral exanthem or contact rash that was more likely to be caused by immersion in polluted ocean water.
7. **Cuts or scrapes that became infected** - several probes were used to delineate a positive answer including more redness, swelling, pus and red streaks around the cut.
8. **Nausea** (not related to pregnancy) - The two probes that were used were, "Did you feel like throwing up?" or "...feel so sick that you couldn't eat?".
9. **Vomiting** - self-explanatory.
10. **Diarrhea** - self-explanatory.
11. **Diarrhea with blood** - would narrow condition down to certain diseases that present with this symptom, like Shigellosis or *E. coli* 0157.
12. **Stomach pain or cramps** - menstrual cramps were excluded. Interviewers were instructed to circle which symptom was experienced if not both.
13. **Coughing** - a probe for allergies and smoking was used.
14. **Coughing with phlegm** - self-explanatory.
15. **Nasal congestion/runny nose** - allergies/smoking probe used.
16. **Sore throat** - interviewers probed by asking if one had trouble with swallowing or eating (e.g, "Was it difficult to swallow food?").

water. Appendix B contains pamphlets and forms used on the beach. (The field sheet is in Appendix A.)

The number of staff members required at the beach sites ranged from 3 to 12 depending on the expected size of the crowd that day. Anticipating the crowd size depended primarily on weather prediction, and the number of interviews collected from a particular day of the week during previous weeks. For example, unless unusual weather was predicted, Sundays and holidays were consistently the days with the largest crowds at all three beach sites. Generally numbers increased at all the sites as the week progressed from Monday to Friday. Sometimes, uncertainty in the weather resulted in office staff being sent to the beach when beach crowds were unexpectedly large.

The average work day at the beach usually began around 11:00 A.M. Monday through Thursday; 10:00 - 10:30 A.M. Friday through Sunday. Beach interviewers could be easily identified by blue T-shirts bearing the "Santa Monica Bay Beach Study" logo. Upon arrival, the first item of business for the beach supervisor was to measure the areas within 50 and 100 yards on both sides of the selected storm drain. This was usually done by pacing off steps and was done daily because the outlets shifted for two of the three storm drains. The storm drain at Ashland was fixed (concrete), whereas those at Will Rogers and Malibu were often dredged by bulldozers or temporarily maintained by dry weather flows. They were occasionally reforming, straying, multiplying or disappearing.

The area boundaries (at 50, 100, and 400 yards) were marked with visible objects such as trash cans or beach umbrellas, although these markers were not used when the area happened to be bordered by a life guard station. In either case, survey areas could be easily delineated without arousing suspicion by beachgoers as to why these areas were important to the study.

Beach interviewers were responsible for determining and recording the locations of eligible participants. On the field sheet (see Appendix A) the storm drain was designated as point **0** (as indicated by the diagram on the next page, subjects did not have to be in the middle of the drain to be coded as point 0; they had to be in the water within a range of distance (usually a matter of 2-20 yards) where the flow from the drain entered methods for training telephone interviewers were maintained throughout the summer as new staff members were enlisted.

Data Collection:

Personnel Structure:

The scope of data collection and management required the availability of workers seven days a week from 9 A.M. to 9:30 or 10 P.M. Each task accomplished at the beach and at the study office was managed by a mid-level supervisor. The study employed three telephone room supervisors and seven beach supervisors. Although specialists were developed for each task, the success of the study depended on staff flexibility. In essence, each full-time staff member had a main job (e.g. beach interviewer) and an alternative job (e.g. data editor or telephone interviewer.) Most workers were skilled in multiple tasks and clerical tasks were shared. Staff members generally settled into the roles where they felt most comfortable, resulting in maximum productivity.

Project coordinators organized and supervised mid-level supervisory personnel and at times assumed some of their responsibilities. Beach and telephone supervisors, along with at least two project coordinators, attended weekly meetings during which schedules were planned and employee performances were discussed. Supervisors staggered beach interviewers' schedules to insure adequate crews on the beach during the afternoons when beaches tended to be busier. Basically, flexibility was encouraged so that beach interviewers, phoners and data editors could switch tasks depending on weather conditions and beach attendance on a particular day.

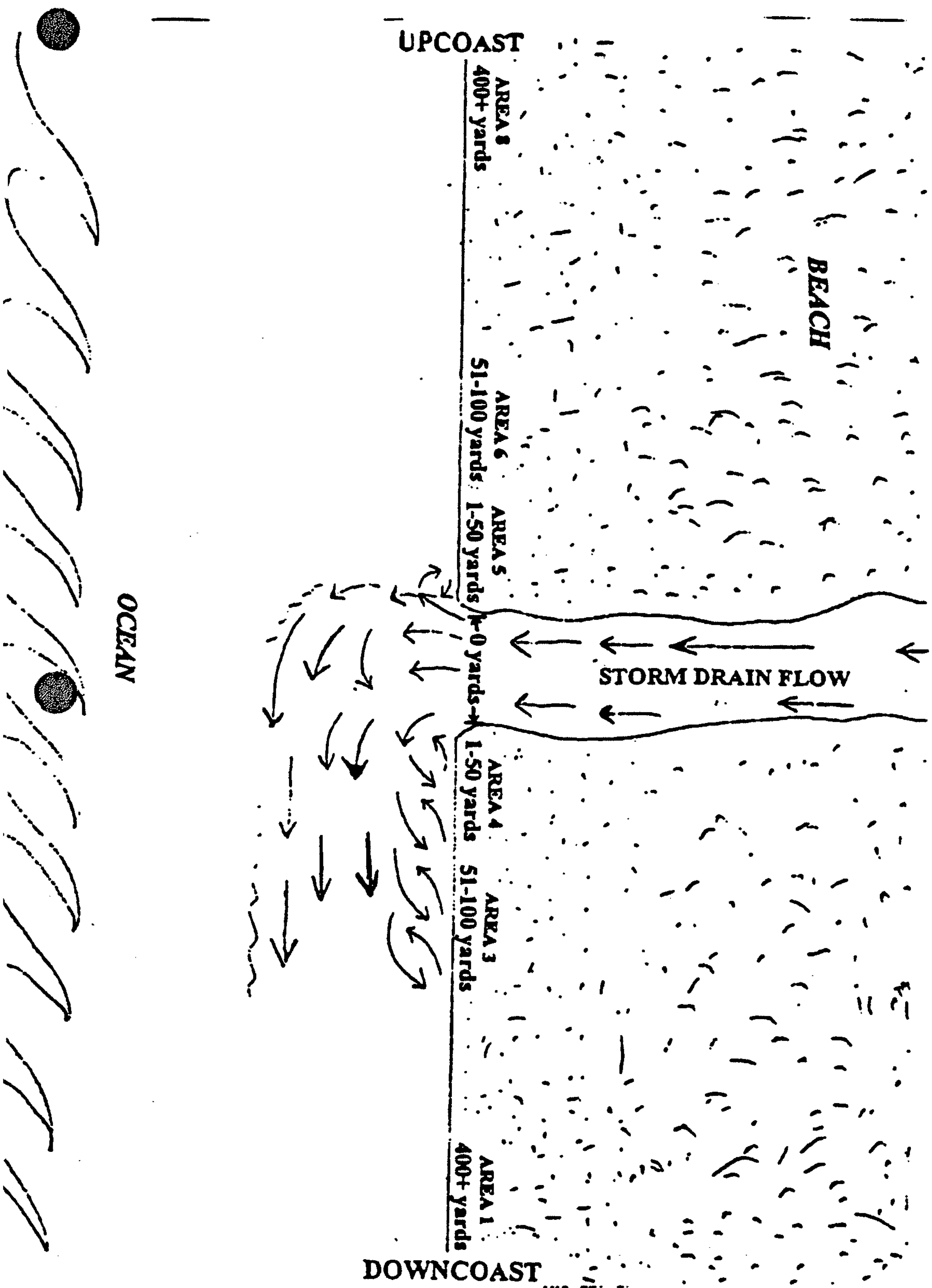
Beach Interviews:

Staff assigned to recruit subjects at the beach sites gathered each morning one half hour before leaving the office in carpools. The selected supervisor of each beach site was responsible for insuring that the crew assigned to her/his beach was transported and had the appropriate supplies. Supplies included pencils and clipboards, field sheets, forms on which to tally non-participants and ineligibles, forms on which to tally completed interviews and monitor interviewers, information pamphlets in English and Spanish, gifts for respondents (frisbees, visors and buckets), umbrellas, beach towels, ice chests, and the bay); the two zones spanning up to 50 yards on either side of point **0** were designated **4** and **5**; zones **3** and **6** spanned from 50 to 100 yards in either direction; and zones **1** (downcoast) and **8** (upcoast) were 400 yards and beyond in either direction. All zones except for **1** and **8,** i.e., up to 100 yards on either side of the storm drain, were considered exposure zones and were referred to as **Study Area 1**. Zones **1** and **8,** i.e., 400 yards and beyond, were considered control zones and were referred to as **Study Area 2**. Mostly zones 1 and 8 served as Study Area 2 at Malibu and Ashland beaches, respectively. The sampling strategy required that one subject be recruited from Study Area 2 for every 3 subjects in Study Area 1. It was extremely rare that a subject either swam across zones or entered the water in different zones. When this occurred, the subject was coded in the zone closest to the drain.

Generally one or more interviewers covered each zone, but this depended on the number of interviewers working that day and on the number of beachgoers occupying each zone. Bilingual interviewers were often placed strategically, either in heavily populated areas, one on each side of the drain, or were encouraged to traverse zones -- often being called out of assigned zones to assist in an interview. Covering small areas of the beach insured that surveyors could recognize those in their area who were newly arrived, those who had already been approached, and those who did not need to be approached since they had not immersed their heads in the water. Having individuals responsible for small areas provided the best opportunity for contacting every eligible participant. This system also insured that beachgoers were not disturbed by repeated approaches about the survey.

On a typical weekday during the earliest phase of the study, the majority of time was spent recruiting participants from Study Area 1 (exposure). Recruitment from Study Area 2 (control) was usually left until later in the day when the beach crew had an idea of the number of people needed from that area. For instance, if by 2:00 p.m. 30 interviews had been completed in Study Area 1, the supervisor would send a team to Study Area 2 until the necessary number of interviews was accumulated, say 10 or more. As the study progressed, the supervisors became more familiar with the beaches and knew how to

DIAGRAM ILLUSTRATING ZONES



Participants were told that someone from the beach study office would phone them in 9 days and asked the number and time of day at which they could most easily be contacted. All respondents received an information pamphlet that described the study, provided the study office telephone number, and served as a reminder of the follow-up telephone interview. This pamphlet was printed in English as well as Spanish. Participants were encouraged to call the study office to be interviewed if they happened to be inaccessible on the scheduled phone interview date. Information about all members of a particular household was recorded on the same field sheet.

Unsuccessful interviews were tallied on a "Log of Non-Participants" sheet by race, gender and reason for non-participation (Appendix B). Only individuals who could be approached directly were tallied, as it was not feasible to determine the identity and number of accompanying children under 12.

Most essential to data quality was the careful observation of the bathing/swimming behaviors of the respondents approached for interview. Different techniques were used to approach potential subjects. Sometimes an interviewer waited until a group came back from the water to their towels, let them rest for a few minutes, and then approached. An alternative approach involved waiting until several unassociated groups had gone in and come out of the water. The interviewer then made "rounds" of 4-8 groups at a time. Many of the written parts of the interview were completed later at the encampment where beach interviewers were situated.

Since the beach contact laid the groundwork for the follow-up telephone interview, the interviewers spent as much time as each individual or family needed to establish rapport and convey a sense of professional interest in their swimming behavior. A level of trust had to be established in order to obtain phone numbers. In the early stages of the study, telephone interviewers were faced with a significant percentage of calling attempts resulting in wrong telephone numbers. Some of these were undoubtedly due to people's reluctance to give out their correct numbers. However, the percentage of wrong numbers decreased considerably when it became policy for beach recruiters to repeat the number aloud and verify it as written with the person being interviewed.

dispatch interviewers to Study Area 2 earlier in the day. On crowded days, such as weekends, interviewers were automatically assigned to Study Area 2 for the entire day, and supervisors provided them with regular notice as to the numbers needed from their area. Similarly, interviewers provided supervisors with regular reports on the quantity of their interviews.

Interviewers approached every potentially eligible beach visitor in their assigned zones. During the first few weeks of data collection, eligibility for adults and children was determined differently. Adults were eligible only if their heads or faces had been submerged in the ocean water (subjects with only incidental wetting of their faces, e.g. from splashing, were not recruited). Early on, children 12 years and younger were eligible if they had had any contact with the water, preferably hands and face (we assumed a lower standard of sanitary practices might place them at risk of exposure); however, once it seemed as though the projected sample size would easily be achieved, project coordinators decided to have children recruited under the same criteria as adults. Members of the same family were allowed to be subjects in this study because a) we judged that it would have been very difficult to identify and recruit only one member per family and b) it would have been impossible to achieve our sample size since we had to approach every potentially eligible subject throughout the study period to achieve our sample size.

A single adult or any adult member of a family could serve as the source of information on him-/herself or other family members. That adult was also often the source of information on children who were not part of the family but had come to the beach under his/her supervision. Children 12 years or older could be questioned directly if the interviewer had obtained consent from an accompanying adult. Teenagers who were not accompanied by adults were recruited and told to inform their parents about the follow-up telephone interview. Finally, in theory, a person could have been recruited into the study more than once, if they met the eligibility criteria each time. In reality, only a handful (perhaps 5) of subjects participated in the study twice.

temporarily affected by algal blooms that made swimming unpleasant. One of the study zones at Ashland within Study Area 2 is approximately 250 yards from the Pico-Kenter storm drain -- a drain with a history of high indicator counts, usually diverted during previous summers.

Telephone Interviews:

The majority of telephone interviews were conducted from the beach study office, although occasionally an interviewer called from home if an interview could not be completed during regular office hours. Interviewers were scheduled to begin calling at 8 A.M. and interviewing generally continued until 9 or 10 P.M. Study participants were telephoned 9 to 14 days after their interviews at the beach. Interviews were conducted in English and Spanish.

In order to conduct telephone interviews, callers needed the field sheet in hand so that they could review the household size, names and ages of potential study eligibles, and read useful comments regarding eligibility and approachability. For this reason, a "calling queue" system was established in which field sheets were organized by scheduled call date, preferred call time (i.e., morning, afternoon, evening), and whether or not they were Spanish-only or out-of-area calls. Often phone numbers had to be obtained for participants that were interviewed as part of a group at the beach but lived in a different household.

Usually the contact person for the telephone interview was the respondent who had provided information at the beach interview; however, other options were utilized. A spouse could answer questions about the other's health when knowledgeable and comfortable with the idea; otherwise, the interview was conducted with each spouse separately. Interviewers were instructed not to allow participants existing in non-marital relationships to answer for partners, since they were considered more likely to be in a "honeymoon" phase wherein confidences about health problems might not be shared.

Adults were generally required to answer for children under 12, but could do so for any of their children if preferred. Often interviews were conducted with the parent asking the child questions. A divorced or separated parent could respond for a child only

Interviewers carrying toys experienced enhanced success upon approaching households with children. In such cases, it was advantageous to have two interviewers approach the group, one with toys and the other with paperwork. The interviewer with the toys was able to keep the children occupied, relieving the parent's concern or need to watch them while participating in the interview, probably offsetting a fair number of refusals. An example of a typical beach interview is included in Appendix C.

Beach interviewers usually left the beach to return to the study office around 4:30 P.M. on weekdays and 5:30 P.M. on weekends. Supervisors collected the field sheets and non-participation log sheets, edited them for accuracy and completeness, and tallied the day's interviews on the "Beach Interview: Daily Tally Sheet" (Appendix B). One of the office staff was responsible for reviewing the field sheets on a daily basis and contacting beach interviewers, if necessary, to obtain missing information.

Several conditions at the study beaches resulted in logistical dilemmas for the survey. At study onset, the creek outlet at Malibu was close to the pier and most of the interviews were conducted on its south side where the people were swimming. In addition, no-flow days were common, i.e., there was no visible outlet from the creek to the ocean. Moreover, lifeguards often placed flags designating surfing-only areas such that Study Area 1 was off-limits to families and swimmers. When strictly enforced, swimmers were made to leave the area before they became eligible for the study. It was also not uncommon for lifeguards to approach people playing directly in the area of the storm drain and tell them to move to a "safer" area before they could become eligible to be interviewed. This happened at Ashland and Will Rogers as well.

Malibu's creek outlet was eventually moved upcoast for the summer in order to create greater accessibility to the more popular beach area during peak season. The noise and fumes emitted by bulldozers disrupted several days of interviewing, especially since it took several park service outings to get the outlet to stay upcoast. The outlet at Will Rogers beach also shifted positions so that it was subjected to bulldozings in order to create more usable beach. When the outlet was dredged, parts of the beach, especially within Study Area 1, were not available to beachgoers. Ashland and Will Rogers were following the beach interview (the first calling day), the field sheets were placed in a "call-back" compartment to receive priority attention during the next 5 days. All "call-backs" were attempted at least 3 times a day. Generally, interviews were completed within the 9- to 14-day window period, but there were exceptions. For a few days beyond the 5th calling day, field sheets were kept in a compartment for special priority calls. If these participants were accessed after the 5th day, interviewers made sure that the reported symptoms had occurred within the study window period. Families with small children were not called after 9 P.M., while the success rate among young singles was enhanced when calling hours were extended to 10 P.M. on some nights. At least one bilingual (English/Spanish) interviewer telephoned from the study office. Unattainable phone interviews were tracked on the "Log of Weekly Loss-To-Follow-Up" sheet (Appendix B).

The interviewing staff became very skilled at developing immediate rapport with the respondents over the phone. The interview proceeded smoothly once the interviewer introduced her/himself, the purpose for the call, and established eligibility. The telephone questionnaire was relatively easy to administer, as there were no open-ended questions. Interviewers sometimes linked questions about symptoms that regularly occur together, improving the flow of the interview without de-emphasizing the importance of each symptom. Information regarding swimming location was generally bubbled after the interview was completed, and interviewers were always blinded as to any preliminary analyses relating locations to health outcomes. The average interview took about 3 minutes per respondent. Appendix C contains a typical example.

When attempted calls were answered by an answering machine or someone other than a designated contact person or eligible participant, the interviewer left a message asking that the contact person return the call by phoning the study office and asking to speak to "Toni" -- a unisex name which none of the interviewers normally used. Afterwards, the corresponding field sheet was placed in the appropriate "Toni" folder according to beach, so as to be easily retrievable upon call-back. In this way, anyone answering the telephone could interview a caller asking for "Toni", having been trained if he/she was the custodian since the beach interview. With older children, interviews were facilitated once the interviewer had introduced her/himself and the study to a parent or guardian. Only rarely, when a language difficulty was otherwise unresolvable, would a capable child be allowed to interpret for an adult or another child. Nannies or babysitters who were daily care-givers could answer for charges.

Beach participants were eligible to respond to the follow-up telephone interview if they had not been back in the water at any of the 3 study beaches or at Mothers' Beach in Marina del Rey and the area around Santa Monica Pier since the day of the beach interview (subjects in the water at Mother's Beach or around the Santa Monica Pier were excluded because these areas are associated with high bacterial counts and swimming there may have caused symptoms such as the ones under investigation in this study). Very few subjects visited beaches other than the study beaches. Ineligible participants were tallied on a "Log of Weekly Loss-To-Follow-Up" sheet (Appendix B) according to ethnicity, age group (younger than 12, 12 and older), gender and map code. The telephone interviewer also verified that the participant had gotten her/his face wet in ocean water on the beach interview day. If both these criteria were met, the participant was deemed study eligible. A telephone interview form was dedicated to each participant who was then assigned a unique identifier.

The identifier consisted of a letter corresponding to the visited beach, a number designating the household, and a letter specific to a participating household member. Telephone interview forms were preprinted with sequential household identifying numbers and grids premarked with those numbers. At the time of the phone interview, an interviewer reviewed the field sheet to determine the number of forms required. The interviewer bubbled (i.e. darkened in pencil the circle indicating the correct data item) in the beach letter, the household number, and the participant letter in the provided section on the telephone interview form. The same identifier(s) was recorded on the field sheet.

The first attempt at calling the contact person was determined by the preferred time indicated on the field sheet. Respondents who said they could be called "anytime" were first called in the morning. If calling attempts were unsuccessful on the 9th day to the beach visit, the interviewer asked for a description of how often the symptom was experienced. This was done to decide whether the symptom was associated with an ongoing condition such as an allergy or smoker's cough, etc. In the majority of cases, if the symptom was already present at the time of the beach visit, it was not considered an event. A "don't know" (DK) was also not considered an event.

Phone interviewers were encouraged to write comments on the questionnaire form. Comments volunteered by the respondent were written on the left side of the page to differentiate them from answers to standard probes that were written on the right side. These comments were used in symptom ascertainment, especially when the respondent reported having had the symptom prior to the beach visit. The study physician reviewed these comments, and if the information was unclear, would question the interviewer for a better understanding. Sometimes, the study physician would re-phone the respondent to clarify the response. There were a few rare cases where an existent symptom worsened so dramatically after the beach visit that it was considered an event. In these cases, the study physician darkened the extra bubble associated with each symptom on the far right of the questionnaire form.

Data Editing:

Each completed telephone questionnaire underwent at least four reviews before it was scanned. Interviewers reviewed each questionnaire upon completion, although on busy telephoning shifts this step might have been bypassed. Telephone supervisors reviewed each interview and addressed any immediately apparent inconsistencies or omissions prior to the form's subsequent examination by a project coordinator. The study physician verified all ambiguous symptom events. Finally the forms were subjected to the final edit step.

In the final edit step, one staff person reviewed the field sheet while another reviewed the accompanying telephone form(s). The editor with the telephone form read aloud all the information which appeared on the top, i.e., identifier, beach and phone dates, interviewer numbers, age category, gender, map code, and whether or not respondent had gotten his/her face wet. The editor with the field sheet would check this in advance to recognize a "Toni call." On average, 10 to 15 interviews were conducted in this fashion on a daily basis.

Interviewers kept track of their calls on the "Telephone Tally Sheet" (Appendix B), an instrument designed to keep account of the telephone activity of each work shift, i.e., 9 A.M. - 3 P.M.; 3 P.M. - 9:30 P.M. Calls were tallied within the following categories: completed interview, answering machine, "Toni call", busy signal, later appointment, no answer, disconnected, and wrong number. Also tallied were the number of households and individuals, and the number of attempts to complete these interviews. These tally sheets were helpful in allocating staff to the most productive hours.

The close supervision of telephone interviews allowed for optimum quality control. Telephone interviews were always monitored by a supervisor to insure that probes were used uniformly and answers to respondents' questions were addressed in an accurate and unbiased manner. Supervisors reviewed each questionnaire for content soon after the interview took place so that interviewers were directed as to how to unravel inconsistencies and recall or obtain missing information, even calling the respondent back if necessary. There were occasions when supervisors made these calls in order to validate information. All interviews were also reviewed by a project coordinator within 24 hours after completion.

Office Operations (Other Than Telephoning):

Symptom Evaluation:

For our purposes, determining that a participant experienced a specific health outcome depended on the self-report of having one or more representative symptoms. Each of the 16 symptoms listed in the phone questionnaire was associated with 3 possible questions. For each symptom, the first question was asked, "Did you or your child have (symptom) at any time since your visit to the beach?" When the response was negative, the interviewer moved on to the next symptom. If the response was positive, the interviewer continued by asking, "Was this a problem you had before going to the beach?" If the answer was "no", this was considered a symptom event, and the interviewer moved on. However, if the respondent reported having had the symptom prior

A similar method was used for the detection and correction of logical errors, for example, inadherence to skip patterns. Records containing logical errors were listed and corrections were entered into a computer file that was merged with the original data set.

Other aspects of data management involved the creation of new variables like symptom groups, and the merging of bacterial indicator counts and household income estimates with the questionnaire data. Bi-weekly progress reports describing the numbers of completed interviews as well as respondent characteristic were generated using Excel 5.0. Excel was also used to enter and report daily beach interviews, daily non-participation and weekly loss-to-follow-up counts.

Collection of Water Samples

Samples were collected daily from mid-June to September at three locations; Santa Monica Beach near the Ashland Avenue storm drain (Ashland), Will Rogers Beach near the Santa Monica Canyon storm drain (Will Rogers), and Surfrider Beach near Malibu Creek (Malibu). Four samples were taken at each location. Three of the sampling points at each location (0 yards, 100 yards upcoast and downcoast of the storm drain flows) represented a grid presumably covering the most elevated indicator bacteria counts in the surf-zone. The fourth sample (400 yards upcoast or downcoast) represented a control site that was presumably unaffected by high indicator densities from storm drain flows. For quality assurance purposes, one duplicate per beach site was collected on each sampling day. Discharge flow rates at the time of sampling were not made.

All samples were collected at ankle depth with sampling poles and one liter, high-density, sterile polypropylene bottles. Samples were taken at ankle depth because 1) all shoreline monitoring is done with ankle depth samples; 2) children were presumed to be at higher risk and are exposed mostly to water at ankle depth; 3) previous studies (SMBRP, 1990) demonstrated that bacterial densities at chest depth were at least an order of magnitude lower than ankle depth samples; 4) additional samples would increase the costs and demands on the lab to unacceptable levels. The samples were collected from the incoming surf as the surf foam reached the sample bottle at the height of the sampler's ankle. The sample bottles were immediately sealed and placed on ice. All samples were vocalized information against that on the field sheet. Any necessary corrections were made on the telephone form and the entire telephone form was inspected for dark and thorough marking (bubbling.) Unresolvable inconsistencies were referred to the telephone interviewer and corrected. Once edited in this manner, the telephone forms were set into a pile separate from the field sheets, ready for scanning. The field sheets were stamped "Completed", initialed by the editor, and filed in sequential identifier order for later reunification with the telephone form.

Data Management:

The telephone interview forms were scanned on a NCS OPSCAN 5 optical mark reader. Edit checks were conducted to locate and correct miscoded identifiers, inappropriately missing responses to variables, and logical response errors. In most cases, missing data were the result of the scanner having failed to pick up marked responses.

Miscoded identifiers and missing data for selected variables, i.e., beach and phone interview dates, gender, age, interviewer numbers, and map code, were initially manually edited in the data set if the information was written on the form but not coded or lightly bubbled. At this point, the forms were reunited with the field sheets and filed.

Most data management tasks were performed using Dbase IV. The data manager printed a list of identifiers and values from the telephone forms that could be verified with the field sheets. This list was used as a final check for data consistency between the two interview forms. Corrections were made to the telephone forms along with brief notations describing the corrections, and photocopies of the forms were given to the data manager to perform manual edits.

The data manager next produced a hard-copy list and computer file on which to enter the remaining missing responses. Office staff examined the field sheet and telephone interview and either entered the correct responses or confirmed the nonexistence of data. The missing data were entered into the computer file and merged with the original data set.

(52 grams per 1 liter, with the addition of 10 mL of 1% of Bacto rosolic acid in 0.2N NaOH) was used for fecal coliforms. Difco mE Agar (7.12 grams per 100 mL with the addition of 0.024 grams nalidixic acid and 1.5 mL of 1% triphenyl tetrazolium chloride) was used for the initial isolation of enterococci. BBL Esculin Iron Agar (16.5 grams per 1 liter) was used for the substrate test for enterococci. Each batch of agar media was tested for pH and sterility. Positive and negative control cultures were also inoculated onto representative portions of the prepared plates. Only media that passed all QA checks were used.

E. coli was analyzed using Hach m-ColiBlue24 Broth, which is commercially prepared and packaged in PourRite ampules. The ampules were refrigerated until the day of use when the tops were broken and the liquid broth aseptically poured onto a sterile absorbent pad in a sterile 47mm petri dish with a tight-fitting lid. All ampules were used before their expiration dates.

Sterile phosphate buffered water was used as the diluent for all dilutions and also as a rinse water during membrane filtration. The phosphate buffer was made according to Standard Methods for the Examination of Water and Wastewater (American Public Health Association, 1992) Section 9050C1. The buffer was prepared with 1.25 mL stock phosphate buffer solution (34 grams potassium dihydrogen phosphate in 1 liter deionized water) and 5 mL stock magnesium chloride solution (81.1 grams magnesium chloride per 1 liter deionized water) per 1 liter deionized water. Buffer was dispensed into either 1 liter screw-capped flasks (for rinse water) or into screw-capped test tubes (9 mL per tube) for dilution blanks. The buffer was autoclaved, cooled, and then tested for pH and sterility. Buffer was stored at room temperature until used. The holding time for the prepared buffer was three months.

Membrane Filtration Procedure

Water samples were analyzed by the membrane filtration procedure according to Standard Methods. Total coliform densities by membrane filtration were determined as recommended in Standard Methods Section 9222B and fecal coliform densities were determined according to Section 9222D. Enterococci densities were analyzed according collected between 8:00 A.M. and 11:00 A.M. in the following order; Malibu, Will Rogers, and Ashland. After all samples were collected, they were transferred to the Los Angeles Bureau of Sanitation's Environmental Monitoring Division's microbiology laboratory at the Hyperion Treatment Plant by noon for analysis. Samples were taken in the morning because a) it was not feasible to collect samples later in the day and have them analyzed given the daily schedule in the lab and b) it was not advisable to have staff obviously collecting water samples at specific locations relative to the drain at the same time subjects were being interviewed on the beach.

Laboratory Determination of Bacterial Indicators (Total and Fecal Coliforms, *E. coli*, Enterococcus)

All laboratory work was conducted by the City of Los Angeles, Environmental Monitoring Division, Biology Section - Microbiology Unit.

Samples

All samples were collected using clean, sterile 1 liter polypropylene sample bottles, leaving ample air space in the bottle to facilitate mixing by shaking. After collection, samples were transported to the lab in an iced cooler to maintain sample temperature below 10°C. Samples were received within six hours of sample collection and analyses started within two hours of arrival to the lab.

Media

Agar used for the culturing of the indicator bacteria total coliforms, fecal coliforms, and enterococci were prepared according to the manufacturers' directions using a New Brunswick Scientific Co., Inc. AgarMatic benchtop sterilizer. Each agar was cooled to approximately 45°C and aseptically dispensed via a pump and sterile tubing into sterile, disposable 60mm petri dishes for total coliforms and enterococci. Agar for fecal coliforms was dispensed into 47mm sterile petri dishes with tight-fitting lids. Prepared plates were placed in covered containers and refrigerated until used. The maximum holding time for the prepared plates was two weeks.

Difco mEndo Agar LES (51 grams of dehydrated media to 1 liter of deionized water containing 20 mL of 95% ethanol) was used for total coliforms. Difco mFC Agar

10. The walls of the funnel are rinsed down three times with approximately 30 mL of sterile, buffered rinse water. When the rinse water has drained through, the vacuum is turned off.

11. The funnel is lifted off and the filter is aseptically removed using a sterile forceps. The filter is aseptically placed, using a rolling motion, grid side up onto the surface of the appropriately labeled petri dish containing agar or a broth-saturated pad. Care is taken to avoid trapping air between the agar or pad surface and the filter.

12. Steps 6-11 are repeated for each sample volume or dilution required for the sample. The smallest sample volume is filtered first, followed by increasing sample volumes.

13. If dilutions are required, 1:10 serial dilutions are made, using sterile 9 mL dilution blanks and 1 mL of sample. The most dilute sample aliquot is filtered first, followed by increasing sample concentration dilutions.

14. When all the sample volumes or dilutions have been filtered for the sample, the plates are placed into the appropriate incubators.

    a. Total coliform mEndo LES agar plates are incubated for 24 ± 2 hours at 35.0 ± 0.5°C.

    b. Fecal coliform mFC agar plates are incubated for 24 ± 2 hours at 44.5 ± 0.2°C. These plates are incubated within 20 minutes of filtration to ensure heat-shock of the non-fecal bacteria. The plates are placed in either dry heat-sink incubators or sealed in water-proof bags and placed in a 44.5 ± 0.2°C water bath.

    c. Enterococcus mE agar plates are incubated for 48 ± 2 hours at 41.0 ± 0.5°C.

    d. *E. coli* broth plates are incubated for 24 ± 4 hours at 35.0 ± 0.5°C.

15. All sample collection, filtering, and incubation times are recorded in the sample log book.

B. Colony Morphology

to Section 9230C. *E. coli* densities by membrane filtration were determined as recommended by Hach Method 10029 for m-ColiBlue24 Broth.

A. Filtration/Incubation

Millipore's Microfil System, consisting of disposable 100 mL polypropylene "push-fit" sterile funnels and HA 0.45 μm sterile membrane filters, were used for filtering each sample. Samples were filtered under partial vacuum provided by a vacuum pump. The filtration procedure used is as follows:

1. Using an alcohol flamed-sterilized forceps, a new sterile membrane filter is aseptically placed, grid side up, onto the sterile filter support base.
2. The Microfil sterile, disposable funnel is aseptically placed on the support and pushed down to fix it firmly in place.
3. The funnel is rinsed with approximately 20-30 mL of sterile, buffered water. This is the sample QA blank to ensure that the equipment and the buffered rinse water were sterile.
4. The vacuum is applied and the buffered rinse water is allowed to drain through the filter. The vacuum is turned off.
5. The funnel is lifted off and the filter is aseptically removed using a sterile forceps. The filter is aseptically placed, using a rolling motion, grid side up, onto the surface of the appropriately labeled petri dish containing agar. Care is taken to avoid trapping air between the agar surface and the filter.
6. A new sterile filter is aseptically placed onto the filter support base.
7. The membrane filter is wet with approximately 20-30 mL of sterile, buffered rinse water before the sample aliquot is added, using sterile disposable pipets or sterile graduated cylinders.
8. The sample is swirled in the filter funnel by moving the funnel in a gentle circular motion to evenly distribute bacterial cells on the filter surface.
9. The vacuum is applied and the buffer and sample is allowed to drain through the filter.

adding the counts of all the sample volumes filtered and multiplying by 100 and then dividing by the sum of all the volumes (mL) filtered.

Quality Assurance

Quality assurance and quality control tests were performed to verify the validity of the analytical data collected. All areas that influence the reported data were subjected to established microbiological quality control procedures in accordance with Standard Methods. These areas included sample storage and holding, lab facilities, personnel, equipment, supplies, media, and analytical test procedures. In addition, duplicate analyses were performed on ten percent of all samples. When quality control results were not within acceptable limits, corrective action was initiated. The laboratory also participated in performance evaluation samples sent by the State Department of Health Services. The quality assurance program helped ensure the production of uniformly high quality and defensible data. The Hyperion microbiology laboratory has been certified by the California State Department of Health Services.

Virus Sampling and Assay for Enteric Viruses

All laboratory work was conducted at the Environmental Sciences Laboratory of the County Sanitation District of Orange County.

Sampling Design and Frequency

Method 9510 C g of Standard Methods for the Examination of Water and Wastewater, 18th edition was used in all virus sampling. The sampling was performed at three storm drain sites on Friday, Saturday and Sunday from June 23 to September 24, 1995. Sampling days and duration of the project reflected heaviest beach usage during the 1995 swimming year. Water samples as large as 100 gallons were filtered through electropositive filters at ambient pH. Flow rate through the adsorption filter was kept below 5 gpm. Adsorption filters were eluted in the field with one liter of sterile 3% beef extract adjusted to pH 9.0 with sodium hydroxide.

Field eluates were returned to the laboratory where they were reconcentrated using an organic flocculation procedure described by Katezenelson et al., 1976. In this method, the eluate was adjusted to pH 3.5 by dropwise addition of 1N HCI while mixing

A stereoscopic microscope with a fluorescent lamp is used to aid in identifying and counting colonies after the appropriate incubation times. All colony counts, counting times, and any other notable information is recorded on the sample data worksheet.

1. Total coliforms: typical colonies have a pink to dark-red color with a shiny, greenish-gold, metallic surface sheen. The sheen may appear only in the central area or on the periphery.
2. Fecal coliforms: any colony exhibiting any light or dark blue color, whether covering the entire colony or only in or on part of the colony.
3. Enterococcus: after 48 ± 2 hours incubation, mE filters with growth on them are transferred to room temperature EIA plates. These EIA plates are incubated for 20 minutes at 41.0 ± 0.5 °C. Enterococci are pink to red-brown colonies with black or reddish-brown precipitate or halos on the underside of the filter when place on EIA agar.
4. *E. coli*: all blue to purple colored colonies (total coliforms are all red plus blue/purple colored colonies).

C. Calculations

Due to the possible adverse effect of colony crowding on sheen or color development on the membrane filter, and to be assured of a statistically valid colony count, minimum and maximum levels are adhered to for each of the indicator organisms. The minimum and maximum ranges are as follows:

1. Total bacteria: <200 total colonies (background and indicator bacteria)
2. Total coliform: 20 - 80 coliform colonies
3. Fecal coliform: 20 - 60 fecal coliform colonies
4. Enterococcus: 20 - 60 enterococcus colonies
5. *E. coli*: 50 coliform colonies

Indicator bacteria are expressed as bacterial density - colony forming units (CFU) per 100 mL of sample. Counts within the statistical range for the bacterial indicator are calculated by multiplying the colony count by 100 and dividing by the volume (mL) of sample filtered. If no counts fall within the ideal range, the density is calculated by final concentrate that could be quantified. The remaining concentrate volume was split in half and analyzed using the liquid overlay technique known as the cytopathic effect assay (CPE). The CPE assay is generally considered to detect a greater number of viruses, but it is not quantitative. All flasks of BGMK cells used in the CPE method were frozen after a maximum of 10 days. The flasks were then thawed and a portion of the original flask was transferred to a fresh flask of BGMK cells. Flasks that did not exhibit CPE in the initial CPE assay or the subsequent passage to fresh cells were considered to be negative for detectable infectious viruses. Any flask exhibiting CPE in either initial or subsequent passages was further examined by the plaque forming unit method to confirm the presence of infectious viruses.

Statistical Analyses

From the initial data set of 11,793 subjects who were successfully contacted and eligible, 107 were excluded due to reporting that they (or their child) did not get their face wet when swimming, leaving a total of 11,686 subjects included here. When looking at the bacteriological exposures, subjects with missing values (for the bacterial densities) were excluded (subject counts for each of these exposures are given in the tables). Socioeconomic status (SES) was estimated from census data (based on median values for each subject's zip code); missing SES values (for 1,546 subjects) were imputed as the median value among all subjects.

To assess the health effects of swimming near storm drains and high bacteriological levels, we first used simple descriptive statistics, such as histograms, tabular comparisons, and stratified analyses. We then calculated odds ratios (ORs) and 95% confidence intervals (CIs) from logistic regression models. These models provided approximate relative risks while allowing for control of potential confounding. We fit models for the two primary exposures (i.e., distance of swimming from the storm drain and measures of bacteriological exposure) for each of the outcomes of interest. We present results from modeling the exposure categorically and continuously. For the continuous models, we either present ORs and 95% CIs, or P values for trend; note that one can assess the trend P from the continuous 95% CIs.

continuously on a magnetic mixer. After reaching pH 3.5, mixing continued for an additional 30 minutes in order to maximize the potential for virus particles to adsorb to the organic floc. The entire eluate was then centrifuged at 3000 X g for 10 minutes in order to recover the floc. The pelletized floc was then resuspended in 0.45N Na_2HPO_4. In most cases, the final concentrate was in the 10 to 15 mL range.

Analyses of initial samples on tissue culture indicated that some of the final concentrates were toxic to host cells. Because of this toxicity, all final concentrates were detoxified prior to assay using the procedure described by Glass et al, 1978.

Additional parameters measured by the field team was ambient pH, temperature, conductivity and Total Dissolved Solids.

Seed Studies

Seed studies were performed at the laboratory using water collected from each sample location. Six studies were performed in water collected from Santa Monica Canyon, seven in water from Malibu and seven in water from Ashland. These studies were done to measure the effectiveness (i.e., percent recovery) of the virus adsorption, elution and reconcentration procedures in actual storm drain effluent.

Two 35 gallon containers were filled with water from each location. The water was trucked to the L.A. County Sanitation Districts Laboratory where a known amount of vaccine strain poliovirus was added to the water. Three grab samples were taken from the 35 gallon containers at the beginning and end of each experiment. These grab samples were diluted 1:10 in Hank's Balanced Salt Solution (HBSS) to minimize any toxic effect to the virus by the water itself. Percent recovery was measured by comparing the concentration of virus as measured in the grab samples to the concentration measured in the final sample concentrates.

Enteric Virus Assay

All samples were analyzed for infectious human enteric viruses on Buffalo green monkey kidney cells (BGMK). Ten percent of the final concentrate volume was initially analyzed by the plaque forming unit (PFU) technique. The reason for this initial screening was to determine whether there were viruses present in a small portion of the participants at the beach, ineligible, lost to follow-up, or from whom we obtained completed interviews did not differ by beach site (Figure 2). Reasons for non-participation are listed in Table 2. The major reason for non-participation was that the subject was ineligible because of a prior visit to a study beach (usually the same beach) or Mothers' Beach in the prior seven days (17% of beach contacts). Of the 22,085 persons approached on the beach, only 1761 (8%) refused to participate. Whites were slightly more likely to be non-participants than other racial ethnic groups (usually because they were ineligible). There were no major differences in the ethnicity or gender of non-participants across beaches (Figure 3). Reasons for "non-actualized" telephone interviews, meaning the attempt did not result in a completed interview from a subject interviewed at the beach, are presented in Table 3. The major reason was that subjects were found to be ineligible because they had returned to a study beach and immersed their heads in the water subsequent to the day of the beach interview (10% of beach interviews). The major reason for losses to follow-up was an apparently wrong or disconnected number (8% of beach interviews), which occurred predominantly early in the study. The proportions of "non-actualized" telephone interviews did not differ substantially by ethnicity, gender, or age (Figure 4) (although there was a slight tendency for whites and older subjects to fall into this category).

Table 4 presents characteristics of the 11,793 subjects who remained eligible throughout the study and completed the beach and telephone interviews. An objective was to have a ratio of 3:1 for subjects 0-100 versus greater than 400 yards from the storm drain. We achieved a ratio of 2.9:1. The majority of subjects (78%) came from family units where we included more than one subject per family. Only ten percent of subjects had residences in zip codes where the median household income was less than $25,000. This percentage was slightly higher at Ashland (13%). Eighty-eight percent of subjects were residents of California and there were no differences in this percentage by beach. We compared the study subjects with residents of Los Angeles County using the Population Estimation And Projection System (PEPS) for 1993 provided to us by the Toxics Epidemiology Program of the Department of Health Services of Los Angeles

Potential confounders adjusted for include: age, beach, race, gender, SES, California versus out-of-state residence and worry about potential environmental hazards due to swimming in the Santa Monica Bay. In addition, we adjusted the distance results for each of the bacteriological exposures and we adjusted the bacteriological results for distance. We also performed subgroup analyses by age and beach for the exposures/outcomes of interest. Interactions between distance from the drains and bacteriological exposures were assessed (with logistic regression) as well. Finally, for the significant results, we estimated the number of cases attributable to the corresponding exposure. The list of variables available for analysis is presented after the narrative portion of the Results and Discussion sections.

III. RESULTS

For clarity of presentation, we will describe all major results in this narrative section, followed by the Discussion Section. All of the tables and figures are provided after the References Section (before the Appendices). Results will be described in four sections: descriptive data from the beach and telephone interviews, descriptive data from the laboratory determinations of bacterial indicators, associations between risk of health outcomes and distance from the storm drain, and associations between bacterial indicators and risk of health outcomes. At the end of the last section, we present results of multivariate modeling where we included both distance from the drain and the bacterial indicators in the same model. After the section on multivariate modeling, we present an analysis of the virus data. Final results for all associations we examined are included here.

Descriptive Data (from the beach and telephone interviews)

Table 1 presents a calendar with the number of completed interviews by day. As expected, more interviews were completed on weekends. Also, more interviews were completed in July than other months. As stated earlier, we were able to successfully complete telephone follow-up interviews for 84% of the eligible subjects who were interviewed on the beach (Figure 1). The proportions of subjects who were non-be due to swimming in the ocean making it more difficult to detect any excess risk due to swimming). This decision was made prior to seeing what risk ratios were associated with this variable.

With respect to proportions of subjects reporting symptoms, there were no differences by gender. There were no substantial differences by age, although the proportion of children 0-12 with fever and vomiting was slightly higher than among older subjects and the proportion of children 0-12 with cuts that became infected was slightly lower than among older subjects. There were generally no differences by ethnicity, socioeconomic status (SES), or residence in California versus outside of California, with the following minor exceptions. Latino/a subjects reported less diarrhea, stomach pain or cramps, and nasal congestion. Based on the opinion of many of our bilingual staff, we suspect this may reflect some underreporting of these symptoms, rather than a real difference in outcomes. Persons who lived in zip codes where the median household income was less than $25,000 reported higher rates of fever, while subjects who lived in zip codes with median household incomes greater than $25,000 reported higher rates of diarrhea, but generally there were no striking differences by this ecological measure of SES. Overall, there was a tendency for California residents to report more symptoms than non-residents, but these differences were small.

Finally, Table 11 also presents results for the variable regarding level of concern about environmental hazards at the beach. As level of concern increases, the proportion of subjects reporting symptoms increases. This question was asked only at the end of the telephone interview because we did not want to bias responses to the list of symptoms by asking before then and we did not want to ask it at the beach because we wanted a streamlined questionnaire and we did not want to raise concerns about the beach for subjects who participated in this study. The manner in which it was asked does not enable us to distinguish between two possibilities: people with a high degree of concern overreported their symptoms relative to the other subjects or, more plausibly, those who subsequently experienced symptoms after the beach interview had their level of concern raised (after the fact). In either event, this variable was not strongly associated with

County (Table 5). As expected, the study subjects were younger (e.g. 48% were under 12 years of age versus 22% from PEPS). This reflects the fact that beachgoers who enter the water tend to be younger, which allowed us to examine possible differences in effects by age. The proportion of male study subjects was slightly higher in the study than in Los Angeles County (55% vs 50%). For White and Latino/a subjects, there were no substantial differences between study subjects and their proportions in L.A. County.

Table 6 presents subject age by map area (distance from the drain) for each beach. Table 7 presents similar data by gender for each beach and Table 8 presents these data by ethnicity. A summary for all beaches combined is presented in Table 9. Children 0-12 years of age tended to swim at the drain more than older subjects (63% of subjects swimming at the drain were children 0-12, whereas children 0-12 represented only 48% of all subjects). There were no differences by gender (e.g. 53% of subjects swimming at the drain were males and they constituted 55% of all study subjects). There was a tendency for Latino/a subjects to swim at the drain more so than Whites (59% of subjects swimming at the drain were Latino/a, whereas they comprised 43% of the total study subjects).

Table 10 presents counts of each symptom ascertained from the telephone interview. Table 11 presents rates for each symptom by various categories. The most commonly reported single symptoms were: nasal congestion (reported by 9.1% of respondents), coughing (7.1%), sore throat (6.8%), stomach pain or cramps (6.2%), diarrhea (5.3%), and fever (4.8%). The most commonly reported composite variable was significant respiratory disease or SRD (5%), which is defined as all those reporting any one or more of the following symptom groups: 1) fever and nasal congestion or 2) fever and sore throat or 3) cough with phlegm. The other composite variables were HCGI 1 (3%) and HCGI 2 (0.9%). HCGI 1 included all those experiencing any one or more of the following symptom groups: 1) vomiting or 2) diarrhea and fever or 3) stomach ache and fever. HCGI 2 includes all those reporting both vomiting and fever (we decided to exclude diarrhea in this second composite since diarrhea was reported relatively commonly by study subjects and much of it may represent background rates that may not

Avenue for each indicator, Figures 6A-D present the counts for Malibu, and Figures 7A-D for Will Rogers.

From the tables and figures, four major points are evident: 1) the counts were highly variable from day to day; 2) for a substantial proportion of days, the counts exceeded the established cutoffs; 3) the counts were generally higher in front of the drain and then dropped off with increasing distance from the drain; 4) the water samples taken at 400 yards were not always "clean" with respect to the bacterial indicators (i.e. counts occasionally exceeded the established cutoffs). Also, in general, the water quality (as judged by these indicators) was relatively poor compared to previous years.

Associations Between Distance from the Drain and Health Outcomes

As a measure of the strength of association, we rely predominantly on the risk ratio (labeled RR in the tables). This ratio expresses the risk (proportion of subjects who report a given symptom) among subjects who swam, for example, in front of the drain (designated 0 yards) versus the risk among subjects who swam 400+ yards from the drain. For the sake of brevity, subjects who swam 400+ yards from the drain are referred to as "controls" since they served as the reference group for all calculations in this section. Ninety-five percent confidence intervals are presented for each RR. For example, in Table 17, the RR for fever is 1.57, suggesting that the risk of fever for subjects swimming at 0 yards (in front of the drain) is 57% higher than the corresponding risk for subjects who swam at 400+ yards from the drain. The interval estimate is 1.17-2.10, which is narrow and the lower bound is above 1.0, indicating the result is informative and statistically significant at alpha = .05. For interested readers, we also present the absolute number of subjects in each comparison group who reported a symptom and the absolute risk in each group, facilitating calculations of excess risk and attributable numbers.

Since the predominant direction of the plumes traveling from the storm drains into the ocean was downcoast, we distinguished distance from the drain by designating upcoast and downcoast distances. Tables 17-21 present risks and RR's for subjects swimming at 0 versus 400+yards, 1-50 yards upcoast versus 400+yards, 51-100 yards upcoast vs. 400+ yards, 1-50 yards downcoast vs. 400+ yards, and 51-100 yards downcoast vs. 400+ yards, respectively. The effects for 0 yards and the downcoast distances are also summarized in Table 22, and the 0 yards and upcoast distances are summarized in Table 23. Comparing subjects who swam at 0 versus 400+ yards from the drain, we observed statistically significant increases in risk for fever, where the RR=1.57 (95% C.L. = 1.17-2.10), chills RR=1.58 (1.04-2.39), ear discharge RR=2.27 (1.14-4.51), vomiting RR=1.61 (1.01-2.56), coughing with phlegm RR=1.59 (1.10-2.29), HCGI 2 RR=2.11 (1.12-3.97), and SRD RR=1.66 (1.25-2.21). These increases in risk appeared to be limited to the 0 yards distance, since we observed very few significant effects at other distances upcoast or downcoast from the drain, and no significant trends with increasing distance from the drain (data not shown).

As we noted earlier, there were a number of days when the bacterial indicators at 400 yards exceeded the cutoff points, suggesting that this distance was not always a "clean control" area. As we describe in the next section, one of the better indicators for predicting health risks is the total coliforms to fecal coliforms ratio. We conducted a second set of analyses restricted to the days when the total to fecal ratio was greater than 5 for the water samples taken at 400 yards for a given beach (we noted that the enterococci count was always less than 106 during these times). The rationale was to exclude days when the plume from the drain (or some other source of higher counts, such as septic tanks) apparently reached the 400 yard point, making this point less than an ideal "control" zone. The prior expectation was that health risks associated with distance should increase since we "cleaned up" the control area. Results are presented in Tables 24-30. The relative risk point estimates for the seven outcomes found significant above (fever, chills, ear discharge, vomiting, coughing with phlegm, HCGI 2, and SRD) all increased for the 0 yards versus 400+ yards comparison (see Table 24). The interval estimates were wider since the results were based on fewer numbers of subjects. It was also of interest to see if health effects were observed for the other distances of 1-50 and 51-100 yards versus 400+ yards from the drain. A number of higher RR's were observed for the effect of swimming 1-50 yards upcoast, but none reached statistical significance

(Table 25). For subjects at 51-100 yards upcoast versus 400+ yards, significant increases in risk were observed for sore throat RR=1.45 (1.01-2.09) and SRD RR=1.91 (1.16-3.16) (Table 26). Similarly, for swimmers 1-50 yards downcoast, we observed a number of higher risks (Table 27); only the effect of SRD was statistically significant RR=1.77 (1.07-2.95). At 51-100 yards downcoast, significant increases in risk were observed for coughing, coughing with phlegm, nasal congestion, and SRD. Results are summarized in Tables 29 (downcoast) and 30 (upcoast).

Distance Effects Adjusted For Potential Confounders: We then used logistic regression to adjust for potential confounders. The resulting odds ratios provide close approximations to risk ratios and using logistic regression allows for more efficient and complex modeling of associations. Results are presented in Table 31. Adjusting for beach, age, race, gender, SES, California versus out-of-state residents, and worry about potential health hazards at the beach did not change the essential findings, although the associations for vomiting and HCGI 2 were slightly attenuated and no longer significant. It is possible, but, in our opinion, highly unlikely that we have missed a major confounder of the distance effects.

Possible Heterogeneity By Beach and By Age: We hesitate providing results for subgroups since the study was never designed to have sufficient power to detect subgroup differences. With this caveat, we explored possible differences in effects by beach and by age. Results for each beach separately are presented in Tables 32-34. There appear to be some differences in effects by beach, but it is difficult to judge what is real versus what is due to random variation with smaller numbers; the only noteworthy result from a test of heterogeneity was for earache ($p<0.01$). Results for three age categories (0-12, 13-25, 26+) are presented in Tables 35-37. It appears that children and young adults have higher risks associated with distance than older adults for a number of outcomes. In fact, the highest risks were usually noted for subjects aged 13-25 years of age. A heterogeneity test was significant only for SRD ($p=0.05$)

Associations Between Bacterial Indicators and Health Outcomes

We took a number of approaches to analyzing the effects of bacterial indicators. For each indicator, we calculated risk ratios using the higher and lower cutpoints described earlier (e.g. 200 and 400 cfu for fecal coliforms). This ratio expresses the risk of a given outcome among subjects who swam in water where the bacterial indicator was higher than the cutpoint (presumably higher risk) compared to the risk of the same outcome among subjects who swam in water where the same bacterial indicator was below the cutpoint. It was conceivable that we might have failed to detect a real increase in risk with these cutpoints, particularly since they were not based on prior data that were obtained for Santa Monica Bay, so we also calculated odds ratios from categorical models using quintiles (instead of dichotomies, as above), and from continuous models. For the categorical models, the quintile medians, total number of subjects in each quintile, and the number reporting a given symptom in each quintile are provided in the tables. For the continuous linear (on logistic scale) models, odds ratios correspond to a unit increase equal to the difference between the 90th and 10th percentiles (i.e. the difference between the midpoints of the fifth and first quintiles). Results for each bacterial indicator are presented below.

E. coli. Results are presented in Tables 38-42. We observed no effects on risk using the cutpoints of 35 or 70 cfu for any symptom (Tables 38 and 39). We also investigated effects associated with cutpoints of 160 and 320 (Table 40). At the highest cutpoint of 320, associations were observed for earache RR=1.46(1.06-2.00) and nasal congestion RR=1.24(1.00-1.53). Results for the categorical and continuous models are presented in Table 41. No effects were observed for the categorical model (quintiles). With the continuous model, small but significant effects were noted for skin rash, nausea, and stomach pain. These associations were slightly stronger for skin rash and no longer statistically significant for nausea and stomach pain after adjustment for covariates (Table 42).

Enterococcus. Results are presented in Tables 43-46. No increases in risk were detected when 35 cfu was used as the cutpoint (Table 44). When 106 cfu was used as the cutpoint, significant effects were noted for diarrhea with blood RR=4.23 (1.12-15.91) and HCGI 1 RR=1.44 (1.03-2.03) (Tables 43 and 44). Results from the categorical model suggest positive associations for diarrhea and stomach pain, where the odds ratios for the fifth versus first quintile were 1.31 (1.00-1.72) and 1.31 (1.02-1.68) respectively. In the continuous model, positive associations were noted for fever, skin rash, nausea, diarrhea, stomach pain, coughing, runny nose, and HCGI 1 (Table 45). The categorical findings were substantially weakened, while the continuous results were essentially unchanged after adjustment for covariates (Table 46).

Total Coliforms. Results are presented in Tables 47-50. No significant effects were seen when the cutpoint of 1,000 cfu was used (Table 48). When 10,000 cfu was used as the cutpoint, only skin rash exhibited a positive association RR=3.00 (1.86-4.83) (Tables 47 and 48). Similarly, the categorical model only showed an association with skin rash and the continuous model did not yield any associations (Table 49). Results did not materially change after adjustment for covariates (Table 50).

Fecal Coliforms. Results are presented in Tables 51-54. No significant effects were seen when 200 cfu was used as the cutpoint (Table 52). When 400 cfu was used, only an association with skin rash was evident RR=1.88 (1.21-2.94) (Tables 51 and 52). A similar effect was observed in the categorical model, where the odds ratio for skin rash comparing the fifth to the first quintile was 2.04 (1.09-3.81). In the continuous model, significant effects were observed for fever, skin rash, and HCGI 1. Adjusting for the potential confounders did not change the results except, with the continuous model, nasal congestion was now positively associated with fecal coliforms.

In addition to investigating effects for single indicators, as above, we also assessed the effects of the total coliforms to fecal coliforms ratio and the ratio of total coliforms to enterococcus. Results are summarized below.

Total coliforms to fecal coliforms ratio. As initially suggested by Jack Petralia (Los Angeles County Department of Health Services) we initially used a ratio of 5.0 for the cutpoint, assuming that the risk may be higher when the ratio is smaller than 5.0. When the effects of this ratio were estimated for the entire data set, significant effects were noted for diarrhea RR=1.28 (1.08--1.51) and HCGI 2 RR=1.87 (1.20-2.90) (Table 55). We then estimated effects of this ratio restricted to subjects in water where the total coliform levels were greater than 5,000 cfu. Significant effects were observed for fever, eye discharge, skin rash, nausea, diarrhea, stomach pain, nasal congestion, HCGI 1, and SRD (Table 56). The significant RR's ranged from 2-7. We then conducted a similar analysis restricted to subjects in water where the total coliform level exceeded 10,000 cfu. Here we observed significant increases in risk for eye discharge, ear discharge, skin rash, nausea, diarrhea, stomach pain, nasal congestion, HCGI 1, and HCGI 2 (Table 57). The significant RR's ranged from 2-39. Results for all three analyses (the entire data set, counts > 5,000 cfu, counts > 10,000 cfu) are summarized in Table 58. It is noteworthy that all the effects noted above became consistently stronger as the analyses were increasingly restricted to occasions with higher total counts.

Since this ratio appeared to be informative (using 5.0 as a cutpoint), we decided to explore a range of cutpoints (2, 4, 6, 8) to see which cutpoint yielded the strongest associations (Table 59a for all the data, 59b restricted to times when the total coliforms exceeded 1,000 cfu and Table 59c for occasions when the total coliforms were greater than 5,000. When the ratio cutpoints were analyzed for all days, diarrhea and diarrhea with blood were associated with the ratio at some cutpoints but no consistent patterns across cutpoints was evident. In contrast, when analysis was restricted to times when the total coliforms exceeded 5,000 cfu, there was a strong and consistent pattern of increasing RR's as the ratio decreased, with the strongest effects observed using a cutpoint of 2.0. When the analysis was restricted to times when the total coliforms exceeded 1,000 cfu, the pattern was not as strong or consistent, although most effects were again strongest using the cutpoint of 2.0.

Results for the categorical and continuous models are presented in Table 60 (note: this analysis included the entire data set). The categorical model indicated a positive association with diarrhea, coughing and coughing with phlegm and the continuous model yielded associations with diarrhea, stomach pain, cough, coughing with phlegm, and sore throat. Results were, in general, slightly weaker when adjusted for covariates (Table 61) and statistical significance remained only for cough and cough with phlegm; nevertheless, for the associations with diarrhea, stomach pain, and sore throat from the continuous model, adjusting for covariates only shifted the lower 95% C.I. bound from 1.00 to 0.98 or 0.97.

Total coliforms to enterococci ratio. Accepted cutpoints are not available for this ratio, so the analysis explored a range of cutpoints (4, 7, 10, 13), in addition to categorical and continuous models. Results for the range of cutpoints are presented in Table 62. Diarrhea was associated with this ratio at all cutpoints with an odds ratio of 1.4-1.5. In general, the highest cutpoint of 13 yielded the greatest number of significant associations (fever, nausea, diarrhea, and stomach pain were associated with this ratio when 13 was used as the cutpoint). In the categorical model, the ratio was associated with increases in risk for nausea, diarrhea, and HCGI 1 (Table 63). In the continuous model, no effects were noted. Results were slightly weaker for nausea and HCGI-2 and essentially unchanged for diarrhea and HCGI-1 after adjustment for covariates (Table 64).

Results of Multivariate Modeling With Both Distance and Bacterial Indicators

To further assess the associations for distance and bacterial indicators, these exposures were simultaneously included in logistic regression models. Hence, in these models, distance was adjusted for the bacterial indicator and vice-versa. When modeling the potential associations with distance from the drain, including *E. coli*, enterococcus, total coliform, or fecal coliform one-at-a-time as covariates generally did not alter the findings presented here; the only differences were that earache now appeared positively associated with enterococcus (adjusted OR=1.51, 95% CI=1.0-2.28) and with fecal coliform (adjusted OR=1.61, 95% CI=1.06-2.44) comparing the highest to lowest quintile and that the total coliform-skin rash association was slightly weakened. A model that included both distance and all indicators together did not materially alter our general findings.

To investigate further the potential associations for distance and bacterial measures, we modeled the interactions between these exposures using logistic regression. In particular, we looked at the interaction between swimming (at zero or four-hundred yards from the drain) and swimming when the bacterial level was above or below the highest cutpoints used here. For example, for fecal coliform, we compared the risk for those swimming at the storm drain when fecal coliform > 400 cfu versus the risk for those swimming at 400+ yards when fecal coliform <= 400 cfu (i.e., the referent group). In addition, we compared the risk from swimming at 400+ yards when fecal coliform > 400 cfu and the risk from swimming at the storm drain when fecal coliform <= 400 cfu to the risk for those swimming at 400+ yards when fecal coliform <= 400 cfu. This type of modeling helps distinguish whether a combination of exposures (e.g., swimming at the storm drain and swimming on high count days) increases one's risk over the exposures alone. Based on these models, we observed the following noteworthy results (i.e. a pattern of increased risk associated with both high bacterial counts and distance in front of the drain). In comparison with swimming at 400+ yards when *E. coli* <= 70 cfu, the relative risk of vomiting for swimming at 400+ yards when *E. coli* > 70 cfu was 0.63 (95% CI=0.19-2.05), for swimming at the storm drain when *E. coli* <= 70 cfu was 1.26 (95% CI-0.65-2.47), and for swimming at the storm drain when *E. coli* >70 cfu was 2.11 (95% CI=1.14-3.89). The relative risk of HCGI 2 for swimming at 400+ yards when *E. coli* > 70 cfu was 0.74 (95% CI=0.38-1.44), for swimming at the storm drain when *E. coli* <= 70 cfu was 1.65 (95% CI=0.70-3.90), and for swimming at the storm drain when *E. coli* > 70 cfu was 2.45 (95% CI1.08-5.57), again in comparison with swimming at 400+ yards when *E. coli* <= 70 cfu. Finally, the relative risk of HCGI 2 for swimming at 400+ yards when enterococcus > 106 cfu was 6.34 (95% CI=0.81-49.36), for swimming at the storm drain when enterococcus <= 106 cfu was 1.71 (95% CI=0.76-3.87), and for swimming at the storm drain when enterococcus > 106 cfu was 4.68 (95% CI=1.97-11.10), in comparison with swimming at 400+ yards when enterococci <=106 cfu. Note that the interaction model for distance and total coliform did not converge.

Summary of Bacteriological Results

Tables 65-70 summarize the noteworthy distance and bacterial indicator results presented above. For each association, the relative risk and attributable number are presented. The attributable number is an estimate of the number of new occurrences of the specified outcome that are attributable to the exposure of interest. For example, based on the results from this study, the first row of table 65 indicates that approximately 259 new cases of fever will occur for every 10,000 people who swim at the drain instead of 400 yards (or more) away from the drain. These values are estimated as:

Attributable number = A * (RR-1) / RR,

where A = the number of exposed and diseased subjects, and RR = the risk ratio. The attributable numbers have an important public health interpretation: they provide an estimate of the maximum number of potential cases that could be prevented (based on the specific point estimate and assuming a causal effect) if the exposure was completely eliminated. The attributable numbers per 10,000 subjects exposed ranged into the 100's for a number of exposures. At meetings organized by the SMBRP prior to the start of the study (and attended by senior scientists who were to direct the study, SMBRP staff and technical advisors, and public health practitioners from the L.A. County Department of Health Services), an excess risk of 1 case per 100 exposed subjects was identified by verbal consensus as a "noteworthy" risk. The attributable number corresponds to this excess risk and any number above 100/10,000 represents an excess risk greater than 1/100. For bathing at the drain versus 400+ yards, attributable numbers for fever (259), chills (138), vomiting (115), coughing with phlegm (175) and SRD (303) all exceeded 100 cases/10,000 exposed. For bacterial indicators, when the entire data set was analyzed (Table 66), attributable numbers exceeded 100 cases/10,000 exposed for HCGI1 (130 for enterococcus), skin rash (165 for total coliforms), diarrhea (277 for the total to fecal ratio), nausea (147 for the total to enterococcus ratio), diarrhea (262 for the total to enterococcus ratio, and HCGI1 (111 for the total to enterococcus ratio). The attributable numbers from the continuous models were much smaller because the odds ratios from these models were relatively weak (Table 67). Table 68 presents attributable numbers for the range of cutpoints (2, 3, 4, 5, 8) for the ratio of total to fecal coliforms for the entire data set. Diarrhea was most often associated with higher attributable numbers, but there was no consistent pattern across the range of cutpoints. When a similar analysis was done, but restricted to occasions when the total coliforms exceeded 1,000 cfu (Table 69B), the highest attributable numbers were generally associated with the cutpoint of 2.0. Many of these numbers were in the range of 100-400 cases per 10,000 exposed subjects. When this analysis was restricted to days when the total coliforms were greater than 5,000 cfu, there was a consistent pattern of higher attributable numbers associated with lower cutpoints. At the cutpoint of 2, attributable numbers ranged into the mid- and high 100's of cases per 10,000 exposed subjects for a number of outcomes. Finally, Table 70 presents a similar analysis for a range of cutpoints for the ratios of total coliforms to enterococcus. Diarrhea had the higher attributable numbers across all cutpoints (around 200 cases/10,000 exposed). Higher attributable numbers were associated with the highest cutpoint of 13.

Results of Virus Sampling Procedures

Results of the virus sampling procedures are presented in Tables 71 and 72. The percentage recovery from the seed experiments was quite high. Enteric viruses were detected on 8/11, 8/26, 9/3, 9/9, 9/10, 9/16 for Ashland; 7/21, 7/28, 8/25, 8/26, 9/9, 9/10, and 9/16 for Malibu, and 7/7, 7/18, 7/28, and 8/4 for Santa Monica Canyon. This number of positive samples did not enable us to conduct many analyses; however, we were able to compare the frequency of outcomes reported by subjects who were swimming within 50 yards of the drain on days when samples were tested for viruses and found to be negative versus days when the samples were positive for viruses. Results are presented in Table 73. Although based on small numbers, a number of outcomes were reported more often on days when the samples were positive for viruses, including fever (RR=1.53, 95% CI 0.97-2.42, p-value 0.07); vomiting (RR=1.89, 0.94-3.78), HCGI-1 (RR=1.74, 0.99-3.06) and HCGI-2 (RR=2.26, 0.91-5.60).

In Table 74, we present results for the virus analysis, adjusted for covariates. Results remained essentially unchanged. Finally, we also adjusted these results further by including the bacterial indicators, one at a time, into the model (results not shown). These last series of adjustments made essentially no difference in the results (e.g. for fever, the crude RR=1.53 p=0.07, adjusted for covariates RR=1.56 p=0.06, adjusted for covariates plus fecal coliforms RR=1.57 p=0.06, covariates plus *E. coli* RR=1.58 p=0.06, covariates plus total coliforms RR=1.56 p=0.06, and covariates plus enterococcus RR=1.57 p=0.06).

Research with gene probes is ongoing and will be presented in an addendum to this report sometime in the near future (the lab conducting this work hopes to complete the assays by Spring, 1996).

IV. DISCUSSION

The following circumstances provided the motivation to conduct an epidemiological study of the possible acute health effects of swimming in Santa Monica Bay: A) the beaches are heavily populated in the summer months, B) there is a measurable volume of discharge into the bay from storm drains even in the summer months when there is little rainfall, C) there are numerous days with high levels of bacterial indicators, D) pathogenic human enteric viruses have been isolated from storm drain effluent even when bacterial indicator counts are low, and, E) anecdotal reports raised concern about adverse health effects of swimming in the bay. Based on numerous meetings and extensive peer review, the Santa Monica Bay Restoration Project decided that an epidemiological study of subjects swimming at selected beaches in Santa Monica Bay was the most direct and relevant means of addressing the question of possible adverse health effects.

The initial goal, as stated in the approved protocol, was to recruit 9000 subjects. Through refining our office and field techniques, we were able to complete interviews on 11,793 subjects who remained eligible throughout the follow-up phase of the study while completing the study at least $100,000 below the projected budget. Of the 22,085 subjects approached on the beach, only 1761 refused to participate, for a response rate on initial contact of 92%. Also, of the 15,492 eligible subjects interviewed on the beach, we were able to contact by telephone and interview 13,278 (86% follow-up). The potential for selection biases would seem to be minimal, given the high response rates. It is also worth noting that the proportions and reasons for ineligibility or loss to follow-up were similar by beach.

The three beach sites where the study was conducted, Surfrider/Malibu, Will Rogers/Santa Monica Canyon, and Santa Monica/Ashland Avenue, were selected because prior data indicated they were heavily populated and experienced a wide range of indicator counts in the past. Throughout the summer, we encountered the size of crowds we expected at Malibu and Ashland Avenue. Work at Will Rogers by the Los Angeles County Department of Public Works throughout much of the summer substantially diminished the crowds at this beach. Our prior expectation of a wide range of indicator counts was realized throughout the summer of this study. We also observed a high degree of variability from day to day, and a substantial proportion of days when levels exceeded generally established cutpoints, particularly for samples taken at the drain. Malibu and Will Rogers exceeded cutpoints more often than Ashland Avenue; in fact, the lower standard cutpoints were exceeded the majority of the time for most of the bacterial indicators at Malibu and Will Rogers. Counts were generally highest at the drain and then diminished as distance from the drain increased. Of note, however, is that the counts for water samples taken at 400 yards sometimes exceeded cutpoints at all three beaches, suggesting this distance did not always represent a "clean control area".

We operationalized the issue of health effects from swimming in Santa Monica Bay into two research questions. 1) What are the relative risks of specific health outcomes among subjects bathing at 0, 1-50, and 51-100 yards of a storm drain compared to subjects bathing at the same beach but beyond 400 yards from a drain? We reasoned that if pathogens were coming from a storm drain and causing symptoms in swimmers, the risk of these specific symptoms should be higher in subjects who swim closer to the drain. 2) Are the risks of specific outcomes associated with levels of indicator organisms (as they are commonly monitored by departments of public health). This second question is motivated primarily by policy considerations, so we wanted to test the predictive value of feasible, common monitoring practices. Results addressing each question are discussed below.

Associations between distance and health outcomes.

We observed differences in risk when we compared subjects swimming at 0 yards (meaning where the drain enters the bay) versus subjects swimming at 400+ yards. Significant increases in risk were noted for the single symptoms of fever, chills, ear discharge, vomiting, and coughing with phlegm, and the composite variables of HCGI 2 and SRD. Most of the risk ratios ranged from 1.5-2.0, suggesting a 50-100% increase in risk. The strongest effects were for ear discharge and HCGI 2. Very few increases in risk were observed for subjects swimming at 1-50 or 51-100 yards from the drain compared to subjects swimming at 400+ yards. This was an unexpected result. We are aware of at least two alternative explanations. One is that the risk is actually limited to subjects swimming in front of the drain, possibly because the level of pathogens at greater distances from the drain was quickly diluted below an infectious dose. This seems implausible since the plume clearly traveled beyond this point and high bacterial counts were noted at 1-50 and 51-100 yards (and some of these bacterial indicators were associated with increased risk of disease). Another explanation is that the risk is highest at 0 yards, but there may also be an elevated but smaller risk at 1-50 or 51-100 yards, which we were unable to detect because the reference group (subjects at 400+ yards) was occasionally exposed to water with high bacterial counts. To address this possibility, we analyzed a subset of the data restricted to days and beaches where the total:fecal ratio for the water sample taken at 400 yards was greater than 5.0. We chose this ratio because it was associated with adverse health effects (see below). This reanalysis yielded stronger relative risks when comparing subjects at 0 versus 400+ yards (compared to the original analysis of the entire unrestricted data set) and we also observed some increases in risk at 1-50 and 51-100 yards. This suggests that risk may not be limited to the 0 yards distance, and argues against a standard that discourages swimming only at the mouth of the drain (although the risks are clearly higher there).

The results regarding distance were not changed when we controlled for potential confounders, and are very unlikely to be due to confounding. The concern with confounding has been raised previously (Saliba 1990, Fleischer 1993, Kay 1994,), but it dealt with a different study design, sometimes referred to as the "Cabelli-type" study. In this design, risks in swimmers are compared to risks in non-swimmers. The problem with that design is that swimmers and non-swimmers are self-selected and may differ with respect to background risks since there are presumably many other exposures/pathways that can produce the symptoms under investigation. Some of these are unknown or difficult to quantify, so doubt remains, even after adjustment for the known and measured potential confounders, that the swimmers and non-swimmers are actually comparable. We implemented a design that should have substantially reduced the potential for confounding by restricting it entirely to swimmers (who immersed their heads in the water) and making comparisons between groups of swimmers (defined, for example, by distance from the drain) to estimate risk ratios. A priori, we believed that the background risk of subjects swimming closer to a drain should not be materially different from the background risk of subjects swimming farther away (they are all self-selected swimmers). When we compared a number of characteristics between subjects at different distances, the only variables that were differentially distributed by distance were age and ethnicity. Younger subjects and Latino/a subjects tended to swim closer to the drains. These variables, however, were not independent risk factors for the outcomes. When we controlled for these, as well as other covariates, there was no evidence of confounding.

We limited analyses of subgroups for three reasons: 1) the study was never designed to detect subgroup differences with reasonable power; 2) there were few reasons, a priori, to expect differences in effects between subgroups defined by most variables (e.g. gender, California resident, ethnicity, etc); and 3) policies that may emerge from this work would most likely have to apply to the "general population" and not to specific subgroups (it would seem implausible to establish one policy for one subgroup of the population defined, for example, by age, race, gender, and SES, and other policies for other subgroups). Based on discussions with interested parties, we agreed to explore differences by beach and by age of the subjects. There appeared to be some differences when we stratified by beach; however, it is difficult to judge whether these are real differences or simply the result of random variation with smaller sample sizes per subgroup. When we stratified by age into three categories (0-12, 13-25, >25), the increased health risks observed earlier appeared to be stronger for children and adults less than 25. In fact, the strongest associations were usually evident in the 13-25 year age group. We presume this is due mostly to their increased activity (and hence exposure) in the water, which we did not attempt to quantify, and less so to any increased susceptibility for a given dose of exposure.

We decided not to restrict recruitment to one subject per family for two reasons. 1) It would have been impossible to achieve the sample size we needed. As it was, we approached every single potentially eligible subject throughout the study period to achieve our sample size. 2) We believed it would have been very difficult to only select and recruit one subject per family and explain this to the satisfaction of the family. Given the strong reasons for accepting other family members, we decided to proceed with this plan since we believe the effects on our results and conclusions are trivial. When we consider the effects of possible intra-familial transmission, the following distinction is helpful. If a case of illness was caused by swimming at a study beach and that case infects other family members and results in illness, all of these cases are rightly attributed to the swimming related exposure. On the other hand, if a case of illness was caused by some other exposure and this case transmitted the infection to other cases in the family during the follow-up period for that family, these cases should not be (and are not) attributed to the swimming exposure. Families such as these should be distributed similarly by distance from the drain and by levels of indicator counts and are reflected in the background rates. To the extent this happened, it would reduce our power only. Nevertheless, to further address this issue, we included a family variable as a covariate (controlling for it in the logistic models did not change any of the results) and stratified the results by this variable to look for heterogeneity (and similar effects were noted in the stratum comprised of single subjects and the stratum comprised of subjects from families where more than one subject per family was included). We have added results and text to the Results and Discussion sections to address this issue.

Associations between bacterial indicators and health outcomes.

In general, when we estimated risk ratios using the established cutpoints, there were very few positive associations with any single indicator. There were none for *E. coli* at the lower cutpoints of 35 and 70 cfu. At the highest cutpoint of 320 cfu, earache and nasal congestion were weakly associated with *E. coli*. Only skin rash was associated with total and fecal coliforms at the higher cutpoints of 10,000 cfu and 400 cfu, respectively. Enterococci were positively associated with diarrhea with blood and HCGI 1 at the higher cutpoint of 106 cfu. The risk of diarrhea with blood was four times higher, but this estimate was based on very few cases. There was about a 40-50% increase in risk of HCGI, consistent with previous results by Cabelli (1982) and Genthe (preprint).

We recognize that these cutpoints do not have a strong scientific basis, particularly when applied to West Coast beaches with heavy urban runoff such as Santa Monica Bay, so we also investigated possible effects of the bacterial indicators with the use of categorical models (where quintiles were assessed) and continuous models. For the most part, the categorical models yielded results similar to the dichotomous results described above. The continuous models generally yielded more positive associations, particularly for enterococci. No additional associations were detected for total coliforms; fever, skin rash, and HCGI 1 were associated with fecal coliforms; skin rash, nausea, and stomach pain were associated with *E. coli*. Continuous results for enterococci indicate positive associations with fever, skin rash, nausea, diarrhea, stomach pain, coughing, runny nose, and HCGI 1.

In addition to evaluating single indicators, associations with the total coliform to fecal coliform ratio and the total coliform to enterococci ratio were investigated. For the total:entero ratio, the categorical model indicated inverse associations with nausea, diarrhea, and HCGI 1. This ratio was not more predictive of health risks than the continuous model for enterococci alone. In contrast, the ratio of total to fecal coliforms proved to be quite informative. There were two components to the rationale for this analysis. First, as the level of fecal coliforms increased relative to total coliforms (i.e. the ratio was low), concern increased that there was substantial fecal contamination of the storm drain, possibly increasing risk of adverse health effects. Second, the effect of this lower ratio should be stronger when there was a higher degree of contamination, indicated by total coliform counts in excess of 1,000, 5,000 or 10,000 cfu. The results were consistent with this rationale. Using a ratio of 5.0 as the cutpoint, diarrhea and HCGI 2 were associated with a lower ratio when all the data were analyzed, regardless of the absolute level of total coliforms. When this analysis was restricted to subjects in water where the total coliforms exceeded 5,000 cfu, significantly higher risks were detected for nine different outcomes. Further, when this analysis was restricted to subjects in water where the total coliforms exceeded 10,000 cfu, the risk ratios for these nine outcomes all increased again (with the absolute risk in the exposed group reaching 14-19% for each symptom). Although the number of subjects became small in some subgroups, the strong consistency of the results across the increasing levels of total coliforms is persuasive that the associations are probably real. Which cutpoint (for the ratio) is associated most consistently with risk is an important question. When a range of cutpoints (2, 3, 4, 5, 6, 8) was analyzed using the entire data set, no consistent pattern emerged. This is not entirely surprising since an analysis of all data points treats all ratios of similar numerical value equally, even though a ratio of 5 when the total coliforms are very low may not increase risk (although the same ratio of 5 may be associated with increased risks when the density of total coliforms is high (say, above 1,000 or 5,000 cfu). When this type of analysis was restricted to days when the total coliform densities were high (above 1,000 cfu and particularly above 5,000) a consistent pattern emerged, with higher risks and attributable numbers associated with low ratios.

For reasons developed in the previous section on distance effects, it is very unlikely that the bacterial indicator associations observed in this study are confounded to any substantial degree. It is highly unlikely that the background risks are different for subjects exposed to higher or lower levels of a given indicator level, which were unknown to the subjects, particularly if one stratifies by distance.

It is worth considering which bacterial indicators are the most useful. This will depend, of course, on criteria used to define "usefulness". It would seem that the magnitude of the attributable numbers and the frequency that selected cutpoints are exceeded may be useful components of any set of criteria. From Tables 66 and 67, when all data are considered together no single indicator (or ratio of indicators) stood out as having the highest attributable numbers. Enterococci (at levels above 106 cfu) were associated with an attributable number of 130 cases of HCGI 1 per 10,000 exposed subjects; total coliforms (at levels above 10,000 cfu) were associated with an attributable number of 165 cases of skin rash; the ratio of total to fecal coliforms had an attributable number of 277 cases of diarrhea; and the ratio of total coliforms to enterococci had attributable numbers of 147 and 262 for nausea and diarrhea, respectively. From the continuous models, enterococci had the greater number of associations but the effects (estimated by odds ratios) and the attributable numbers were small. The largest attributable numbers were observed for the total to fecal coliforms ratio when the analyses were restricted to subjects in water where the total coliforms exceeded 5,000 cfu. The attributable numbers increased very consistently as the ratio decreased from 8 to 6 to 5 to 4 to 2. However, these stronger effects would be limited to a smaller proportion of the beach going population (those swimming in water where the total coliforms exceeded 5,000 cfu). It is also worth noting (from Table 65) that the effect of swimming at the drain (0 yards) versus 400+ yards from the drain was associated with relatively large attributable numbers (e.g. 303/10,000 exposed subjects for SRD, 115 for vomiting, 175 coughing with phlegm).

We very briefly review results of other studies to lend a broader context to our results, although we point out that results of other studies may not be relevant to the situation in Santa Monica Bay and different designs were employed in these other studies.

The question of whether acute infectious disease can be acquired through bathing in marine water contaminated with sewage has been the subject of several large epidemiological studies conducted throughout the world. The most consistent finding of these studies is that bathers, defined as those that immerse their heads in water while swimming, are at a higher risk of contracting gastrointestinal (GI) disease than those who do not immerse their heads, the non-bathers. However, this has not always been observed. Another aspect of these studies has been to investigate whether elevated counts of certain bacterial indicators commonly found in sewage contaminated water are predictive of disease, even though the bacteria themselves may not be pathogenic. To date, the reported results trying to associate elevated indicator counts with health outcomes have been inconsistent.

Cabelli (1979) was the first investigator to demonstrate an association between water quality at ocean beaches and health outcomes. He conducted a large, prospective cohort study of 8,000 subjects sponsored by the EPA that has subsequently become a classic study of health outcomes and marine water quality. The study compared symptom rates among bathers and non-bathers at two beaches that had been classified as relatively unspoiled (RU) and barely acceptable (BA) using coliform counts as the indicators to make this determination. Family groups were interviewed on the beach to document bathing behavior and again by phone 8-10 days later to assess the development of GI and respiratory symptoms. Water sampling for bacterial indicators (total and fecal coliforms, *E. coli*, Enterobacter, Enterococcus, Klebsiella and P. aeruginosa) was done concurrently at the two beaches. The BA beach not only reported higher symptom rates than the RU beach but also mean levels of the bacterial indicators were significantly higher than at the RU beach. A noteworthy result of this study was that measurable health effects occurred at both marine beaches within guidelines (total and fecal coliforms standards) developed for fresh water beaches.

Cabelli (1982) next used the results of a large prospective cohort study to develop a linear regression model for the relationship between mean enterococci density and gastroenteritis among bathers. Almost 26,000 subjects were identified on weekends over a six year period in three locations: two ocean beaches (New York and Boston), and one brackish/fresh water lake (Louisiana). Exposure status (bathers were defined in Cabelli's study as having the head immersed underwater, non-bathers included waders and those who stayed out of the water) was determined by interview on each study day. Individuals who swam immediately prior to or after the weekend under study were excluded from the analysis. Incidence of gastroenteritis was obtained by telephone interview 8-10 days later; subjects did not make use of a toll-free number or local clinic for medical advice/diagnosis. Enterococci densities were determined for each study day. Based upon the results of the regression analysis, the authors concluded that bathing in water containing as little as 10 enterococci/100 ml of sample represented an absolute risk of GI illness of 10 per 1000 bathers and a relative risk of 2.0 comparing bathers and non-bathers.

Current EPA criteria concerning the sanitary quality of marine waters are based upon these results (Cabelli, 1984; Cabelli, 1989). Several criticisms have been leveled against the 1982 study (Fleisher, 1991): (1) Results were pooled for marine and estuarine water locations, despite the fact that survival of pathogenic organisms may be inversely correlated with salinity (Dufour, 1984); (2) Results from several beach locations were combined without considering local differences in marine flora, sewage outflow, immunity/demographic characteristics of subjects, beach contour and sediment/turbidity characteristics. Fleisher's analysis of Cabelli's data showed significant variation in the mathematical relationship between indicator levels and disease outcome among the beaches studied: in addition, a surprisingly poor fit for HCGI relative to total GI symptoms in the linear regression model led Fleisher to fit an alternative (logistic) model to the data -- one with more "biological support" -- choosing covariates "not based solely on statistical considerations but rather on hypotheses generated by previous epidemiologic studies" (Fleisher, 1991, p. 262). From this reanalysis, Fleisher concluded that "not only the magnitude...but the existence of any relationship between enterococci density and gastroenteritis may be site specific" (Fleisher, 1991, p. 263). (3) Cabelli had speculated earlier (1979) that the primary disease outcome -- an acute, relatively mild gastroenteritis which had a short incubation period and duration -- was most compatible with exposure to human rotaviruses or Norwalk-like viruses, so that estimates of water quality based upon proxy measures might be subject to considerable error (further discussed below).

The Cabelli-EPA study design has been endorsed by the World Health Organization and the United Nations environment program. "Cabelli-style" ocean studies have been carried out at a number of locations throughout the world. Most report higher morbidity among bathers (head immersed in water) as compared to non-bathers for gastrointestinal illness, eye and ear infections. Correlations with indicator organisms however are inconsistent (for review, see Saliba 1990). In Hong Kong (Cheung, 1990), Staphylococci levels were correlated with ear, respiratory, and total illness, while *E. coli* was found to be the best predictor of gastroenteritis. In South Africa (von Schirnding, 1992), bathers and non-bathers were compared for incidence of gastro-intestinal, respiratory, and skin symptoms at two beaches, one with high levels of indicators (enterococcus and coliforms) and the other relatively clean: symptom rates were higher for swimmers at the polluted beach, but "were not statistically significant." In the United Kingdom (Balarajan, 1991), enterococcus and coliform levels "varied appreciably" and could not be correlated with illness; overall, a relative risk of 1.31 (95% confidence interval 1.04 to 1.64) was obtained for occurrence of at least one symptom (GI, respiratory, other) in bathers compared to non-bathers after controlling for age and sex. Genthe (19..) reported that enterococcus was the most predictive of gastroenteritis, although fecal coliforms were also significantly associated with risk. Staphylococcus was not associated with risk. Several investigators have recently suggested that these studies may underestimate the true risk: (1) Non-differential measurement error in estimated organism densities could result in a 30 to 57% underestimate of true risk (Fleisher, 1990). Both the MPN and MF methods of enumerating coliforms are imprecise; Fleisher points out that none of the studies cited above made use of replicate determinations on individual samples, nor did they consider diurnal and other variations which may occur in bacterial indicator levels, particularly at marine locations. (2) Bacterial indicators do not reflect the occurrence of enteroviruses in marine waters, which are likely to be the true pathogen of interest (Gerba, 1979), nor do they reflect levels of Vibrio spp., marine pathogens recently linked to a variety of human health outcomes including necrotizing wound infections (Howard, 1988) (3) These studies attempted to gain power by including subjects from a variety of locations without accounting for variations between beaches. Smaller studies focussing on subgroups (such as snorkelers, windsurfers, and bathers) within a given location have reported a more pronounced effect (Dewailly, 1986; Philipp, 1985; Deitmer, 1990); for example, Dewailly reported a relative risk of 5.5 for symptoms of gastroenteritis among windsurfers at a specific estuarine location.

Using a Cabelli-like approach the New Jersey Department of Health commissioned a large prospective cohort study in the late 1980's to investigate water quality and health outcomes after swimming in fresh and ocean water in that state. 16,089 subjects were recruited from nine ocean and two lake beaches. Again, bathers and non-bathers were identified, interviewed on the beach and telephoned up to 10 days later to ascertain the development of symptoms. Water sampling for bacterial indicators, total and fecal coliforms, enterococcus, C. Perfringens as well as F2 male-specific bacteriophage (developed by Cabelli et al to estimate levels of viral pathogens) was concurrently done. Bathers at all beaches had higher symptom rates than non-bathers (an excess of 12.1 cases per 1000 subjects was reported) even though illness could not be correlated with any elevation of any of the bacterial indicators. However, these findings are not surprising since none of the beaches were located near any areas of heavy urban run-off. The water tested was "generally of high quality"[3] leading the authors to conclude that the observed health effects were "the natural consequences of bathing, not the result of contaminated water".

A number of concerns have been raised about the New Jersey study. (See our original proposal for a detailed description - available from the Santa Monica Bay Restoration Project). Some of the concerns were: (1) The study had little power to detect an association between health effects and sewage contamination. None of the beaches studied were located near heavy urban runoff areas, so that the water tested was "generally of high quality" at all beaches. Little variability in indicator levels was observed between sampling sites, so that the effect of a range of indicators (either within or across beaches) was not assessed. Water samples were collected only at chest depth and not ankle depth; children (at increased risk for symptoms in most studies when compared with adults) wade, play and swim in the near shore areas where their activities and wave action may disturb sediments, releasing absorbed bacteria and virus into the water. (2) The conclusions rely heavily on p-values. Measures of effect, such as risk ratios with confidence intervals, were not calculated. (3) The issue of residual confounding was not addressed; confounding may be due to lack of comparability of exposed and unexposed groups.

Finally, it should be noted that Cabelli-like studies are not the only kind that have been used to investigate health outcomes after immersion in marine water contaminated by sewage. Fleisher, (1993) using a randomized intervention and follow-up design, conducted the first epidemiological study that related indicator organism density to an individual bather. In 1989 and 1990, he recruited 484 subjects from various locations in the United Kingdom. Subjects were given an interview, a physical exam to exclude ongoing illness and then randomly assigned to a bather or non-bather group. On the day of the trial non-bathers were assigned to a roped off beach area while bathers were carefully monitored. Water sampling for elevated bacterial indicators, total and fecal Coliforms as well as enterococcus (in his papers, Fleisher uses the older nomenclature for enterococcus, Streptococcus faecalis) was done at the actual time bathers were in the water. Food consumption habits at the time of the trial were also monitored in order to exclude food-borne illness as a confounder. After the trial, follow-up for GI disease was done through either an interview or a mailed questionnaire. Results showed that only enterococcus cultured from water samples taken from the surface at chest depth was predictive for development of GI symptoms. Fleisher continued the randomized intervention and follow-up studies with more detailed follow-up exams after bathing (1993), the results of which still support enterococcus as the best predictor of GI disease.

As was mentioned, the study design employed here is different in fundamental ways from the study designs commonly employed by other investigators. The major difference between the design used here and the Cabelli-type study design is that all of our analyses were between different groups of swimmers whereas studies employing the Cabelli-type design compare risks between swimmers and non-swimmers. A major challenge with the Cabelli-type design is to ensure comparability between swimmers and non-swimmers. For example, in one of Cabelli's studies, there was an anomalous finding among children of a significantly higher rate of gastrointestinal symptoms for nonbathers relative to bathers at the unpolluted beach, suggesting that the two groups were not comparable. Perhaps parents tended to keep children out of the water who were feeling ill or incubating gastrointestinal illnesses. Differences between persons who choose to bathe and those who do not are difficult to measure and account for in the analysis of such studies (Saliba, 1990). The Cabelli-type design is similar to the one used here in that it is an observational cohort study and it relies on measurements of bacterial indicators that are feasible on a large scale and are similar to those that are commonly practiced by various health agencies. Fleischer (1993) and Kay (1994) have raised additional concerns with this type of study. The major concern deals with measurement errors and misclassification of exposure status due to "failure to control for the substantial amount of temporal and spatial variation in indicator organism densities shown to occur within just a few hours at marine water bathing locations" and the fact that "the microbiological quality of water was not assigned to each bather at the time and place of bathing".

To address the concerns with confounding and misclassification of exposure status, Fleischer and Kay used a very different design. Instead of an observational study, they used a randomized trial wherein subjects were randomly assigned to bathing and non-bathing groups and numerous water samples were taken every half-hour over the exposure period every 20 meters and at three depths (at surf, mid, and chest depths). In principle, if the trial is large enough, randomization should generate a balance between comparison groups ("exposed" and "unexposed") with respect to the distribution of other risk factors for the health outcomes under study. Also, as they argue, the water testing protocol should reduce misclassification of exposure status for individual subjects.

As we see it, with respect to measurement of bacterial indicators, the two approaches are addressing slightly different questions and may be seen, at some level, as complementing each other. The approach taken by Fleischer aims at estimating a more accurate dose-response relationship for indicator counts as they pertain to individuals by reducing misclassification of exposure for individual subjects as it pertains to this objective. This generates interesting, useful data and may detect associations missed by a Cabelli-type approach, but it is also a step further removed from helping to set policy based on bacterial indicators. Given a predictive result generated from this more intense sampling scheme, the policy implication for where, when, and what to monitor for is not obvious, given limited resources of the agencies responsible for monitoring. For example, Kay (1994) suggests that, based on their results, enterococci should replace coliforms as the basis for setting standards and that adverse health effects were identified when concentrations exceeded 32 per 100 ml. It is not so obvious where and when one should monitor for enterococci. Clearly the intense protocol used in the trial is not feasible. If one does less (read less accurate in terms of assessing exposure for a given subject) monitoring, the nature of the dose-response curve probably changes since "dose" is being measured differently. A level of 32 per 100 ml may no longer be associated with the same risk as in the trial. The approach taken by Cabelli addresses more directly the question of whether bacterial indicators, as they are commonly measured by health departments, do in fact predict risk of adverse health effects. If the results of such a study are negative, as they have been in a number of studies with respect to specific indicators, the only appropriate conclusion is that these indicators, **as measured**, do not predict risk. Left unanswered is whether different, perhaps more intense, sampling and measurement protocols would yield different results. If the results are positive, the connection to a monitoring policy is more obvious since the sampling scheme employed in the study is close to the usual monitoring protocol.

Since there is no perfect design for all scientific and policy purposes, we settled on an observational design that would minimize the potential for confounding, which we viewed as a major lingering concern with previous studies. We had doubts about the feasibility and ethics of trying to conduct a randomized trial given the "charged" nature of the debate regarding Santa Monica Bay. Given the observational design, we chose to focus on two questions (Is distance associated with risk of adverse health outcomes? Do bacterial indicators, as they are commonly monitored, predict risk of adverse health outcomes?) that were primarily motivated by policy considerations.

Aside from the emphasis on distance and bacterial indicators, this is the first large scale study of which we are aware that also included measurements of viruses. The standard method, which appeared to be running very well, as judged in part by the excellent recovery rates, detected virus on a number of occasions. Only limited statistical analysis was possible. It was of interest that a number of adverse health effects were reported more often on days when the samples were positive, suggesting assays for viruses may be informative for predicting risk. The research involving gene probes is ongoing. We hope to include the results as an addendum to this report. Cabelli (1982) and Kay (1994) both mention that Norwalk-like viruses are a plausible cause of gastroenteritis. Enteroviruses, the commonest viruses in sewage effluent, can cause respiratory symptoms. As pointed out by Walker (1992), testing for viruses is potentially important. Not only are viruses potentially responsible for many of the symptoms associated with swimming in ocean water but they decay at a slower rate in sea water than bacteria and they can cause infection at a much lower dose.

In summary, we believe that the results of this study are valid for the purposes of addressing the two research questions we posed in the beginning. Distance from the storm drain, particularly swimming in front of the storm drains that we studied, is associated with an increased risk for a relatively broad range of adverse health effects, including HCGI and significant respiratory disease. A number of bacterial indicators, particularly the total coliforms to fecal coliforms ratio and enterococcus, measured in a manner similar to routine monitoring, are also associated with increased risk of adverse health effects. Both sets of results suggest that there is an increased risk of a relatively broad range of symptoms caused by swimming adjacent to the drains at the beach sites included in this study. The estimated attributable numbers, which reached into the 100's per 10,000 exposed subjects, suggest these risks are not trivial when we consider the millions of persons who visit the beaches in Santa Monica Bay. In numerous discussions organized by the SMBRP, prior to the start of this study, an excess risk of 1 case per 100 exposed was generally considered a noteworthy health risk, so the study was designed to detect this level of risk (of course, the relative magnitude of these risks compared to other health risks will be a matter of judgement by interested parties). It is also probable that the risk is higher than we observed in this study since both distance and bacterial indicators are proxy measures of the actual pathogens causing these adverse health effects. It is worth recalling here that we excluded subjects who frequently entered the water at these beaches. We did this so we could link reported outcomes with a specific set of bacterial indicators for the one day and place a subject was in the water, which we needed to address the second research question we posed. If there is a dose-response relationship such that increasing exposure is associated with increasing risk, which seems plausible, then one may conclude that surfers, lifeguards, and other subjects who frequently enter the water and immerse their heads may be at an increased risk of adverse health outcomes (perhaps substantially so) than the relatively infrequent recreational swimmers included in this study. A counter-argument that has been raised is that frequent swimmers may develop an immunity to the pathogens and thereby have a lower risk. This would seem to be an important issue that warrants further study. Surfers would seem to be an appropriate group to study since there are not enough lifeguards at a given beach to achieve the statistical power one needs. The study design would have to be different than the one used here to address the issue of frequent use. Interested readers are referred to the original proposal for this study, where an adjunct study of surfers was presented. We consider the policy implications of the present study to be beyond the scope of this final report. They will be the subject of a separate report issued by the Santa Monica Bay Restoration Project.

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von Schirnding Y, Kfir R, Cabelli V, et al. Morbidity among bathers exposed to polluted seawater. A prospective epidemiologic study. S African Med J 81: 534 (1992).
Walker, A. Swimming - the hazards of taking a dip. Br Med J 304:242-5 (1992).
Am J of Public Health 83:-1706 (1993)

LIST OF VARIABLES

ITEM	RANGE	CODES
BEACH ID	A,M;W	A=ASHLAND,M=MALIBU,W=WILL ROGERS
PARTICIPANT #	1-12500	
RELATION	A,B,C,D,E,F,G,H,I,J	
PRE PRINTED #	1-12500	
BEACH INT MONTH	06-10	06=JUNE,07=JULY,08=AUG,09=SEPT,10=OCT
BEACH INT DAY	1-31	
PHONE INT MONTH	06-10	06=JUNE,07=JULY,08=AUG,09=SEPT,10=OCT
PHONE INT DAY	1-31	
WATER CLEAN?	1-2	1=NO,2=YES
GENDER	1-2	1=FEMALE,2=MALE
AGE	1-9	1=0-12,2=13-18,3=19-25,4=26-35,5=36-45,6=46-55,7=56-65,8=66-75,9=>75
EXACT AGE FOR UNDER 12	1-12	
MAP CODE	1-8	
BEACH INTR #	0-999	
PHONE INTR #	0-999	
Q1 FACE WET	1-2	1=NO FACE NOT WET,2 YES FACE GOT WET
Q2	1-3	1=NO CHILD DID NOT GET FACE WET,2=YES GOT FACE WET,3=DON'T KNOW/REMEBER
Q3.1.A FEVER	1-3	1=NOT HAVE SYMPTON SINCE VISIT,2=YES HAD SYMPTON SINCE VISIT, 3=DK
Q3.1.C FEVER	2	2=EVENT DUE TO BEACH VISIT
Q3.2.A CHILLS	1-3	1=NOT HAVE SYMPTON SINCE VISIT,2=YES HAD SYMPTON SINCE VISIT, 3=DK
Q3.2.C CHILLS	2	2=EVENT DUE TO BEACH VISIT
Q3.3.A EYE DISCHARGE	1-3	1=NOT HAVE SYMPTON SINCE VISIT,2=YES HAD SYMPTON SINCE VISIT, 3=DK
Q3.3.B EYE DISCHARGE	1-3	1=NOT HAD SYMPTON BEFORE VISIT,2=YES HAD SYMPTOM BFORE VISIT, 3=DK
Q3.3.C EYE DISCHARGE	2	2=EVENT DUE TO BEACH VISIT
Q3.4.A EARACHE	1-3	1=NOT HAVE SYMPTON SINCE VISIT,2=YES HAD SYMPTON SINCE VISIT, 3=DK
Q3.4.B EARACHE	1-3	1=NOT HAD SYMPTON BEFORE VISIT,2=YES HAD SYMPTOM BFORE VISIT, 3=DK
Q3.4.C EARACHE	2	2=EVENT DUE TO BEACH VISIT
Q3.5.A EAR DISCHARGE	1-3	1=NOT HAVE SYMPTON SINCE VISIT,2=YES HAD SYMPTON SINCE VISIT, 3=DK
Q3.5.B EAR DISCHARGE	1-3	1=NOT HAD SYMPTON BEFORE VISIT,2=YES HAD SYMPTOM BFORE VISIT, 3=DK
Q3.5.C EAR DISHCARGE	2	2=EVENT DUE TO BEACH VISIT
Q3.6.A SKIN RASH	1-3	1=NOT HAVE SYMPTON SINCE VISIT,2=YES HAD SYMPTON SINCE VISIT, 3=DK
Q3.6.B SKIN RASH	1-3	1=NOT HAD SYMPTON BEFORE VISIT,2=YES HAD SYMPTOM BFORE VISIT, 3=DK
Q3.6.C SKIN RASH	2	2=EVENT DUE TO BEACH VISIT
Q3.7.A INFECTED CUT	1-3	1=NOT HAVE SYMPTON SINCE VISIT,2=YES HAD SYMPTON SINCE VISIT, 3=DK
Q3.7.B INFECTED CUT	1-3	1=NOT HAD SYMPTON BEFORE VISIT,2=YES HAD SYMPTOM BFORE VISIT, 3=DK
Q3.7.C INFECTED CUT	2	2=EVENT DUE TO BEACH VISIT

LIST OF VARIABLES

Q3.8.A NAUSEA	1-3	1=NOT HAVE SYMPTON SINCE VISIT,2=YES HAD SYMPTON SINCE VISIT, 3=DK
Q3.8.B NAUSEA	1-3	1=NOT HAD SYMPTON BEFORE VISIT,2=YES HAD SYMPTOM BFORE VISIT, 3=DK
Q3.8.C NAUSEA	2	2=EVENT DUE TO BEACH VISIT
Q3.9.A VOMITING	1-3	1=NOT HAVE SYMPTON SINCE VISIT,2=YES HAD SYMPTON SINCE VISIT, 3=DK
Q3.9.B VOMITING	1-3	1=NOT HAD SYMPTON BEFORE VISIT,2=YES HAD SYMPTOM BFORE VISIT, 3=DK
Q3.9.C VOMITING	2	2=EVENT DUE TO BEACH VISIT
Q3.10.A DIARRHEA	1-3	1=NOT HAVE SYMPTON SINCE VISIT,2=YES HAD SYMPTON SINCE VISIT, 3=DK
Q3.10.B DIARRHEA	1-3	1=NOT HAD SYMPTON BEFORE VISIT,2=YES HAD SYMPTOM BFORE VISIT, 3=DK
Q3.10.C DIARRHEA	2	2=EVENT DUE TO BEACH VISIT
Q3.11.A DIARRHEA W/ BLOOD	1-3	1=NOT HAVE SYMPTON SINCE VISIT,2=YES HAD SYMPTON SINCE VISIT, 3=DK
Q3.11.B DIARRHEA W/ BLOOD	1-3	1=NOT HAD SYMPTON BEFORE VISIT,2=YES HAD SYMPTOM BFORE VISIT, 3=DK
Q3.11.C DIARRHEA W/ BLOOD	2	2=EVENT DUE TO BEACH VISIT
Q3.12.A STOMACH PAIN	1-3	1=NOT HAVE SYMPTON SINCE VISIT,2=YES HAD SYMPTON SINCE VISIT, 3=DK
Q3.12.B STOMACH PAIN	1-3	1=NOT HAD SYMPTON BEFORE VISIT,2=YES HAD SYMPTOM BFORE VISIT, 3=DK
Q3.12.C STOMACH PAIN	2	2=EVENT DUE TO BEACH VISIT
Q3.13.A COUGHING	1-3	1=NOT HAVE SYMPTON SINCE VISIT,2=YES HAD SYMPTON SINCE VISIT, 3=DK
Q3.13.B COUGHING	1-3	1=NOT HAD SYMPTON BEFORE VISIT,2=YES HAD SYMPTOM BFORE VISIT, 3=DK
Q3.13.C COUGHING	2	2=EVENT DUE TO BEACH VISIT
Q3.14.A COUGH W/ PHLEGM	1-3	1=NOT HAVE SYMPTON SINCE VISIT,2=YES HAD SYMPTON SINCE VISIT, 3=DK
Q3.14.B COUGH W/ PHLEGM	1-3	1=NOT HAD SYMPTON BEFORE VISIT,2=YES HAD SYMPTOM BFORE VISIT, 3=DK
Q3.14.C COUGH W/ PHLEGM	2	2=EVENT DUE TO BEACH VISIT
Q3.15.A RUNNY NOSE/CONGES	1-3	1=NOT HAVE SYMPTON SINCE VISIT,2=YES HAD SYMPTON SINCE VISIT, 3=DK
Q3.15.B RUNNY NOSE/CONGES	1-3	1=NOT HAD SYMPTON BEFORE VISIT,2=YES HAD SYMPTOM BFORE VISIT, 3=DK
Q3.15.C RUNNY NOSE/CONGES	2	2=EVENT DUE TO BEACH VISIT
Q3.16.A SORE THROAT	1-3	1=NOT HAVE SYMPTON SINCE VISIT,2=YES HAD SYMPTON SINCE VISIT, 3=DK
Q3.16.B SORE THROAT	1-3	1=NOT HAD SYMPTON BEFORE VISIT,2=YES HAD SYMPTOM BFORE VISIT, 3=DK
Q3.16.C SORE THROAT	2	2=EVENT DUE TO BEACH VISIT
Q4 WORRIED ABOUT HAZARD	1-4	1=NOT AT ALL WORRIED,2=SOMEWHAT WORRIED,3=A LITTLE WORRIED,4=VERY WORRIED
Q5 ETHNIC BACKGROUND	1-6	1=WHITE,2=BLACK,3=LATINO,4=ASIAN,5=MULTI-ETHNIC,6=OTHER
Q6 ZIP CODE	0-99999	
MEDIAN INCOME FOR ZIP		MEDIAN HOUSEHOLD INCOME FOR RESPONDENTS ZIP CODE
RECODED AGE	1-2	1=0-12,2=>12
RECODED MAP AREA	1-2	1=DIRTY (AREAS 0/3/4/5/6),2=CLEAN (AREAS 1/8)
E COLI FROM SAMPLE AREA1		
E COLI FROM SAMPLE AREA2		
E COLI FROM SAMPLE AREA3		
E COLI FROM SAMPLE AREA4		

LIST OF VARIABLES

E COLI FROM SAMPLE AREA5		
ENTEROCOCCUS AREA1		
ENTEROCOCCUS AREA2		
ENTEROCOCCUS AREA3		
ENTEROCOCCUS AREA4		
ENTEROCOCCUS AREA5		
FECAL COLIFORMS AREA1		
FECAL COLIFORMS AREA2		
FECAL COLIFORMS AREA3		
FECAL COLIFORMS AREA4		
FECAL COLIFORMS AREA5		
TOTAL COLIFORMS AREA1		
TOTAL COLIFORMS AREA2		
TOTAL COLIFORMS AREA3		
TOTAL COLIFORMS AREA4		
TOTAL COLIFORMS AREA5		
FLOW		
FAMILY SIZE		1=INDIVIDUAL,2-9=FAMILY SIZE
HCGI_1		
HCGI_2		
SRD		

Table 1. Completed Interviews by Beach Interview Date

JUNE

	22	23	24	25	26	27	28	29	30	total
Ashland	15	4	61	103	16	19	22	34	20	294
Malibu	3	5	39	36	2	28	13	20	15	161
W Rogers	8	0	13	17	5	11	2	9	13	78
total	26	9	113	156	23	58	37	63	48	533

JULY

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	monthly total
Ashland	114	159	108	133	20	31	52	72	238	43	75	45	46	50	115	41	42	31	39	21	54	181	338	32	29	55	69	51	265	244	31	2824
Malibu	32	70	15	31	21	18	23	37	66	39	22	39	62	40	81	61	43	29	49	32	61	62	139	41	31	38	58	38	196	135	37	1614
W Rogers	38	43	39	31	10	10	21	18	34	34	37	27	37	30	69	26	13	2	20	28	26	45	84	57	13	9	8	30	58	138	18	1053
total	184	272	162	195	51	59	96	127	338	116	134	111	145	120	265	128	98	62	108	81	141	288	561	130	73	102	135	119	519	517	86	5523

AUGUST

BEACH	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	monthly total
Ashland	17	13	29	20	72	203	16	29	12	47	40	166	287	24	22	11	17	21	121	99	18	16	25	18	32	116	151	49	18	37	8	1754
Malibu	51	21	19	18	57	117	20	52	77	35	74	139	101	43	25	19	32	60	117	71	26	21	31	56	21	66	134	30	31	2	45	1611
W Rogers	3		5	7	70	25	29	26	9	32	41	56	56	8	7	2	1	21	10	16	4	0	1	7	8	33	36	3	7	12	6	541
total	71	34	53	45	199	345	65	107	98	114	155	361	444	75	54	32	50	102	248	186	48	37	57	81	61	215	321	82	56	51	59	3906

SEPTEMBER

BEACH	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	monthly total
Ashland	38	118	346	357					21	77						29	20						23	19								1048
Malibu	13	126	150	245					21	30						26	24							15								650
W Rogers	16	28	62	27																												133
total	67	272	558	629	0	0	0	0	42	107	0	0	0	0	0	55	44	0	0	0	0	0	23	34	0	0	0	0	0	0	0	1831
																																11793

Figure 1. Study Eligibles

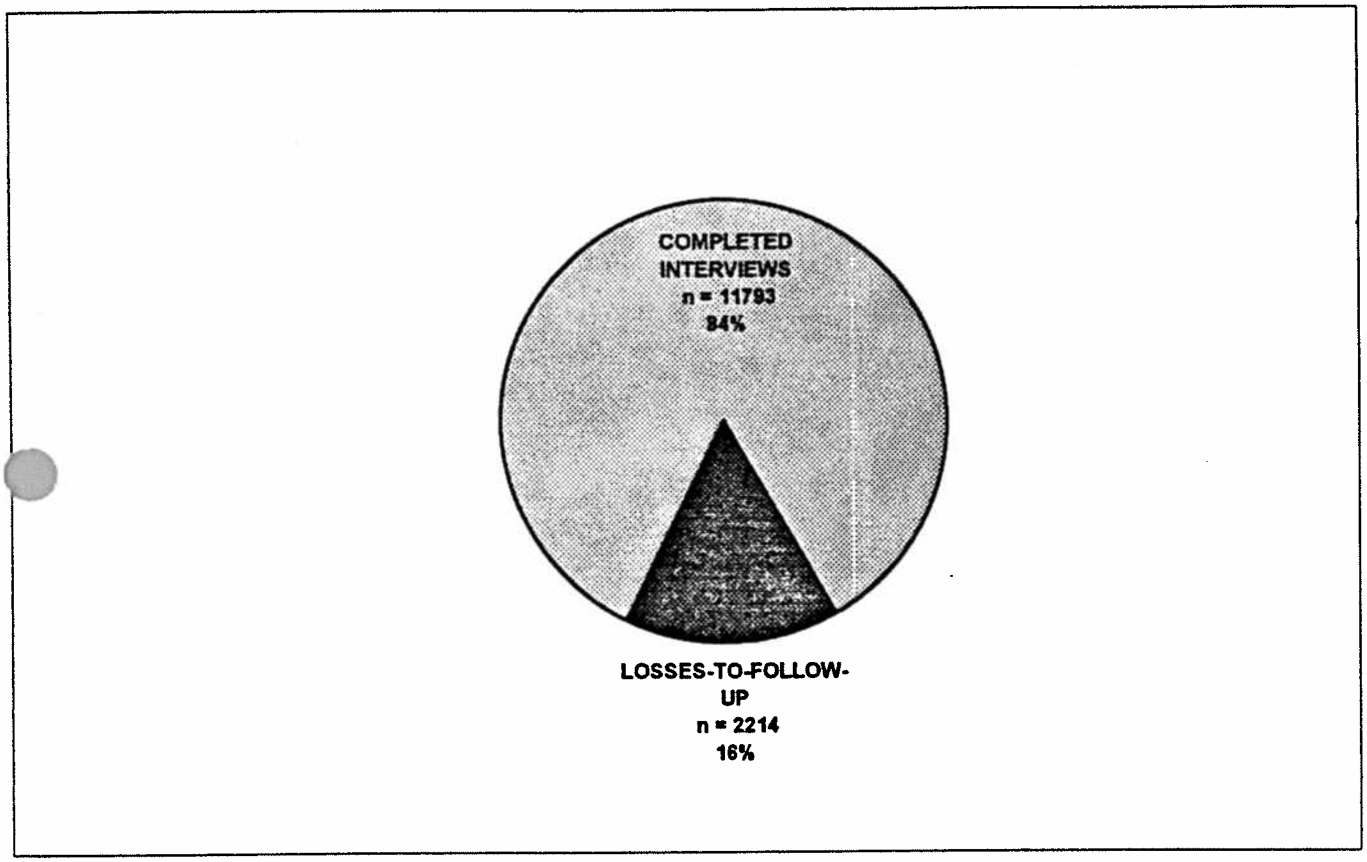
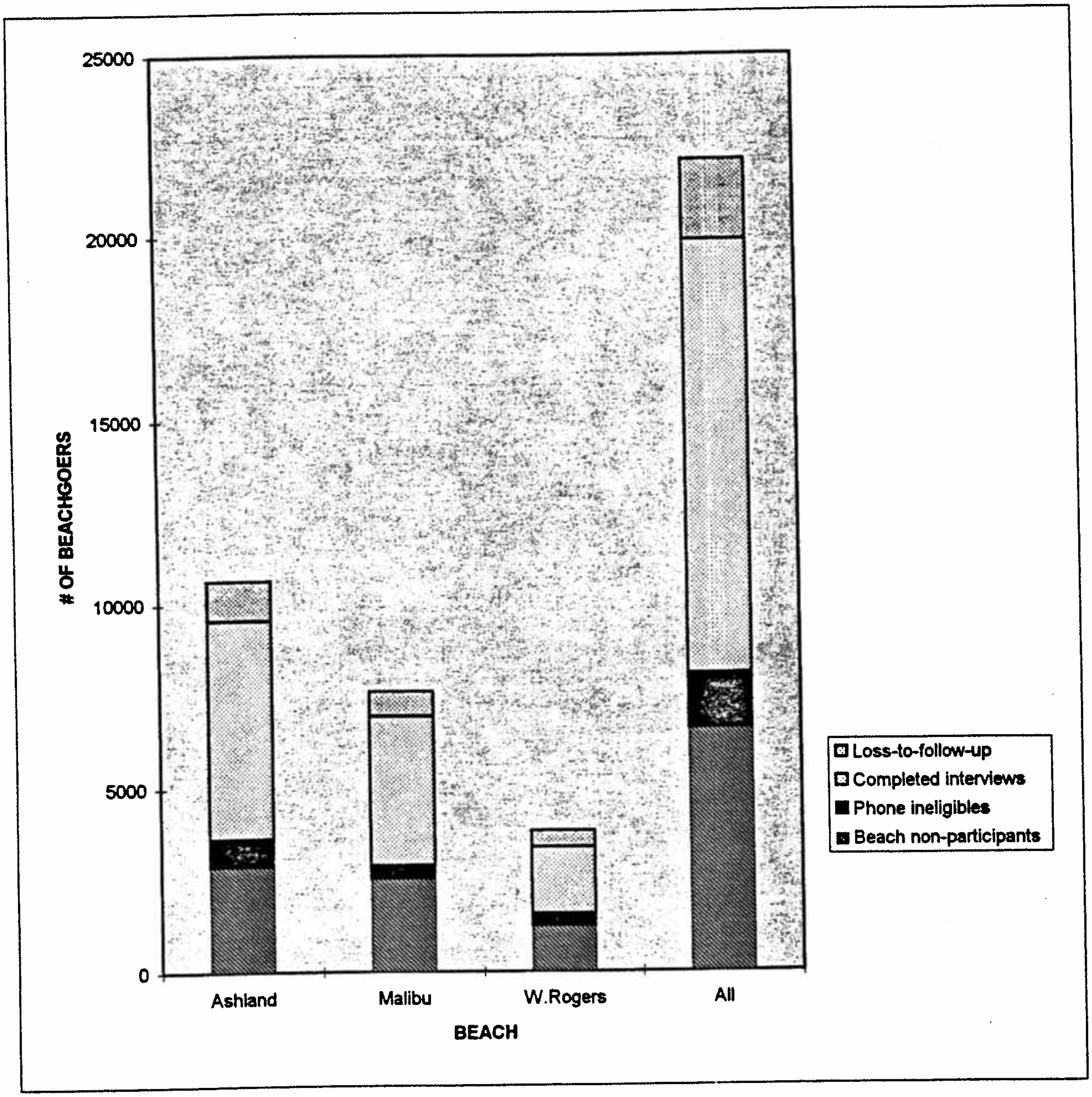


Figure 2. Beach Encounters by Beach



	Ashland	Malibu	W.Rogers	All
Beach non-participants (incl. ineligibles)	2862 (27%)	2508 (33%)	1223 (32%)	6593 (30%)
Phone ineligibles (back to beach)	766 (7%)	380 (5%)	339 (9%)	1485 (7%)
Completed interviews	5920 (56%)	4067 (53%)	1806 (47%)	11793 (53%)
Losses-to-follow-up	1078 (10%)	681 (9%)	455 (12%)	2214 (10%)
	10626	7636	3823	22085

Table 2. Reasons for Non-Participation at the Beach (All Beaches)

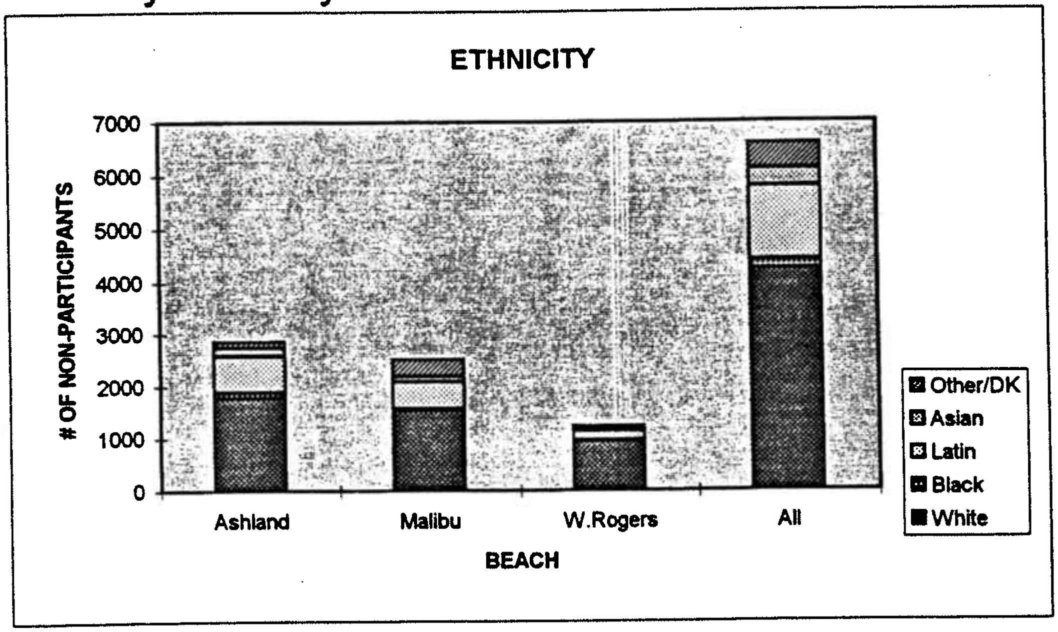
		%	*% of all beach encounters*
Ineligible (been to beach)	3681	56	*17*
Refusal	1761	27	*8*
Language difficulty	648	10	*3*
No telephone	503	8	*2*
	6593	101*	*30*

Table 3. Reasons for Non-Actualized Telephone Interviews (All Beaches)

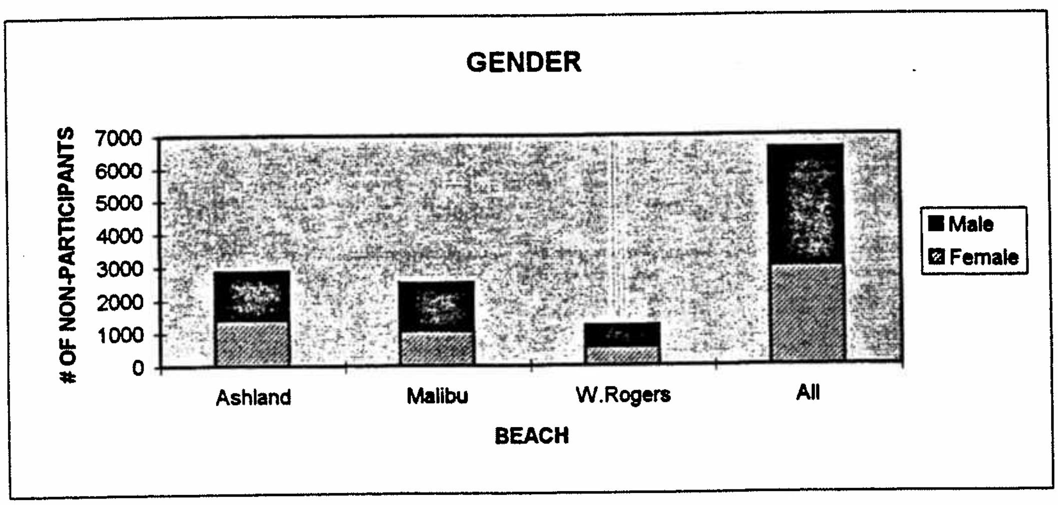
		%	*% of all beach interviews*
Ineligible (back to beach)	1485	40	*10*
Wrong number/disconnect	1170	32	*8*
Answering machine	504	14	*3*
No answer	283	8	*2*
Other reason (moved, etc.)	235	6	*1*
Refusal	22	1	*0*
	3699	101*	*24*

* Does not add to 100% due to rounding.

Figure 3. Non-Participation (Including Ineligibles) at 3 Beaches by Ethnicity and Gender*



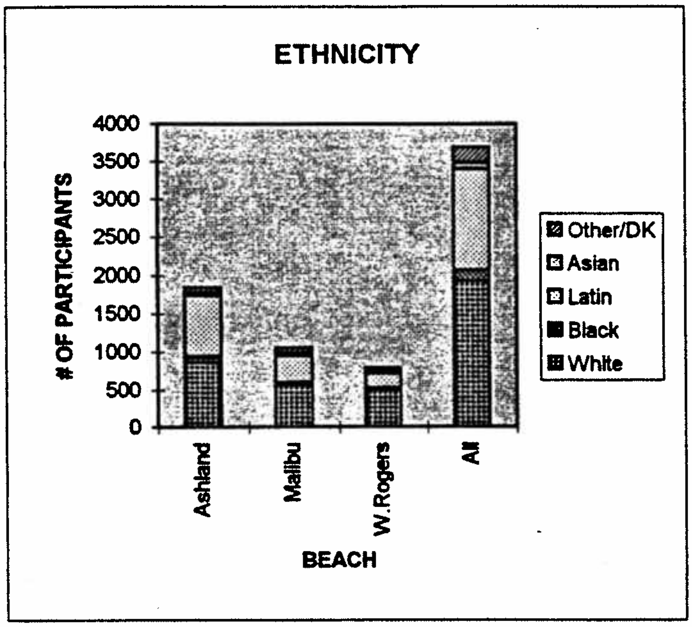
	Ashland	Malibu	W.Rogers	All
White	1768 (62%)	1530 (61%)	930 (76%)	4228 (64%)
Black	123 (4%)	31 (1%)	28 (2%)	182 (3%)
Latin	691 (24%)	509 (20%)	172 (14%)	1372 (21%)
Asian	151 (5%)	113 (5%)	55 (4%)	319 (5%)
Other/DK	129 (4%)	325 (13%)	38 (3%)	492 (7%)



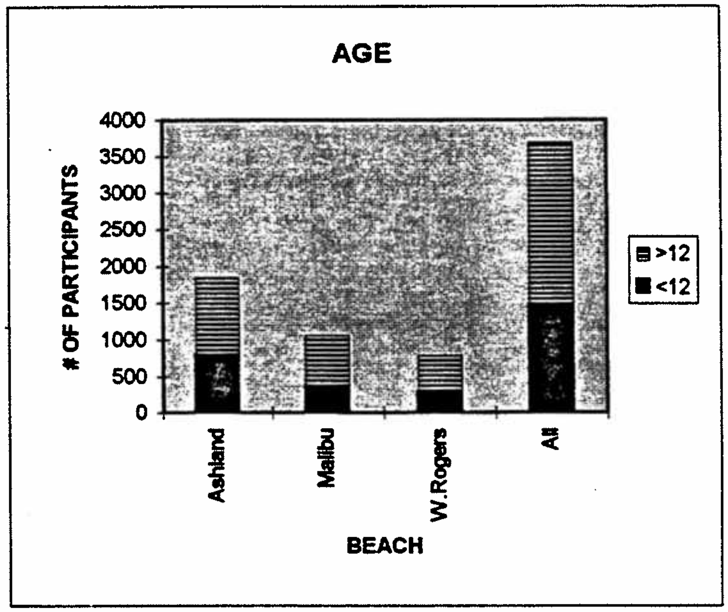
	Ashland	Malibu	W.Rogers	All
Female	1384 (48%)	1057 (42%)	559 (46%)	3000 (46%)
Male	1478 (52%)	1451 (58%)	664 (54%)	3593 (54%)

* Children younger than 12 were not tallied.

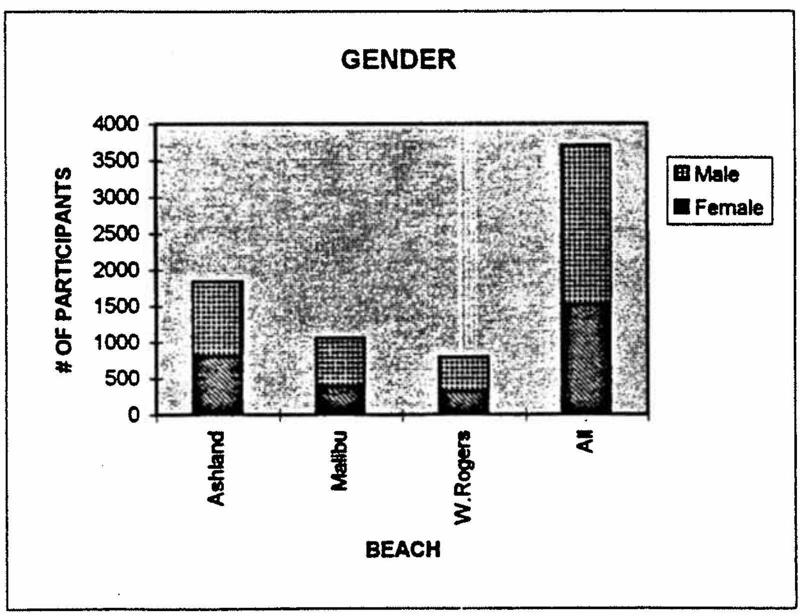
Figure 4. Non-Actualized Telephone Interviews from 3 Beaches by Ethnicity, Age and Gender



	Ashland	Malibu	W.Rogers	All
White	856 (46%)	569 (54%)	505 (64%)	1930 (52%)
Black	88 (5%)	29 (3%)	17 (2%)	134 (4%)
Latin	87 (43%)	353 (33%)	194 (24%)	1334 (36%)
Asian	38 (2%)	31 (3%)	19 (2%)	88 (2%)
Other/DK	75 (4%)	79 (7%)	59 (7%)	213 (6%)



	Ashland	Malibu	W.Rogers	All
≤12	812 (44%)	381 (36%)	299 (38%)	1492(40%)
>12	1032 (56%	680 (64%)	495 (62%)	2207(60%)



	Ashland	Malibu	W.Rogers	All
Female	803 (44%)	392 (37%)	316 (40%)	1511 (41%)
Male	1041(56%)	669 (63%)	478 (60%)	2188 (59%)

Table 4. Beach Study Respondent Characteristics

Proximity to Drain

BEACH	0-100 Yds	>400 Yds	RATIO
Ashland	4388	1532	2.9:1
Malibu	3034	1033	2.9:1
W Rogers	1310	496	2.6:1
	8732	3061	2.9:1

Family Size

BEACH	individuals			family members			totals		
Ashland	1115	(19%)	{43%}	4805	(81%)	{52%}	5920 (100%)		{50%}
Malibu	920	(23%)	{36%}	3147	(77%)	{34%}	4067 (100%)		{34%}
W Rogers	547	(30%)	{21%}	1259	(70%)	{14%}	1806 (100%)		{15%}
	2582	(22%)	{100%}	9211	(78%)	{100%}	11793 (100%)	*	{100%} †

SES based on zip code (California only)

BEACH	<=25000			>25000			totals	
Ashland	655	(13%)	{64%}	4583	(87%)	{50%}	5238 (100%)	{51%}
Malibu	238	(7%)	{23%}	3142	(93%)	{34%}	3380 (100%)	{33%}
W Rogers	128	(8%)	{13%}	1464	(92%)	{16%}	1592 (100%)	{16%}
	1021	(10%)	{100%}	9189	(90%)	{100%}	10210 (100%)	{100%}

Residency based on zip code

BEACH	CA resident			Outside CA			totals	
Ashland	5341	(90%)	{51%}	579	(10%)	{42%}	5920 (100%)	{50%}
Malibu	3472	(85%)	{33%}	595	(15%)	{43%}	4067 (100%)	{34%}
W Rogers	1612	(89%)	{15%}	194	(11%)	{14%}	1806 (100%)	{15%}
	10425	(88%)	{100%}	1368	(12%)	{100%}	11793 (100%)	{100%}

* ( ) row percentages
† { } column percentages

Table 5. Beach Study Respondent Characteristics vs. PEPS

Beach Study Respondents

AGE		
0-12	5,718	48%
13-18	1,772	15%
19-25	1,213	10%
26-35	1,688	14%
36-45	994	8%
46-55	314	3%
56-65	61	1%
66-75	30	0%
>75	3	0%
	11,793	

PEPS*

AGE		
0-14	2,074,678	22%
14-19	539,427	6%
20-24	653,813	7%
25-34	1,746,236	19%
35-44	1,583,407	17%
45-54	1,043,714	11%
55-64	668,540	7%
65-74	538,028	6%
>75	392,559	4%
	9,240,402	

Beach Study Respondents

AGE		
<=12	5,718	48%
13-25	2,985	25%
>=26	3,090	26%

PEPS

AGE		
>=14	2,074,678	22%
15-24	1,193,240	13%
>=25	5,972,484	65%

*Population Estimation and Projection System (Los Angeles County, 1993)

Table 5, cont. Beach Study Respondent Characteristics vs. PEPS

Beach Study Respondents

GENDER		
female	5,319	45%
male	6,474	55%

PEPS*

GENDER		
female	4,726,498	50%
male	4,713,953	50%

Beach Study Respondents

ETHNICITY		
White	5,295	45%
Black	367	3%
Latino	5,103	43%
Asian/other	1,028	9%

PEPS

ETHNICITY		
White	3,414,147	36%
Black	938,202	10%
Latino	3,871,909	41%
Asian/other	1,216,192	13%

*Population Estimation and Projection System (Los Angeles County, 1993)

Table 6. Respondent Age by Map Area for Each Beach

Ashland								
Map Area*	0-12		13-25		>=26		totals	
drain	91 (59%)	{3%}	23 (15%)	{2%}	40 (26%)	{3%}	154 (100%)	{3%}
1-50 down	656 (54%)	{21%}	234 (19%)	{17%}	318 (26%)	{11%}	1208 (100%)	{20%}
1-50 up	688 (51%)	{22%}	353 (26%)	{25%}	309 (23%)	{12%}	1350 (100%)	{23%}
51-100 down	216 (48%)	{7%}	122 (27%)	{9%}	114 (25%)	{5%}	452 (100%)	{8%}
51-100 up	588 (48%)	{19%}	321 (26%)	{23%}	315 (26%)	{15%}	1224 (100%)	{21%}
400+ down	105 (57%)	{3%}	44 (24%)	{3%}	36 (19%)	{2%}	185 (100%)	{3%}
400+ up	714 (53%)	{23%}	309 (23%)	{22%}	324 (24%)	{17%}	1347 (100%)	{23%}
	3058 (52%)	{100%}	1406 (24%)	{100%}	1456 (25%)	{100%}	5920 (100%) †	{100%} ‡

Malibu								
Map Area	0-12		13-25		>=26		totals	
drain	390 (65%)	{21%}	119 (20%)	{11%}	94 (16%)	{9%}	603 (100%)	{15%}
1-50 down	124 (35%)	{7%}	117 (33%)	{11%}	111 (32%)	{5%}	352 (100%)	{9%}
1-50 up	412 (39%)	{22%}	337 (32%)	{31%}	310 (29%)	{16%}	1059 (100%)	{26%}
51-100 down	85 (39%)	{5%}	75 (35%)	{7%}	57 (26%)	{3%}	217 (100%)	{5%}
51-100 up	362 (45%)	{19%}	196 (24%)	{18%}	245 (31%)	{15%}	803 (100%)	{20%}
400+ down	457 (48%)	{24%}	237 (25%)	{21%}	252 (27%)	{19%}	946 (100%)	{23%}
400+ up	49 (56%)	{3%}	22 (25%)	{2%}	16 (18%)	{1%}	87 (100%)	{2%}
	1879 (46%)	{100%}	1103 (27%)	{100%}	1085 (27%)	{100%}	4067 (100%)	{100%}

Will Rogers								
Map Area	0-12		13-25		>=26		totals	
drain	50 (57%)	{6%}	22 (25%)	{5%}	16 (18%)	{3%}	88 (100%)	{5%}
1-50 down	155 (40%)	{20%}	102 (27%)	{21%}	127 (33%)	{23%}	384 (100%)	{21%}
1-50 up	80 (40%)	{10%}	46 (23%)	{10%}	76 (38%)	{14%}	202 (100%)	{11%}
51-100 down	182 (39%)	{23%}	138 (30%)	{29%}	145 (31%)	{26%}	465 (100%)	{26%}
51-100 up	57 (33%)	{7%}	41 (24%)	{9%}	73 (43%)	{13%}	171 (100%)	{9%}
400+ down	234 (52%)	{30%}	115 (26%)	{24%}	99 (22%)	{18%}	448 (100%)	{25%}
400+ up	23 (48%)	{3%}	12 (25%)	{3%}	13 (27%)	{2%}	48 (100%)	{3%}
	781 (43%)	{100%}	476 (26%)	{100%}	549 (30%)	{100%}	1806 (100%)	{100%}

* down = downcoast; up = upcoast
( ) row percentages
{ } column percentages

Table 7. Respondent Gender by Map Area for Each Beach

Ashland								
Map Area*	female			male			totals	
drain	87	(56%)	{3%}	67	(44%)	{2%}	154 (100%)	{3%}
1-50 down	553	(46%)	{20%}	655	(54%)	{21%}	1208 (100%)	{20%}
1-50 up	642	(48%)	{23%}	708	(52%)	{22%}	1350 (100%)	{23%}
51-100 down	212	(47%)	{8%}	240	(53%)	{8%}	452 (100%)	{8%}
51-100 up	548	(45%)	{20%}	676	(55%)	{21%}	1224 (100%)	{21%}
400+ down	75	(41%)	{3%}	110	(59%)	{3%}	185 (100%)	{3%}
400+ up	629	(47%)	{23%}	718	(53%)	{23%}	1347 (100%)	{23%}
	2746	(46%)	{100%}	3174	(54%)	{100%}	5920 (100%) †	{100%} ‡

Malibu								
Map Area	female			male			totals	
drain	271	(45%)	{15%}	332	(55%)	{15%}	603 (100%)	{15%}
1-50 down	124	(35%)	{7%}	228	(65%)	{10%}	352 (100%)	{9%}
1-50 up	457	(43%)	{25%}	602	(57%)	{26%}	1059 (100%)	{26%}
51-100 down	86	(40%)	{5%}	131	(60%)	{6%}	217 (100%)	{5%}
51-100 up	366	(46%)	{20%}	437	(54%)	{19%}	803 (100%)	{20%}
400+ down	452	(48%)	{25%}	494	(52%)	{22%}	946 (100%)	{23%}
400+ up	38	(44%)	{2%}	49	(56%)	{2%}	87 (100%)	{2%}
	1794	(44%)	{100%}	2273	(56%)	{100%}	4067 (100%)	{100%}

Will Rogers								
Map Area	female			male			totals	
drain	42	(48%)	{5%}	46	(52%)	{4%}	88 (100%)	{5%}
1-50 down	164	(43%)	{21%}	220	(57%)	{21%}	384 (100%)	{21%}
1-50 up	85	(42%)	{11%}	117	(58%)	{11%}	202 (100%)	{11%}
51-100 down	186	(40%)	{24%}	279	(60%)	{27%}	465 (100%)	{26%}
51-100 up	85	(50%)	{11%}	86	(50%)	{8%}	171 (100%)	{9%}
400+ down	202	(45%)	{26%}	246	(55%)	{24%}	448 (100%)	{25%}
400+ up	15	(31%)	{2%}	33	(69%)	{3%}	48 (100%)	{3%}
	779	(43%)	{100%}	1027	(57%)	{100%}	1806 (100%)	{100%}

* down = downcoast; up = upcoast
† ( ) row percentages
‡ { } column percentages

Table 8. Respondent Ethnicity by Map Area for Each Beach

Map Area*	Ashland													
	White		Black		Latino		Asian		multi		other		totals	
drain	28 (18%)	{1%}	8 (5%)	{3%}	108 (70%)	{4%}	4 (3%)	{2%}	4 (3%)	{2%}	2 (1%)	{2%}	154 (100%)	{3%}
1-50 down	464 (38%)	{21%}	52 (4%)	{19%}	558 (46%)	{20%}	65 (5%)	{31%}	39 (3%)	{21%}	30 (2%)	{23%}	1208 (100%)	{20%}
1-50 up	457 (34%)	{20%}	60 (4%)	{22%}	725 (54%)	{25%}	35 (3%)	{17%}	49 (4%)	{26%}	24 (2%)	{18%}	1350 (100%)	{23%}
51-100 down	207 (46%)	{9%}	20 (4%)	{7%}	186 (41%)	{7%}	21 (5%)	{10%}	8 (2%)	{4%}	10 (2%)	{8%}	452 (100%)	{8%}
51-100 up	471 (38%)	{21%}	55 (4%)	{20%}	590 (48%)	{21%}	38 (3%)	{18%}	46 (4%)	{24%}	24 (2%)	{18%}	1224 (100%)	{21%}
400+ down	71 (38%)	{3%}	12 (6%)	{4%}	82 (44%)	{3%}	1 (1%)	{0%}	13 (7%)	{7%}	6 (3%)	{5%}	185 (100%)	{3%}
400+ up	564 (42%)	{25%}	64 (5%)	{24%}	609 (45%)	{21%}	45 (3%)	{22%}	31 (2%)	{16%}	34 (3%)	{26%}	1347 (100%)	{23%}
	2262 (38%)	{100%}	271 (5%)	{100%}	2858 (48%)	{100%}	209 (4%)	{100%}	190 (3%)	{100%}	130 (2%)	{100%}	5920 (100%) †	{100%} ‡

Map Area	Malibu													
	White		Black		Latino		Asian		multi		other		totals	
drain	231 (38%)	{11%}	5 (1%)	{10%}	337 (56%)	{21%}	13 (2%)	{10%}	11 (2%)	{10%}	5 (1%)	{5%}	602 (100%)	{15%}
1-50 down	161 (46%)	{8%}	3 (1%)	{6%}	157 (45%)	{10%}	7 (2%)	{6%}	11 (3%)	{10%}	13 (4%)	{14%}	352 (100%)	{9%}
1-50 up	499 (47%)	{24%}	24 (2%)	{49%}	459 (43%)	{28%}	25 (2%)	{20%}	22 (2%)	{20%}	27 (3%)	{29%}	1056 (100%)	{26%}
51-100 down	132 (61%)	{6%}	0 (0%)	{0%}	67 (31%)	{4%}	4 (2%)	{3%}	7 (3%)	{6%}	7 (3%)	{8%}	217 (100%)	{5%}
51-100 up	450 (56%)	{22%}	2 (0%)	{4%}	271 (34%)	{17%}	50 (6%)	{40%}	11 (1%)	{10%}	19 (2%)	{20%}	803 (100%)	{20%}
400+ down	535 (57%)	{26%}	15 (2%)	{31%}	300 (32%)	{18%}	25 (3%)	{20%}	49 (5%)	{44%}	22 (2%)	{24%}	946 (100%)	{23%}
400+ up	36 (41%)	{2%}	0 (0%)	{0%}	50 (57%)	{3%}	1 (1%)	{1%}	0 (0%)	{0%}	0 (0%)	{0%}	87 (100%)	{2%}
	2044 (50%)	{100%}	49 (1%)	{100%}	1641 (40%)	{100%}	125 (3%)	{100%}	111 (3%)	{100%}	93 (2%)	{100%}	4063 (100%)	{100%}

Map Area	Will Rogers													
	White		Black		Latino		Asian		multi		other		totals	
drain	22 (25%)	{2%}	3 (3%)	{6%}	57 (65%)	{9%}	4 (5%)	{7%}	2 (2%)	{3%}	0 (0%)	{0%}	88 (100%)	{5%}
1-50 down	173 (45%)	{17%}	6 (2%)	{13%}	171 (45%)	{28%}	13 (3%)	{22%}	16 (4%)	{27%}	5 (1%)	{10%}	384 (100%)	{21%}
1-50 up	107 (53%)	{11%}	13 (6%)	{28%}	66 (33%)	{11%}	5 (2%)	{9%}	7 (3%)	{12%}	4 (2%)	{8%}	202 (100%)	{11%}
51-100 down	277 (60%)	{28%}	13 (3%)	{28%}	119 (26%)	{20%}	18 (4%)	{31%}	19 (4%)	{32%}	19 (4%)	{39%}	465 (100%)	{26%}
51-100 up	105 (61%)	{11%}	0 (0%)	{0%}	47 (27%)	{8%}	10 (6%)	{17%}	4 (2%)	{7%}	5 (3%)	{10%}	171 (100%)	{9%}
400+ down	277 (62%)	{28%}	11 (2%)	{23%}	127 (28%)	{21%}	7 (2%)	{12%}	10 (2%)	{17%}	16 (4%)	{33%}	448 (100%)	{25%}
400+ up	28 (58%)	{3%}	1 (2%)	{2%}	17 (35%)	{3%}	1 (2%)	{2%}	1 (2%)	{2%}	0 (0%)	{0%}	48 (100%)	{3%}
	989 (55%)	{100%}	47 (3%)	{100%}	604 (33%)	{100%}	58 (3%)	{100%}	59 (3%)	{100%}	49 (3%)	{100%}	1806 (100%)	{100%}

* down = downcoast; up = upcoast

† ( ) row percentages

‡ { } column percentages

Table 9. Age, Gender and Ethnicity by Map Area For All Beaches

	beach											
Map Area*	Ashland			Malibu			Will Rogers			totals		
drain	154	(18%)	{3%}	603	(71%)	{15%}	88	(10%)	{5%}	845	(100%)	{7%}
1-50 down	1208	(62%)	{20%}	352	(18%)	{9%}	384	(20%)	{21%}	1944	(100%)	{16%}
1-50 up	1350	(52%)	{23%}	1059	(41%)	{26%}	202	(8%)	{11%}	2611	(100%)	{22%}
51-100 down	452	(40%)	{8%}	217	(19%)	{5%}	465	(41%)	{26%}	1134	(100%)	{10%}
51-100 up	1224	(56%)	{21%}	803	(37%)	{20%}	171	(8%)	{9%}	2198	(100%)	{19%}
400+ down	185	(12%)	{3%}	946	(60%)	{23%}	448	(28%)	{25%}	1579	(100%)	{13%}
400+ up	1347	(91%)	{23%}	87	(6%)	{2%}	48	(3%)	{3%}	1482	(100%)	{13%}
	5920	(50%)	{100%}	4067	(34%)	{100%}	1806	(15%)	{100%}	11793	(100%) †	{100%} ‡

	age											
Map Area	0-12			13-25			>=26			totals		
drain	531	(63%)	{9%}	164	(19%)	{5%}	150	(18%)	{5%}	845	(100%)	{7%}
1-50 down	935	(48%)	{16%}	453	(23%)	{15%}	556	(29%)	{18%}	1944	(100%)	{16%}
1-50 up	1180	(45%)	{21%}	736	(28%)	{25%}	695	(27%)	{22%}	2611	(100%)	{22%}
51-100 down	483	(43%)	{8%}	335	(30%)	{11%}	316	(28%)	{10%}	1134	(100%)	{10%}
51-100 up	1007	(46%)	{18%}	558	(25%)	{19%}	633	(29%)	{20%}	2198	(100%)	{19%}
400+ down	796	(50%)	{14%}	396	(25%)	{13%}	387	(25%)	{13%}	1579	(100%)	{13%}
400+ up	786	(53%)	{14%}	343	(23%)	{11%}	353	(24%)	{11%}	1482	(100%)	{13%}
	5718	(48%)	{100%}	2985	(25%)	{100%}	3090	(26%)	{100%}	11793	(100%)	{100%}

	gender								
Map Area	female			male			totals		
drain	400	(47%)	{8%}	445	(53%)	{7%}	845	(100%)	{7%}
1-50 down	841	(43%)	{16%}	1103	(57%)	{17%}	1944	(100%)	{16%}
1-50 up	1184	(45%)	{22%}	1427	(55%)	{22%}	2611	(100%)	{22%}
51-100 down	484	(43%)	{9%}	650	(57%)	{10%}	1134	(100%)	{10%}
51-100 up	999	(45%)	{19%}	1199	(55%)	{19%}	2198	(100%)	{19%}
400+ down	729	(46%)	{14%}	850	(54%)	{13%}	1579	(100%)	{13%}
400+ up	682	(46%)	{13%}	800	(54%)	{12%}	1482	(100%)	{13%}
	5319	(45%)	{100%}	6474	(55%)	{100%}	11793	(100%)	{100%}

* down = downcoast; up = upcoast

† ( ) row percentages

‡ { } column percentages

Table 9, cont. Age, Gender and Ethnicity by Map Area For All Beaches

	ethnicity																			
Map Area*	White			Black			Latino			Asian			multi			other			totals		
drain	281	(33%)	{5%}	16	(2%)	{4%}	502	(59%)	{10%}	21	(2%)	{5%}	17	(2%)	{5%}	7	(1%)	{3%}	844	(100%)	{7%}
1-50 down	798	(41%)	{15%}	61	(3%)	{17%}	886	(46%)	{17%}	85	(4%)	{22%}	66	(3%)	{18%}	48	(2%)	{18%}	1944	(100%)	{16%}
1-50 up	1063	(41%)	{20%}	97	(4%)	{26%}	1250	(48%)	{24%}	65	(2%)	{17%}	78	(3%)	{22%}	55	(2%)	{20%}	2608	(100%)	{22%}
51-100 down	616	(54%)	{12%}	33	(3%)	{9%}	372	(33%)	{7%}	43	(4%)	{11%}	34	(3%)	{9%}	36	(3%)	{13%}	1134	(100%)	{10%}
51-100 up	1026	(47%)	{19%}	57	(3%)	{16%}	908	(41%)	{18%}	98	(4%)	{25%}	61	(3%)	{17%}	48	(2%)	{18%}	2198	(100%)	{19%}
400+ down	883	(56%)	{17%}	38	(2%)	{10%}	509	(32%)	{10%}	33	(2%)	{8%}	72	(5%)	{20%}	44	(3%)	{16%}	1579	(100%)	{13%}
400+ up	628	(42%)	{12%}	65	(4%)	{18%}	676	(46%)	{13%}	47	(3%)	{12%}	32	(2%)	{9%}	34	(2%)	{13%}	1482	(100%)	{13%}
	5295	(45%)	{100%}	367	(3%)	{100%}	5103	(43%)	{100%}	392	(3%)	{100%}	360	(3%)	{100%}	272	(2%)	{100%}	11789	(100%) †	{100%} ‡

* down = downcoast; up = upcoast
† ( ) row percentages
‡ { } column percentages

Table 10. Subgroup Specific Symptom Counts

	TOTAL	A) gender		B) age groups			C) ethnicity					
Symptom		Female	Male	<=12	13-25	>=26	White	Black	Latino	Asian	multi	other
Fever	567	257	310	323	121	123	259	21	231	18	27	11
Chills	296	140	156	139	70	87	150	8	114	7	11	6
Redness/discharge from eyes	212	108	104	118	39	55	72	8	112	2	12	6
Earache	407	192	215	185	119	103	212	15	152	6	9	12
Discharge/draining from ears	79	41	38	29	27	23	33	1	41	0	3	1
Skin rash	110	56	54	55	21	34	35	2	65	1	3	4
Cuts becoming infected	76	29	47	21	31	24	46	1	24	2	2	1
Nausea	432	219	213	206	106	119	223	16	155	10	18	10
Vomiting	204	91	113	144	33	27	80	7	98	5	11	3
Diarrhea	627	286	341	307	130	190	365	23	174	15	30	20
Diarrhea with blood	14	7	7	7	4	3	5	0	8	0	1	0
Stomach pain or cramps	736	351	385	370	194	171	387	28	250	23	30	18
Coughing	834	372	462	454	214	166	389	34	333	28	35	14
Coughing with phlegm	390	156	234	195	111	84	176	10	177	8	14	4
Nasal congestion or runny nose	1079	477	602	504	307	268	588	32	361	31	43	23
Sore throat	802	386	416	350	233	219	422	25	291	14	28	21
hcgi_1	355	166	189	223	65	67	164	16	141	9	20	5
hcgi_2	101	39	62	76	15	10	43	2	48	2	5	1
srd	589	264	325	307	158	124	276	20	241	14	26	11

Table 10, cont. Subgroup Specific Symptom Counts

	D) SES		E) residency		F) concern about hazards			
Symptom	<=$25,000	>$25,000	CA resident	non CA	not at all worried	somewhat worried	a little worried	very worried
Fever	64	447	526	40	46	68	122	227
Chills	30	236	272	24	20	39	59	140
Redness/discharge from eyes	15	176	194	16	23	26	46	77
Earache	22	336	363	39	28	56	83	172
Discharge/draining from ears	3	71	75	3	7	5	20	38
Skin rash	22	79	104	6	14	12	25	44
Cuts becoming infected	3	62	67	8	6	14	13	33
Nausea	32	347	387	39	18	55	82	195
Vomiting	12	172	187	13	11	20	47	83
Diarrhea	22	497	532	90	34	98	119	273
Diarrhea with blood	2	10	13	1	1	2	4	5
Stomach pain or cramps	41	598	652	78	53	98	151	295
Coughing	75	663	764	66	85	117	164	324
Coughing with phlegm	30	314	363	24	48	57	71	152
Nasal congestion or runny nose	72	863	964	103	93	171	238	424
Sore throat	61	634	721	75	73	134	178	301
hcgi_1	27	288	322	29	22	36	72	150
hcgi_2	6	89	97	3	5	10	21	47
srd	49	473	547	39	60	87	118	220

Table 11. Subgroup Specific Symptom Rates per 100 Persons

SYMPTOM	TOTALS	A) gender		B) age			C) ethnicity					
		female	male	0-12	13-25	>=26	White	Black	Latino	Asian	multi	other
1 Fever	4.8	4.8	4.8	5.6	4.1	4.0	4.9	5.7	4.5	4.6	7.5	4.0
2 Chills	2.5	2.6	2.4	2.4	2.3	2.8	2.8	2.2	2.2	1.8	3.1	2.2
3 Redness/discharge from eyes	1.8	2.0	1.6	2.1	1.3	1.8	1.4	2.2	2.2	0.5	3.3	2.2
4 Earache	3.5	3.6	3.3	3.2	4.0	3.3	4.0	4.1	3.0	1.5	2.5	4.3
5 Discharge/draining from ears	0.7	0.8	0.6	0.5	0.9	0.7	0.6	0.3	0.8	0.0	0.8	0.4
6 Skin rash	0.9	1.1	0.8	1.0	0.7	1.1	0.7	0.5	1.3	0.3	0.8	1.4
7 Cuts becoming infected	0.6	0.5	0.7	0.4	1.0	0.8	0.9	0.3	0.5	0.5	0.6	0.4
8 Nausea	3.7	4.1	3.3	3.6	3.6	3.9	4.2	4.4	3.0	2.6	5.0	3.6
9 Vomiting	1.7	1.7	1.7	2.5	1.1	0.9	1.5	1.9	1.9	1.3	3.1	1.1
10 Diarrhea	5.3	5.4	5.3	5.4	4.4	6.1	6.9	6.3	3.4	3.8	8.3	7.2
11 Diarrhea with blood	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.2	0.0	0.3	0.0
12 Stomach pain or cramps	6.2	6.6	5.9	6.5	6.5	5.5	7.3	7.6	4.9	5.9	8.3	6.5
13 Coughing	7.1	7.0	7.1	7.9	7.2	5.4	7.3	9.3	6.5	7.1	9.7	5.1
14 Coughing with phlegm	3.3	2.9	3.6	3.4	3.7	2.7	3.3	2.7	3.5	2.0	3.9	1.4
15 Nasal congestion or runny nose	9.1	9.0	9.3	8.8	10.3	8.7	11.1	8.7	7.1	7.9	11.9	8.3
16 Sore throat	6.8	7.3	6.4	6.1	7.8	7.1	8.0	6.8	5.7	3.6	7.8	7.6
HCGI_1	3.0	3.1	2.9	3.9	2.2	2.2	3.1	4.4	2.8	2.3	5.6	1.8
HCGI_2	0.9	0.7	1.0	1.3	0.5	0.3	0.8	0.5	0.9	0.5	1.4	0.4
SRD	5.0	5.0	5.0	5.4	5.3	4.0	5.2	5.4	4.7	3.6	7.2	4.0

Table 11, cont. Subgroup Specific Symptom Rates per 100 Persons

	D) SES		E) residency		F) concern about environmental hazards at beach			
SYMPTOM	<=25,000	>25,000	CA resident	outside CA	not at all worried	somewhat worried	a little worried	very worried
1 Fever	6.3	4.9	5.0	3.1	3.0	3.3	4.9	6.6
2 Chills	2.9	2.6	2.6	1.9	1.3	1.9	2.4	4.1
3 Redness/discharge from eyes	1.5	1.9	1.9	1.2	1.5	1.3	1.9	2.2
4 Earache	2.2	3.7	3.5	3.0	1.8	2.7	3.3	5.0
5 Discharge/draining from ears	0.3	0.8	0.7	0.2	0.5	0.2	0.8	1.1
6 Skin rash	2.2	0.9	1.0	0.5	0.9	0.6	1.0	1.3
7 Cuts becoming infected	0.3	0.7	0.6	0.6	0.4	0.7	0.5	1.0
8 Nausea	3.1	3.8	3.7	3.0	1.2	2.6	3.3	5.7
9 Vomiting	1.2	1.9	1.8	1.0	0.7	1.0	1.9	2.4
10 Diarrhea	2.2	5.4	5.1	7.0	2.2	4.7	4.8	7.9
11 Diarrhea with blood	0.2	0.1	0.1	0.1	0.1	0.1	0.2	0.1
12 Stomach pain or cramps	4.0	6.5	6.3	6.0	3.4	4.7	6.1	8.5
13 Coughing	7.3	7.2	7.3	5.1	5.5	5.6	6.6	9.4
14 Coughing with phlegm	2.9	3.4	3.5	1.9	3.1	2.7	2.9	4.4
15 Nasal congestion or runny nose	7.1	9.4	9.2	8.0	6.0	8.2	9.6	12.3
16 Sore throat	6.0	6.9	6.9	5.8	4.7	6.4	7.2	8.7
HCGI_1	2.6	3.1	3.1	2.2	1.4	1.7	2.9	4.3
HCGI_2	0.6	1.0	0.9	0.2	0.3	0.5	0.8	1.4
SRD	4.8	5.1	5.2	3.0	3.9	4.2	4.8	6.4

Table 12. Percentage of Days in which Bacterial Indicators Exceeded the Standard Cutoff Levels

A. ASHLAND

	AREA				
Bacterial Indicator	Storm Drain 0 Yards (%)	1-100 Yards Upcoast (%)	1-100 Yards Downcoast (%)	400 + Yards Upcoast (%)	Cutoff cfu
E. coli	30.8	7.8	9.1	11.7	35
E. coli	19.2	5.2	2.6	3.9	70
Entercoccus	19.0	6.3	5.1	5.1	35
Fecal Coliforms	11.4	3.8	3.8	1.3	200
Total Coliforms	44.3	12.7	12.8	3.8	1000

B. MALIBU

	AREA				
Bacterial Indicator	Storm Drain 0 Yards (%)	1-100 Yards Upcoast (%)	1-100 Yards Downcoast (%)	400 + Yards Downcoast (%)	Cutoff cfu
E. coli	60.3	24.4	66.7	52.6	35
E. coli	55.1	15.4	53.8	25.6	70
Entercoccus	51.3	19.2	48.7	21.8	35
Fecal Coliforms	52.6	10.3	43.6	11.5	200
Total Coliforms	23.1	3.8	14.1	6.4	1000

C. WILL ROGERS

	AREA				
Bacterial Indicator	Storm Drain 0 Yards (%)	1-100 Yards Upcoast (%)	1-100 Yards Downcoast (%)	400 + Yards Downcoast (%)	Cutoff cfu
E. coli	74.0	21.9	45.2	15.1	35
E. coli	58.9	13.7	17.8	1.4	70
Entercoccus	79.5	23.3	42.5	9.6	35
Fecal Coliforms	56.2	6.8	8.2	1.4	200
Total Coliforms	46.6	5.5	5.5	0.0	1000

Note: Samples collected once daily between 8 am and 11 am.

cfu = colony forming units

Table 13. Percentage of Days in which Bacterial Indicators Exceeded the Higher Cutoff Levels

A. ASHLAND

	AREA				
Bacterial Indicator	Storm Drain 0 Yards (%)	1-100 Yards Upcoast (%)	1-100 Yards Downcoast (%)	400 + Yards Upcoast (%)	Cutoff cfu
E. coli	9.0	1.3	0.0	0.0	160
E. coli	6.4	1.3	0.0	0.0	320
Entercoccus	6.3	0.0	1.3	0.0	106
Fecal Coliforms	10.1	1.3	1.3	0.0	400
Total Coliforms	25.3	1.3	3.8	0.0	5,000
Total Coliforms	15.2	0.0	1.3	0.0	10,000

B. MALIBU

	AREA				
Bacterial Indicator	Storm Drain 0 Yards (%)	1-100 Yards Upcoast (%)	1-100 Yards Downcoast (%)	400 + Yards Downcoast (%)	Cutoff cfu
E. coli	47.4	10.3	33.3	7.7	160
E. coli	39.7	7.7	19.2	1.3	320
Entercoccus	34.6	5.1	17.9	2.6	106
Fecal Coliforms	46.2	6.4	21.8	2.6	400
Total Coliforms	5.1	2.6	1.3	0.0	5,000
Total Coliforms	3.8	1.3	0.0	0.0	10,000

C. WILL ROGERS

	AREA				
Bacterial Indicator	Storm Drain 0 Yards (%)	1-100 Yards Upcoast (%)	1-100 Yards Downcoast (%)	400 + Yards Downcoast (%)	Cutoff cfu
E. coli	42.5	5.5	8.2	0.0	160
E. coli	28.8	1.4	1.4	0.0	320
Entercoccus	45.2	6.8	9.6	1.4	106
Fecal Coliforms	32.9	1.4	2.7	0.0	400
Total Coliforms	16.4	1.4	2.7	0.0	5,000
Total Coliforms	6.8	0.0	1.4	0.0	10,000

Note: Samples collected once daily between 8 am and 11 am.

cfu = colony forming units

Table 14. Total Coliforms/Enterococcus Within Specified Ranges

A. ASHLAND

	AREA			
Total Coliforms/Enterococcus	Storm Drain 0 Yards (% of days)	1-100 Yards Upcoast (% of days)	1-100 Yards Downcoast (% of days)	400 + Yards Upcoast (% of days)
<=7	2.5	21.5	25.6	21.8
<=10	11.4	27.9	26.9	29.5
<=13	15.2	30.4	30.8	42.3

B. MALIBU

	AREA			
Total Coliforms/Enterococcus	Storm Drain 0 Yards (% of days)	1-100 Yards Upcoast (% of days)	1-100 Yards Downcoast (% of days)	400 + Yards Downcoast (% of days)
<=7	44.9	66.7	50.0	51.3
<=10	59.0	78.2	74.4	74.4
<=13	68.0	84.6	80.8	83.3

C. WILL ROGERS

	AREA			
Total Coliforms/Enterococcus	Storm Drain 0 Yards (% of days)	1-100 Yards Upcoast (% of days)	1-100 Yards Downcoast (% of days)	400 + Yards Downcoast (% of days)
<=7	46.6	65.8	69.9	83.6
<=10	60.3	78.1	79.5	91.8
<=13	69.9	82.2	89.0	95.9

Note: Samples collected once daily between 8 am and 11 am.

Table 15. Total Coliforms/Fecal Coliforms Within Specified Ranges

A. ASHLAND

	AREA			
Total Coliforms/Fecal Coliforms	Storm Drain 0 Yards (% of days)	1-100 Yards Upcoast (% of days)	1-100 Yards Downcoast (% of days)	400 + Yards Upcoast (% of days)
<=5	17.7	34.2	30.8	48.7
<=4	17.7	29.1	26.9	41.0
<=2	7.6	20.3	14.1	24.4

B. MALIBU

	AREA			
Total Coliforms/Fecal Coliforms	Storm Drain 0 Yards (% of days)	1-100 Yards Upcoast (% of days)	1-100 Yards Downcoast (% of days)	400 + Yards Downcoast (% of days)
<=5	82.1	85.9	88.5	89.7
<=4	80.8	82.1	82.1	84.6
<=2	51.3	68.0	55.1	60.3

C. WILL ROGERS

	AREA			
Total Coliforms/Fecal Coliforms	Storm Drain 0 Yards (% of days)	1-100 Yards Upcoast (% of days)	1-100 Yards Downcoast (% of days)	400 + Yards Downcoast (% of days)
<=5	52.1	76.7	75.3	84.9
<=4	41.1	72.6	63.0	75.3
<=2	13.7	27.4	24.7	30.1

Note: Samples collected once daily between 8 am and 11 am.

Table 16. Total Coliforms/Fecal Coliforms Within Specified Ranges On Days When Total Coliforms > 1000 and > 5000

A. ASHLAND

> 1000

Total Coliforms/Fecal Coliforms	AREA: Storm Drain 0 Yards (% of days)	1-100 Yards Upcoast (% of days)	1-100 Yards Downcoast (% of days)	400 + Yards Upcoast (% of days)
<=5	0.0	0.0	0.0	0.0
<=4	0.0	0.0	0.0	0.0
<=2	0.0	0.0	0.0	0.0

> 5000

Total Coliforms/Fecal Coliforms				
<=5	0.0	0.0	0.0	-
<=4	0.0	0.0	0.0	-
<=2	0.0	0.0	0.0	-

B. MALIBU

> 1000

Total Coliforms/Fecal Coliforms	AREA: Storm Drain 0 Yards (% of days)	1-100 Yards Upcoast (% of days)	1-100 Yards Downcoast (% of days)	400 + Yards Downcoast (% of days)
<=5	55.6	0.0	54.6	20.0
<=4	55.6	0.0	36.4	0.0
<=2	16.7	0.0	18.2	0.0

> 5000

Total Coliforms/Fecal Coliforms				
<=5	25.0	0.0	0.0	-
<=4	25.0	0.0	0.0	-
<=2	0.0	0.0	0.0	-

Note: Samples collected once daily between 8 am and 11 am.

Table 16 Continued. Total Coliforms/Fecal Coliforms Within Specified Ranges On Days When Total Coliforms > 1000 and > 5000

C. WILL ROGERS

AREA

> 1000

Total Coliforms/Fecal Coliforms	Storm Drain 0 Yards (% of days)	1-100 Yards Upcoast (% of days)	1-100 Yards Downcoast (% of days)	400 + Yards Downcoast (% of days)
<=5	50.0	25.0	75.0	-
<=4	41.2	25.0	75.0	-
<=2	14.7	0.0	0.0	-

> 5000

Total Coliforms/Fecal Coliforms	Storm Drain 0 Yards (% of days)	1-100 Yards Upcoast (% of days)	1-100 Yards Downcoast (% of days)	400 + Yards Downcoast (% of days)
<=5	33.3	0.0	50.0	-
<=4	33.3	0.0	50.0	-
<=2	16.7	0.0	0.0	-

Note: Samples collected once daily between 8 am and 11 am.

Figure 5A. Daily *E.coli* Indicator Counts at Ashland Beach (Cutoff = 35 cpu)

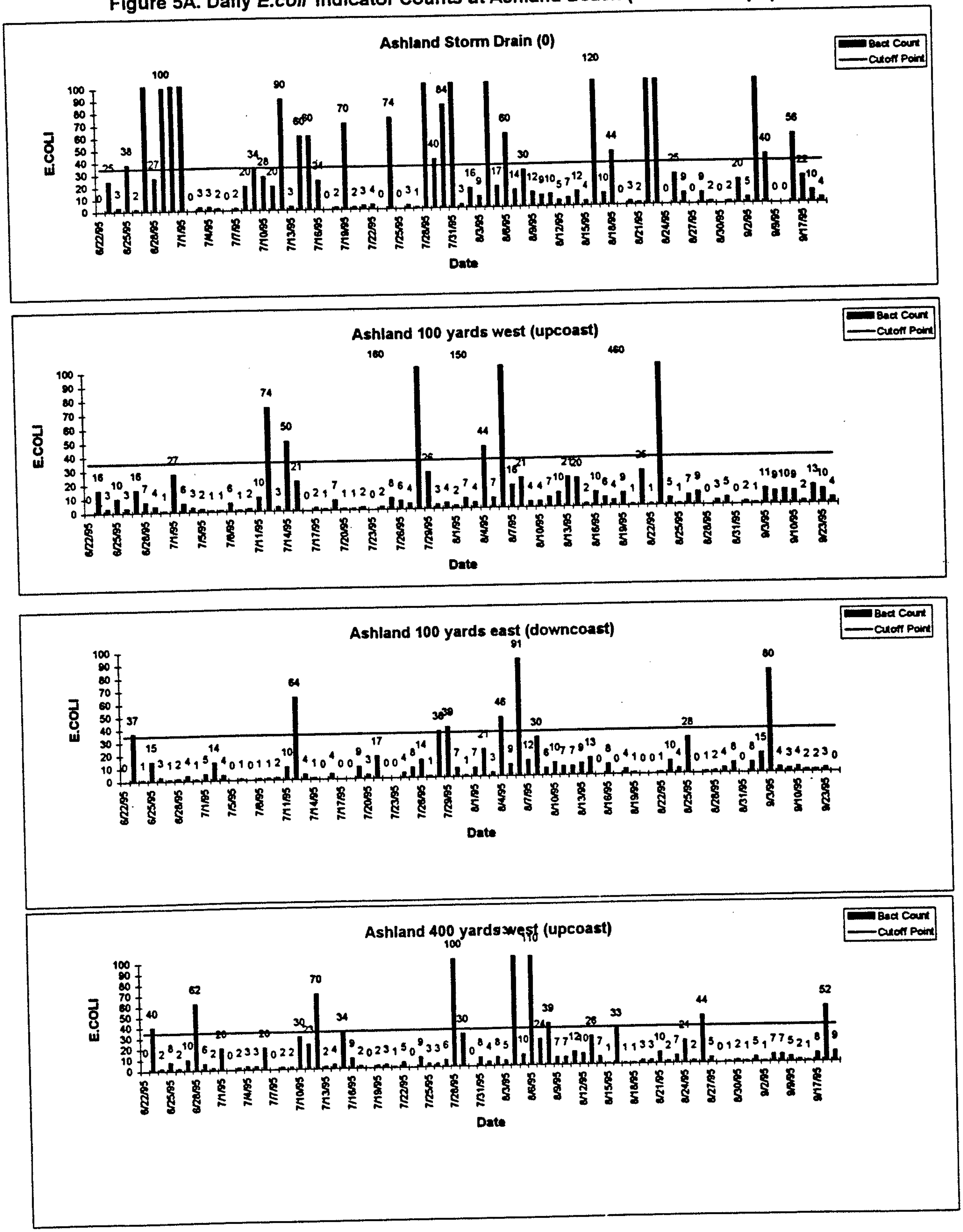
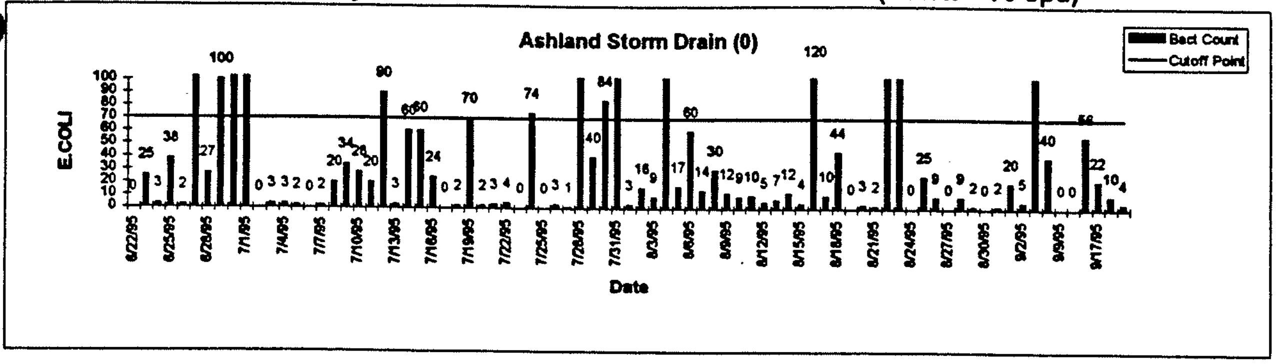
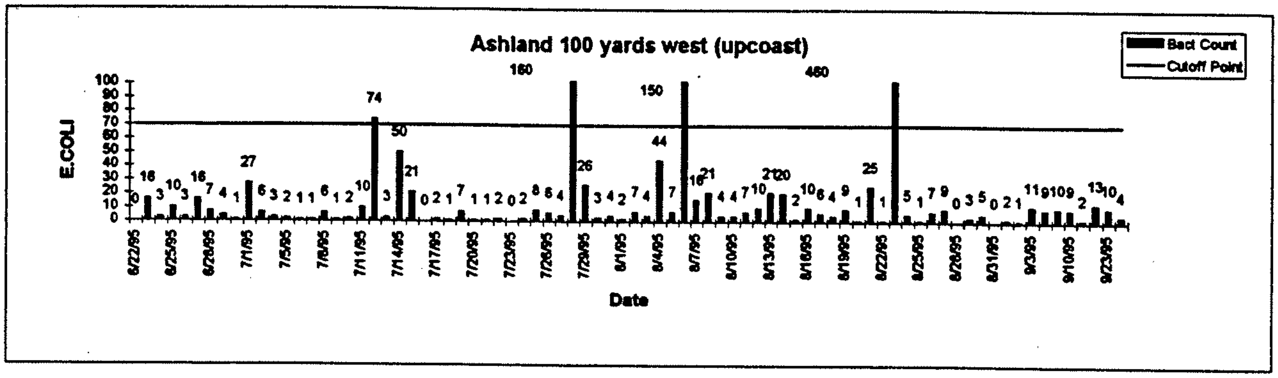
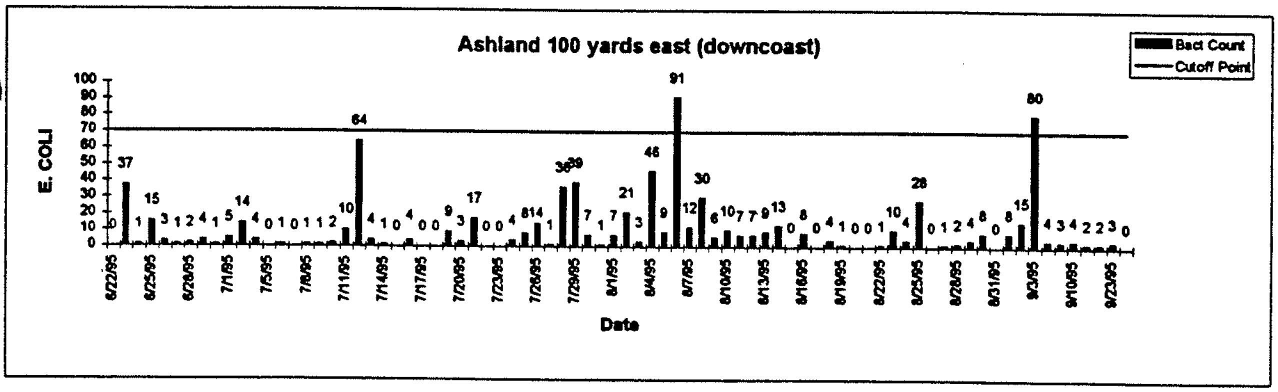


Figure 5A, cont. Daily *E.coli* Indicator Counts at Ashland Beach (Cutoff = 70 cpu)







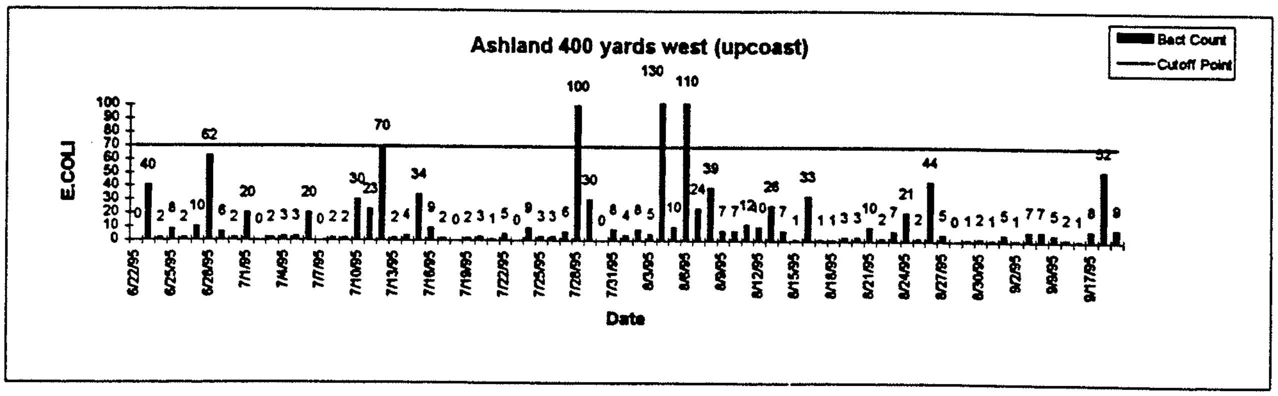


Figure 5B. Daily Enterococcus Indicator Counts at Ashland Beach (Cutoff = 35 cpu)

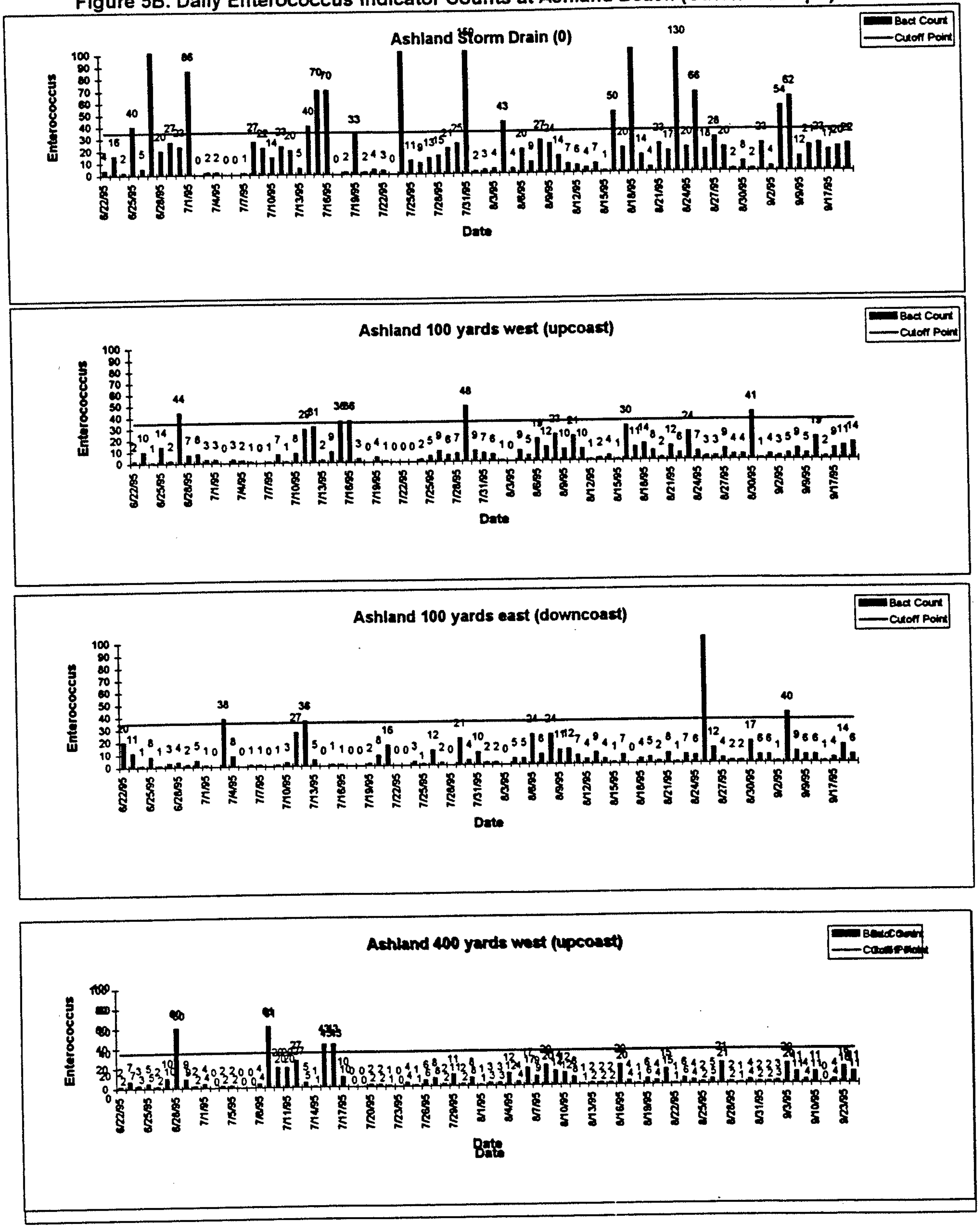
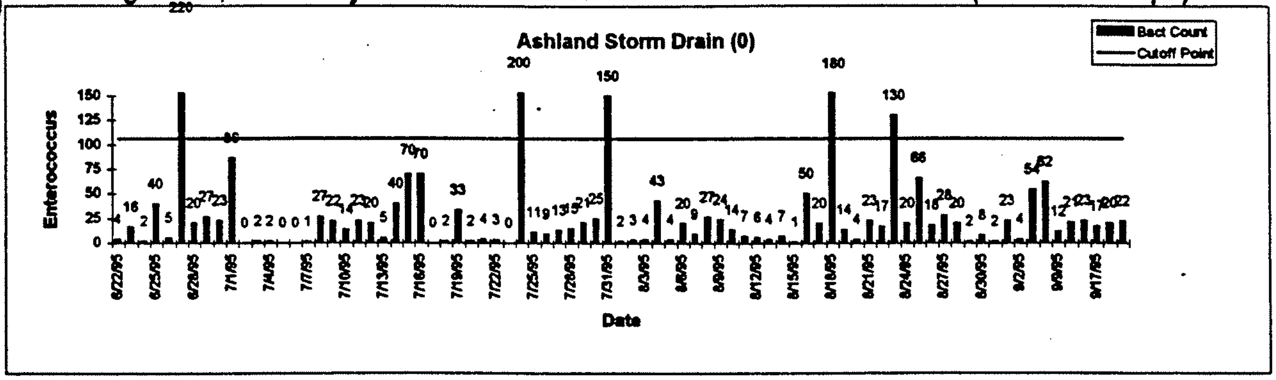
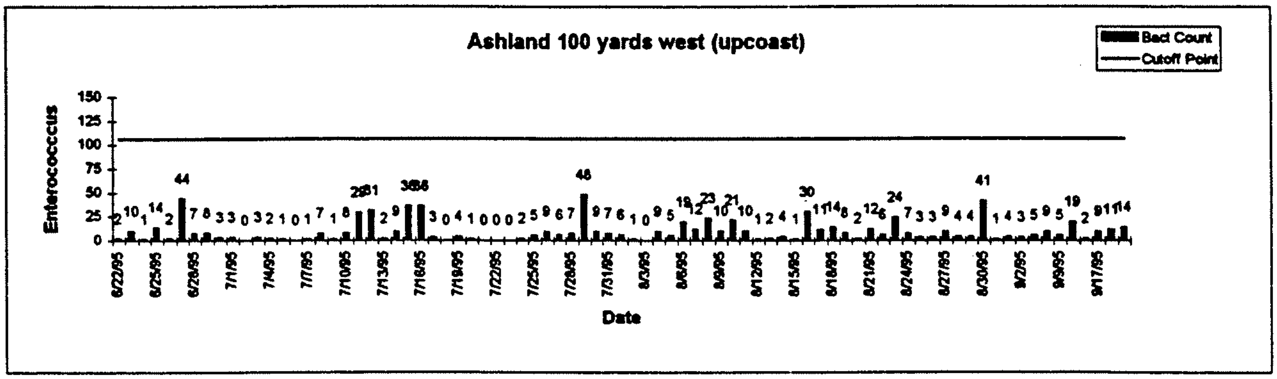
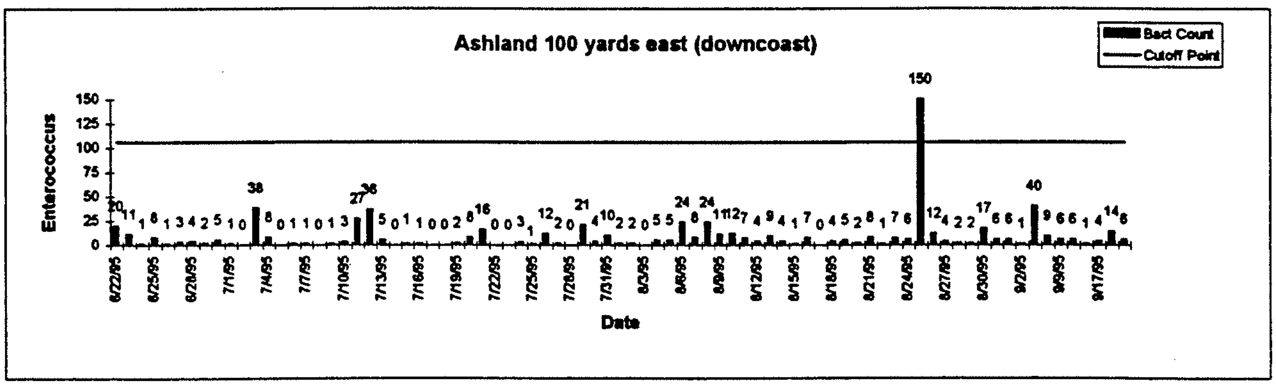


Figure 5B, cont. Daily Enterococcus Indicator Counts at Ashland Beach (Cutoff = 106 cpu)







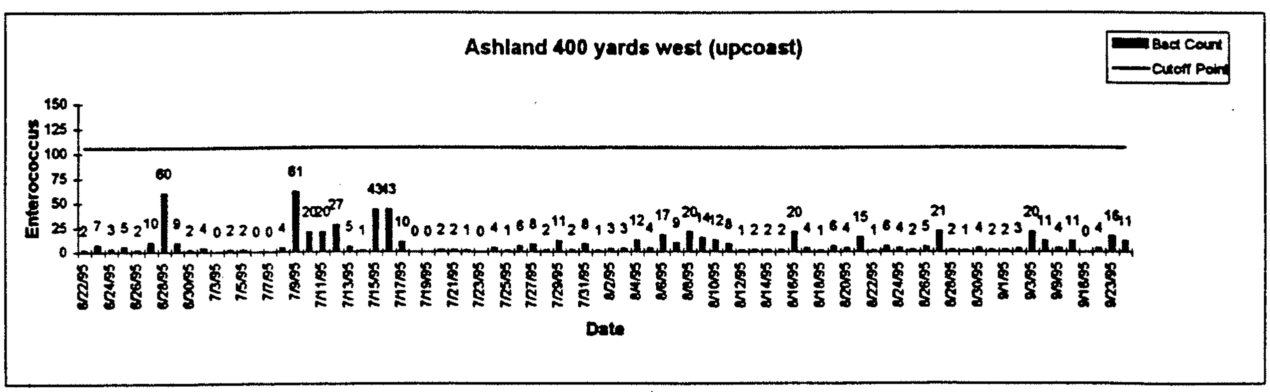


Figure 5C. Daily Fecal Coliform Indicator Counts at Ashland Beach (Cutoff = 200 cpu)

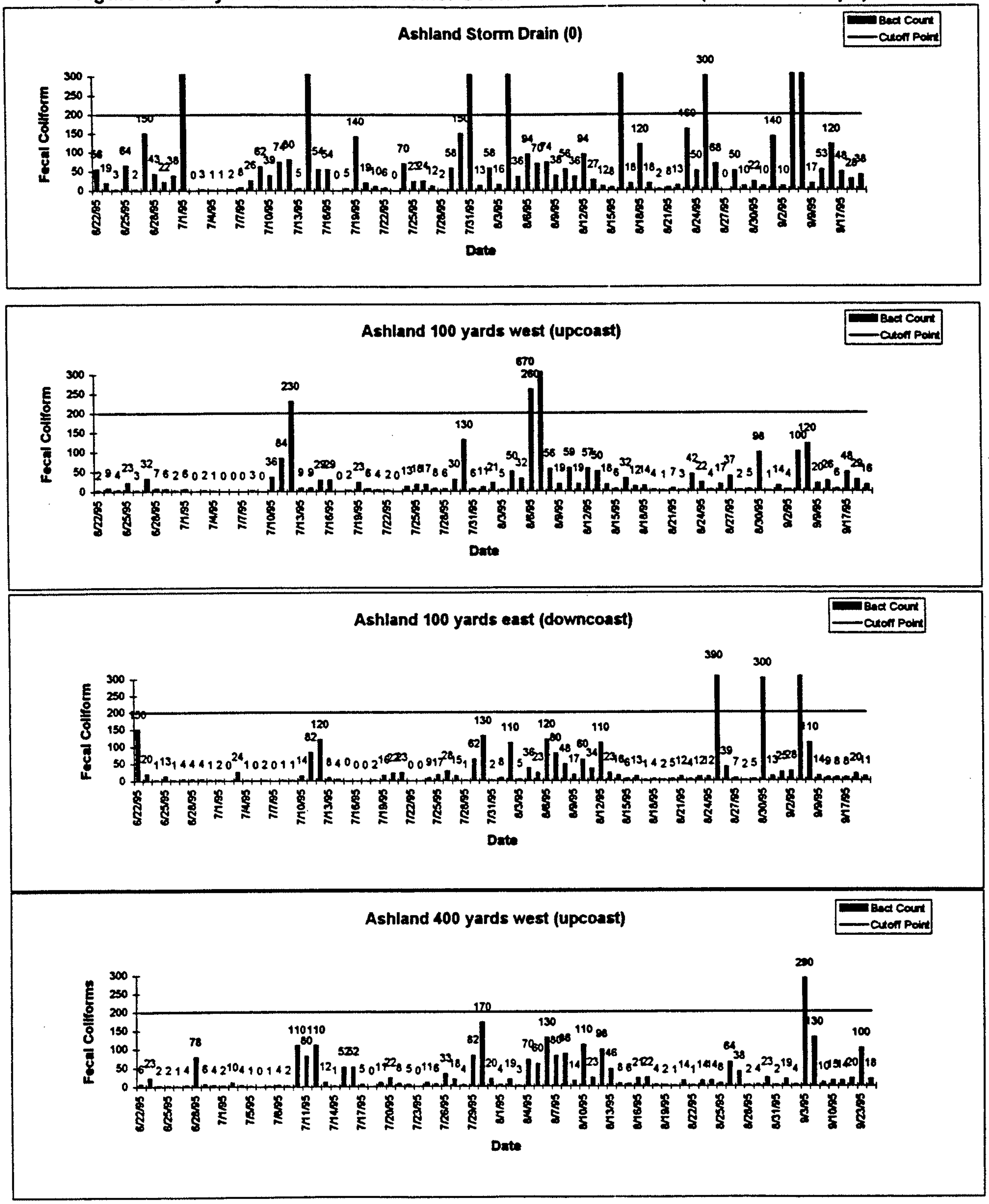


Figure 5C, cont. Daily Fecal Coliform Indicator Counts at Ashland Beach (Cutoff = 400 cpu)

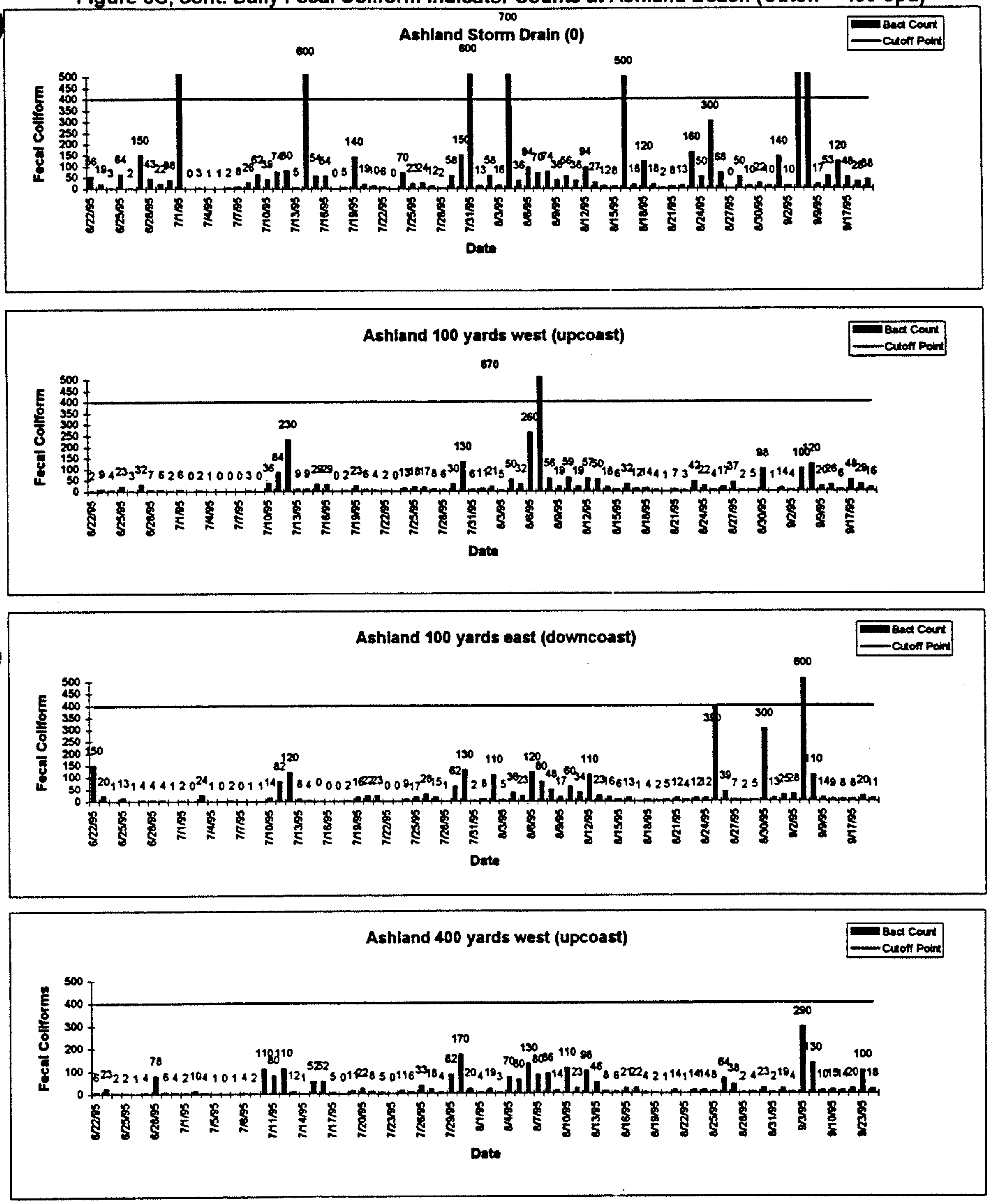


Figure 5D. Daily Total Coliform Indicator Counts at Ashland Beach (Cutoff = 1000 cpu)

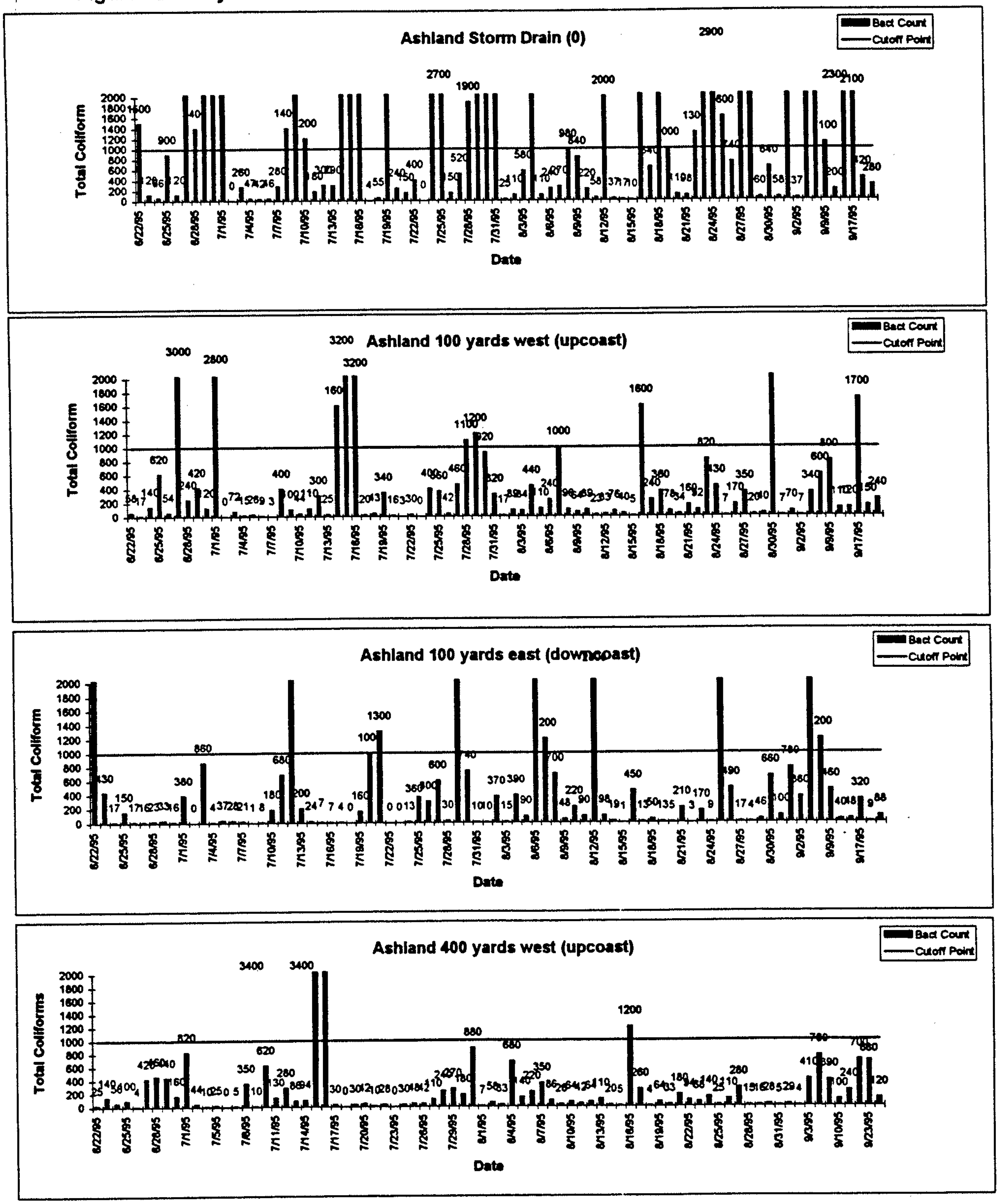


Figure 5D, cont. Daily Total Coliform Indicator Counts at Ashland Beach (Cutoff = 10,000 cpu)

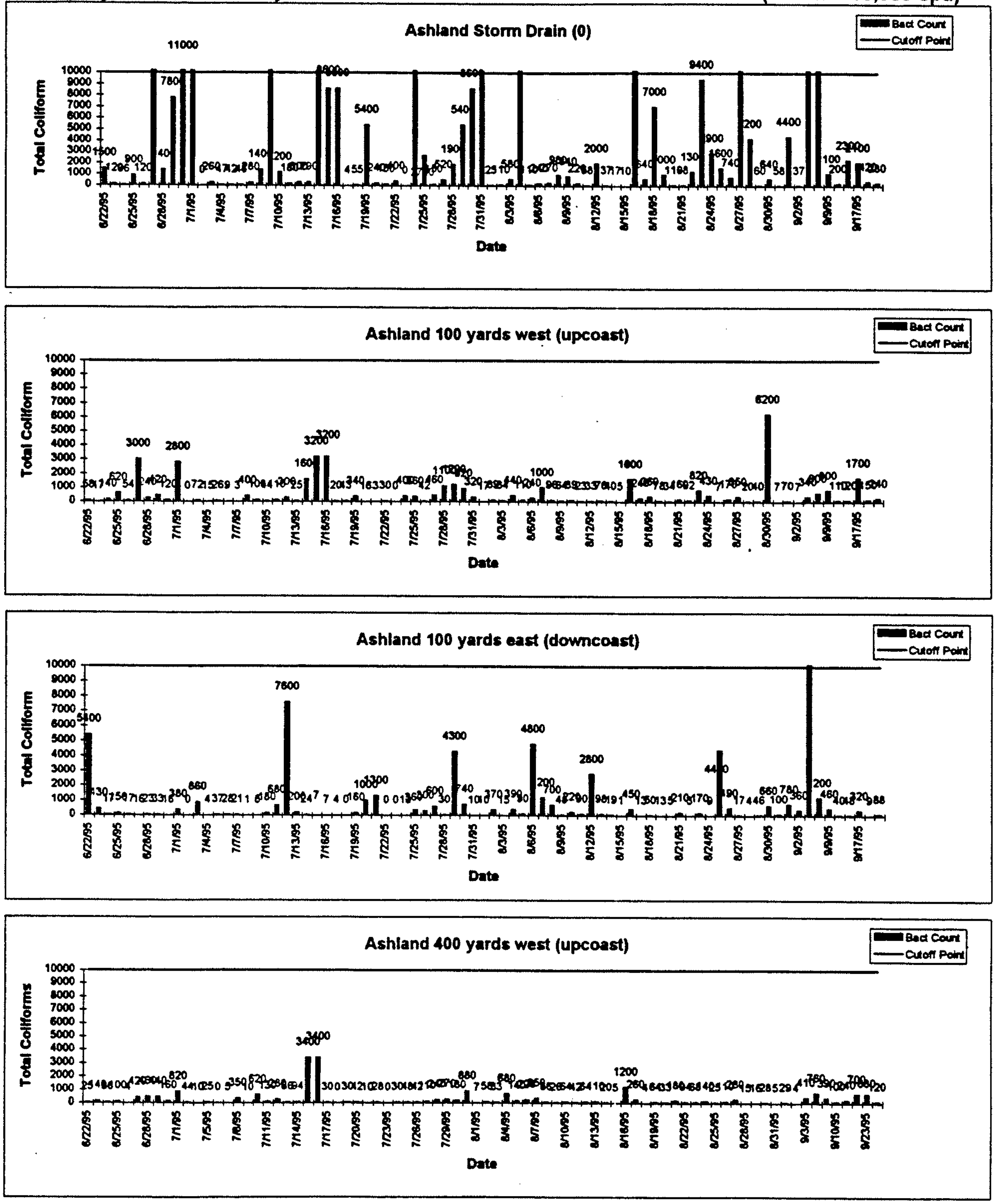


Figure 6A. Daily *E.coli* Indicator Counts at Malibu Beach (Cutoff = 35 cpu)

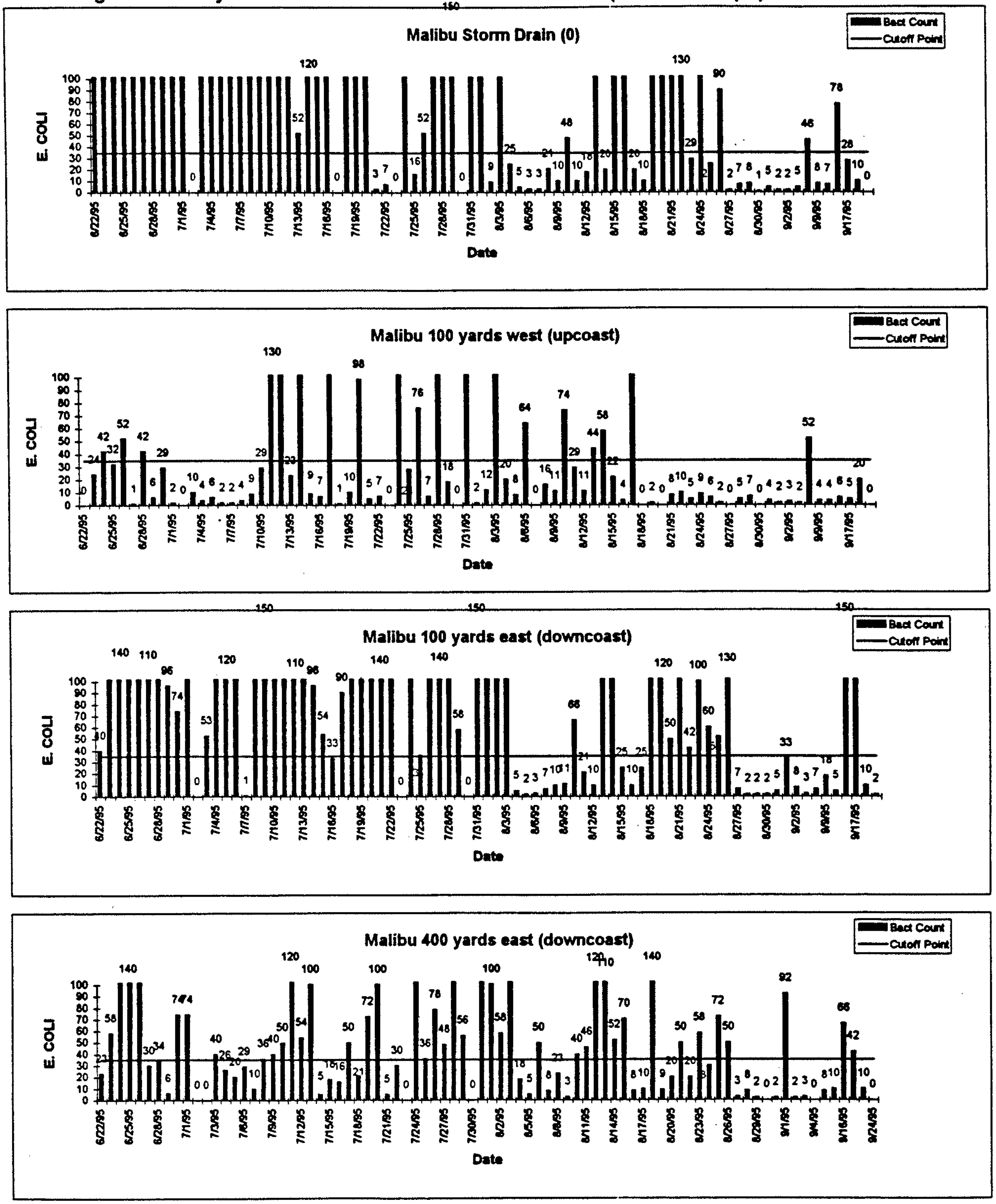


Figure 6A, cont. Daily *E.coli* Indicator Counts at Malibu Beach (Cutoff = 70 cpu)

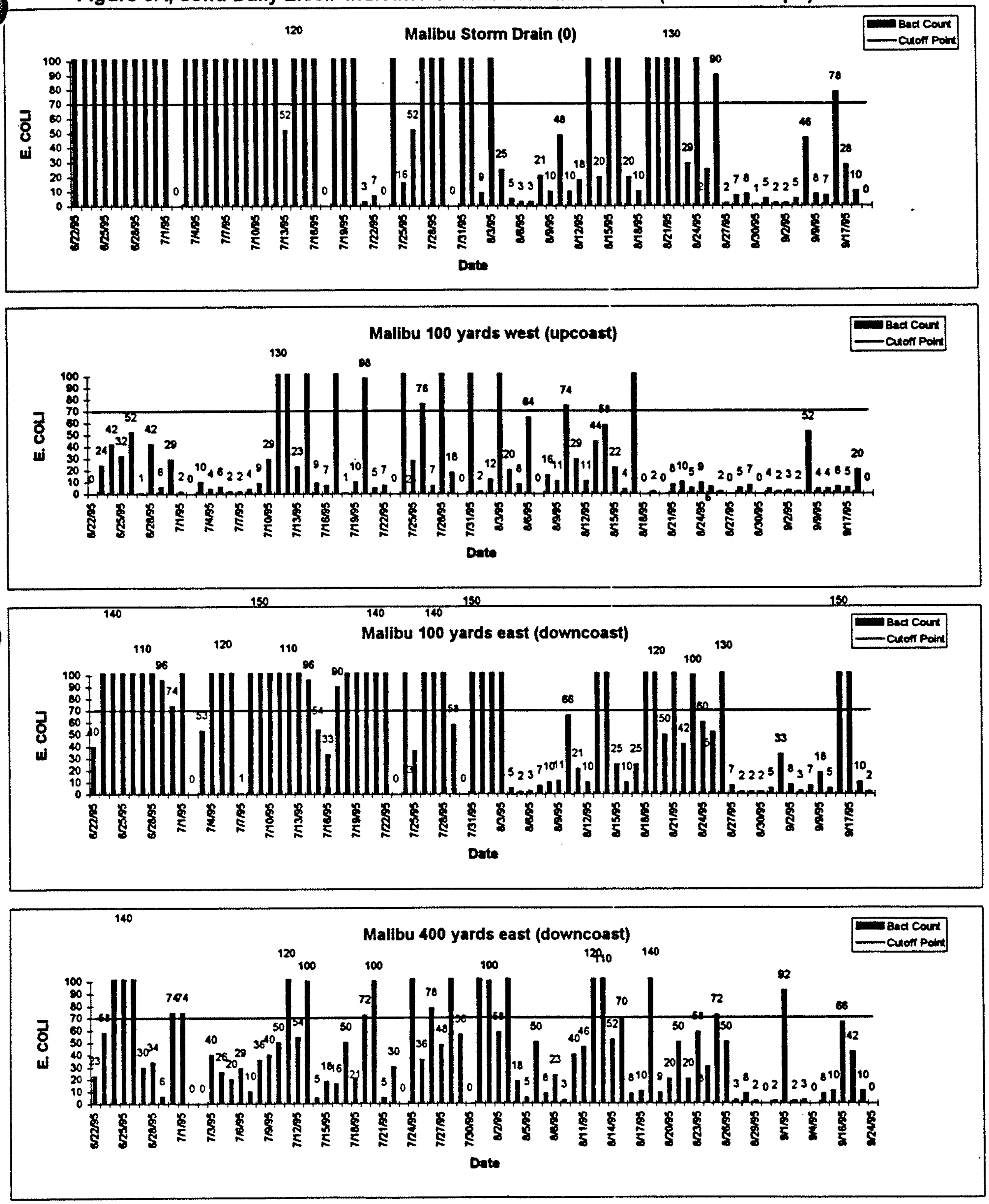


Figure 6B. Daily Enterococcus Indicator Counts at Malibu Beach (Cutoff = 35 cpu)

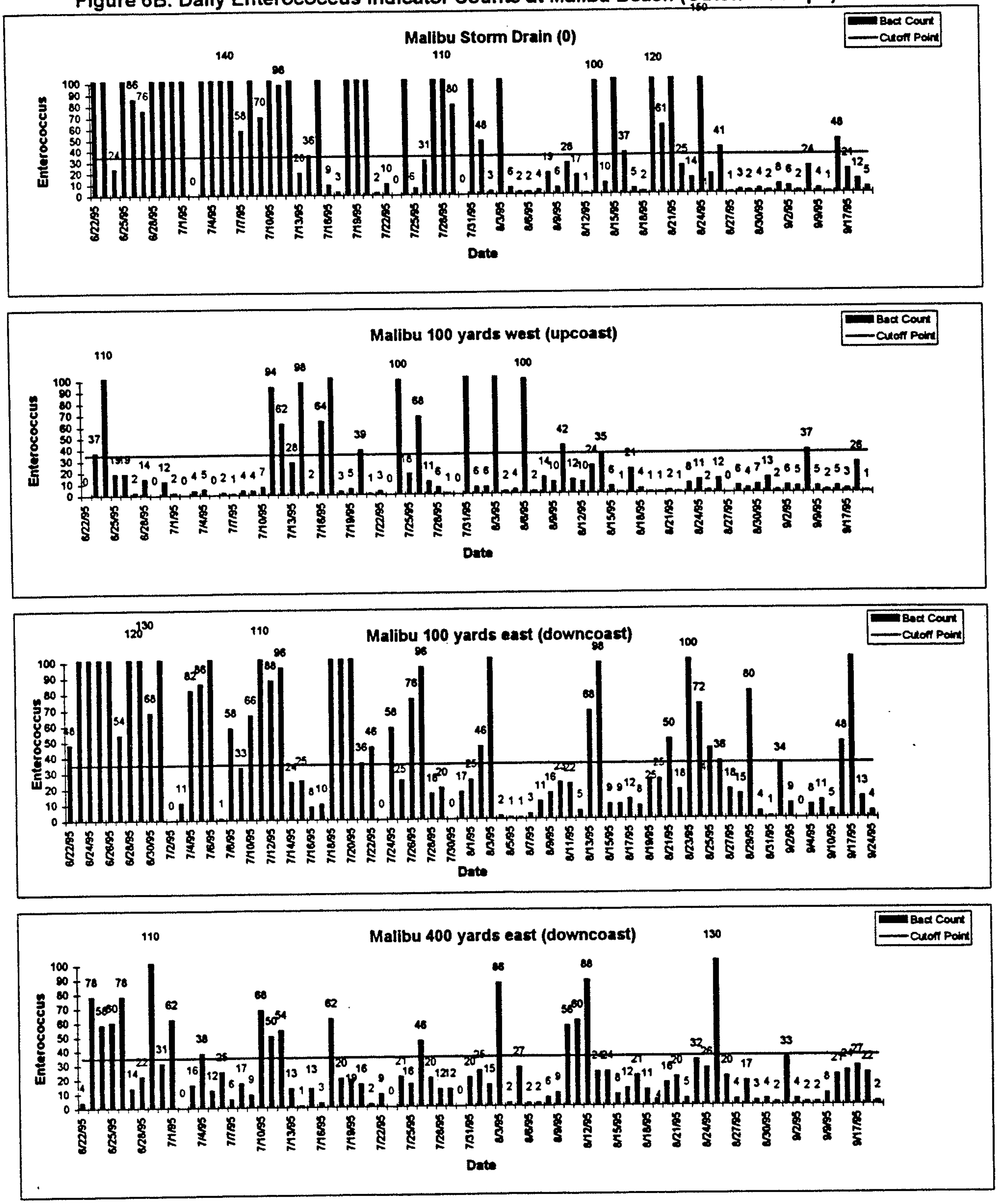
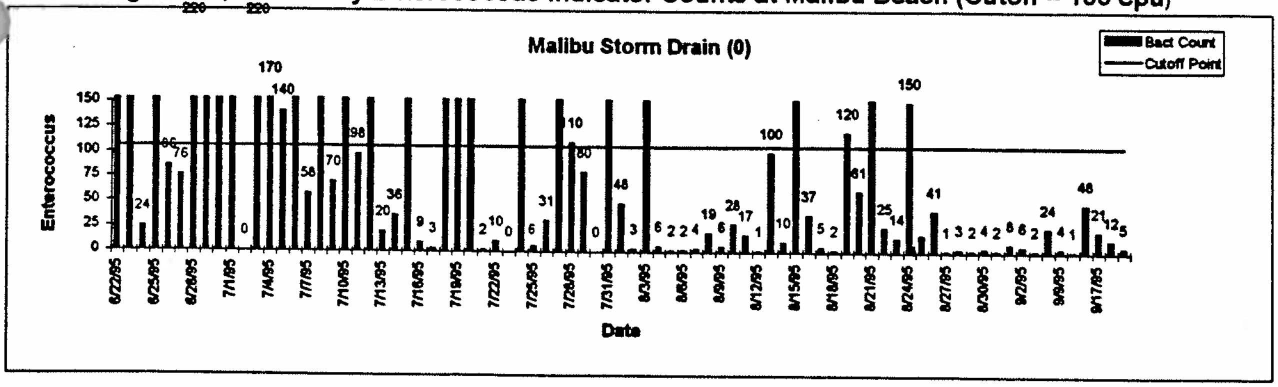
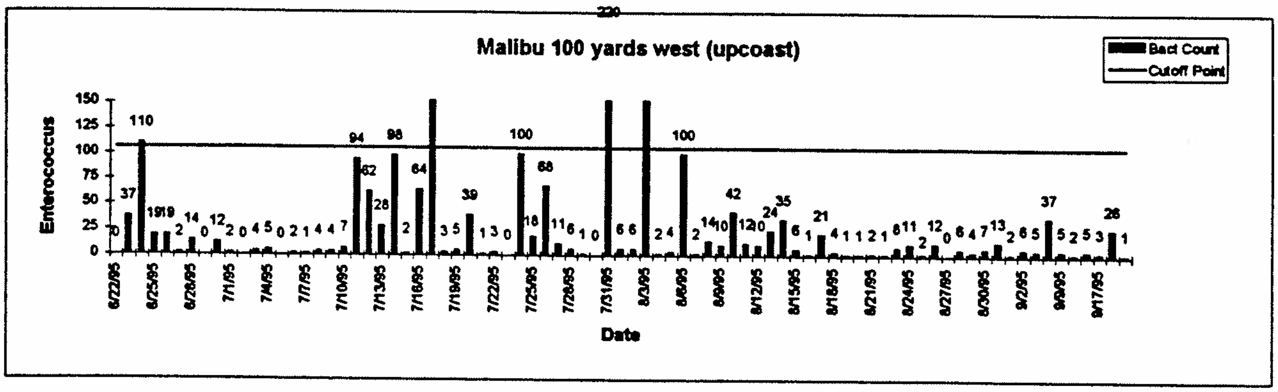
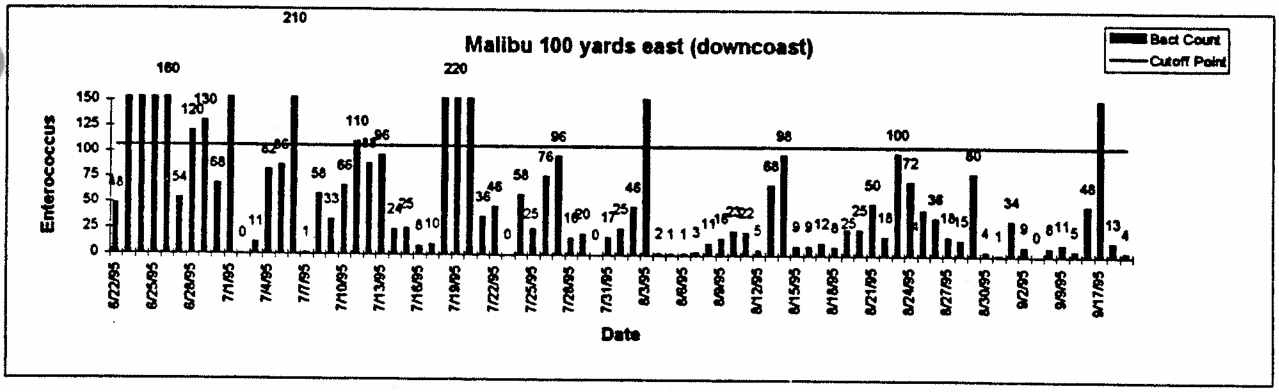


Figure 6B, cont. Daily Enterococcus Indicator Counts at Malibu Beach (Cutoff = 106 cpu)







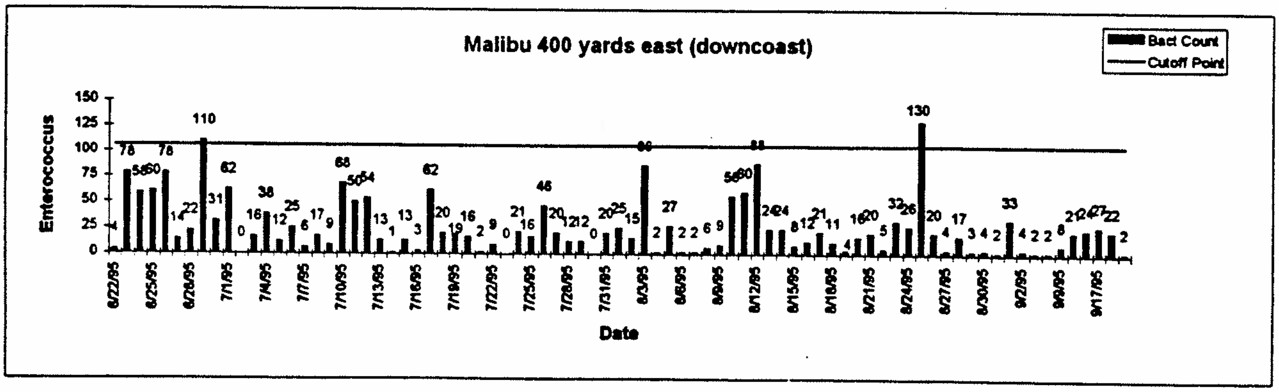
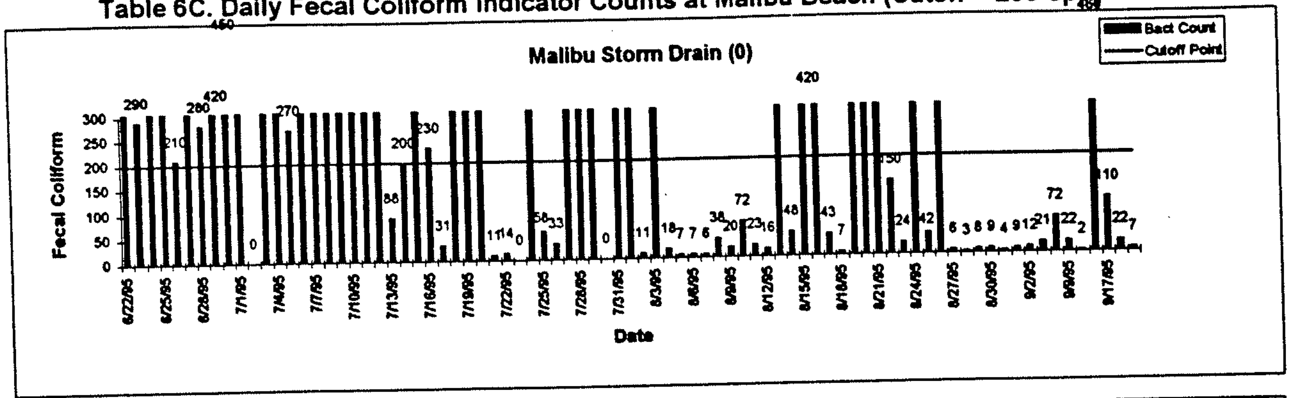
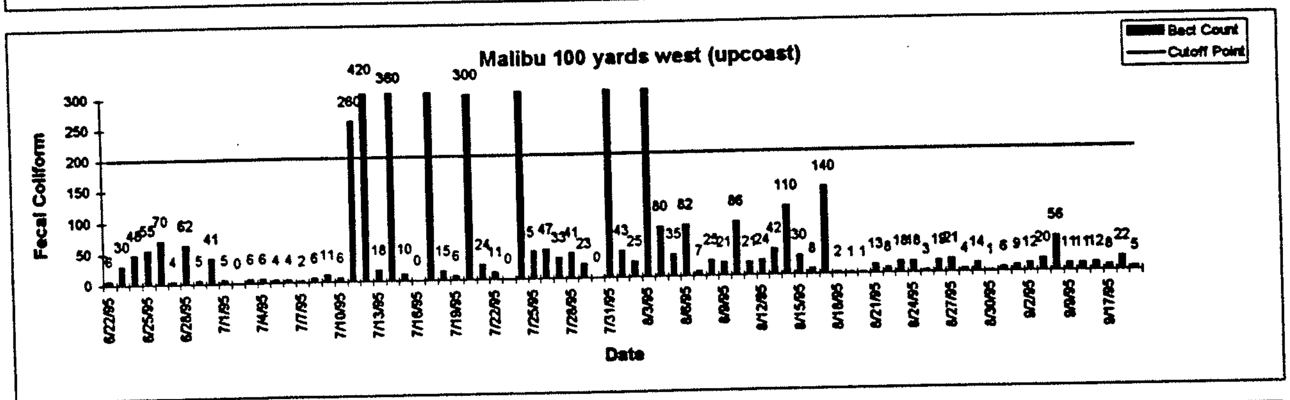
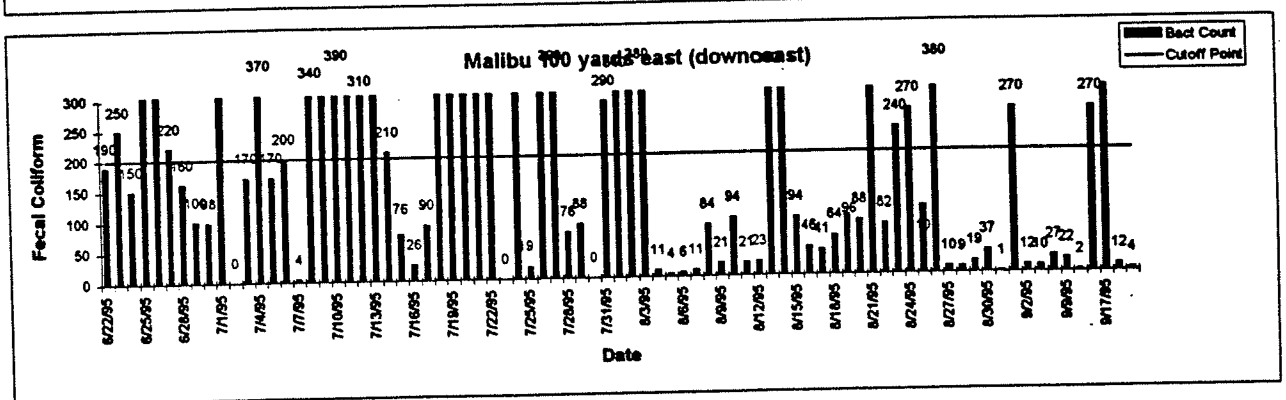


Table 6C. Daily Fecal Coliform Indicator Counts at Malibu Beach (Cutoff = 200 cpu)







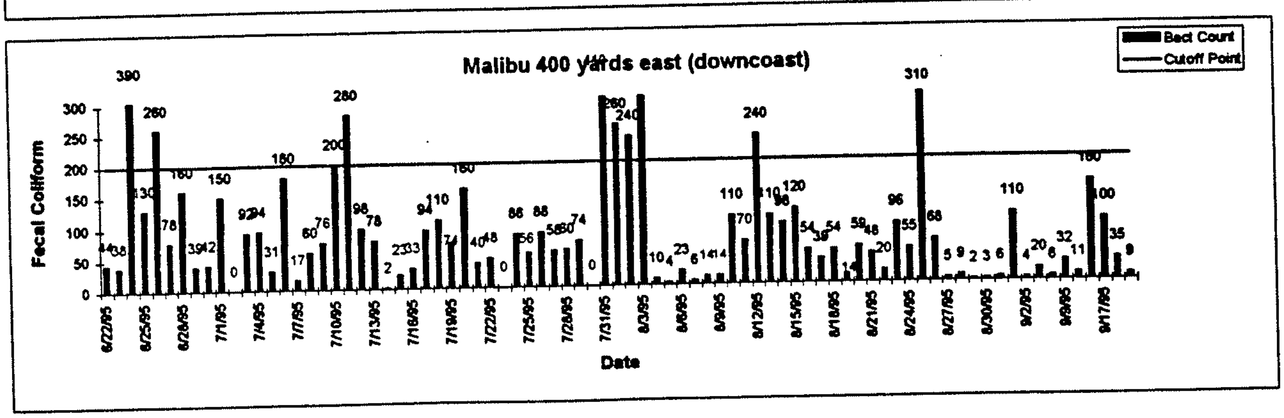


Figure 6C, cont. Daily Fecal Coliform Indicator Counts at Malibu Beach (Cutoff = 400 cpu)

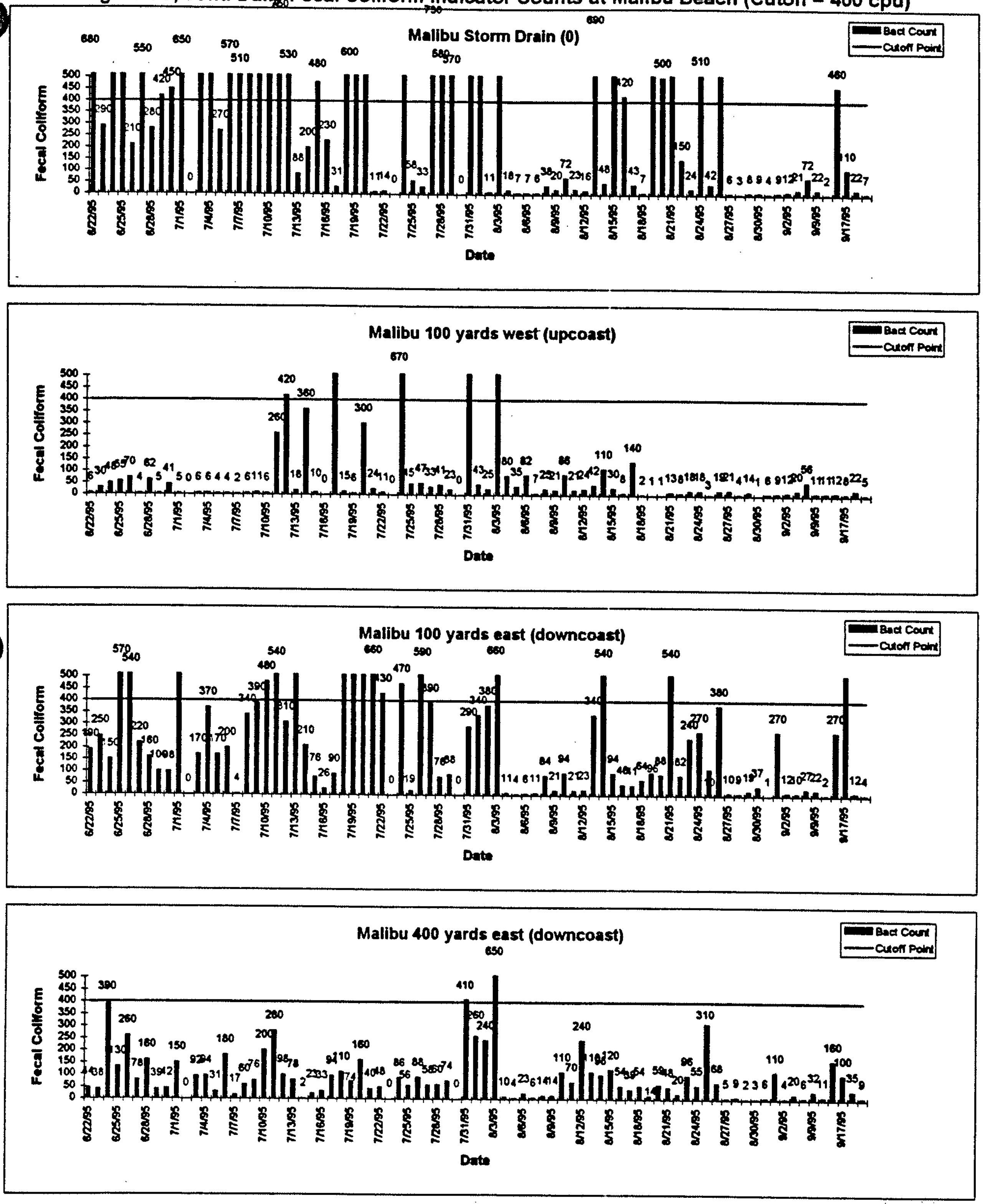
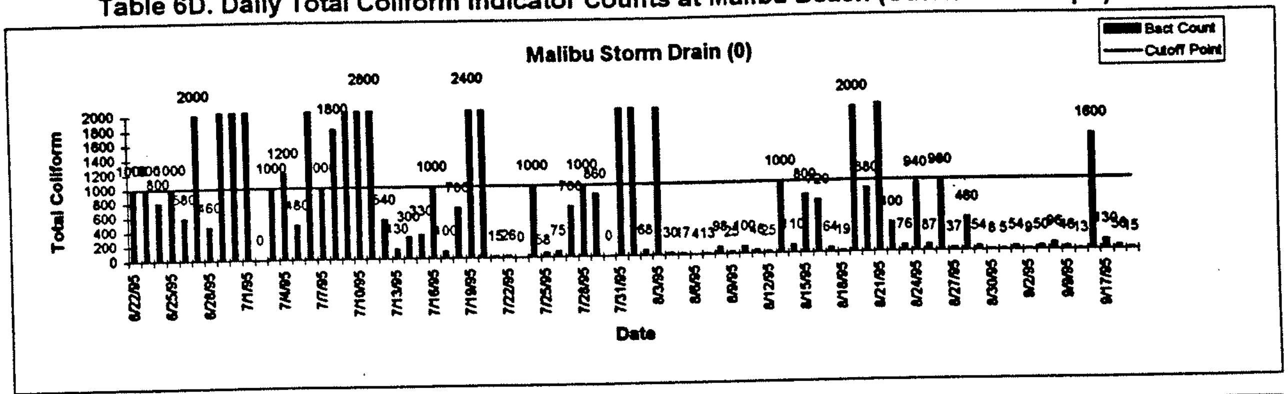
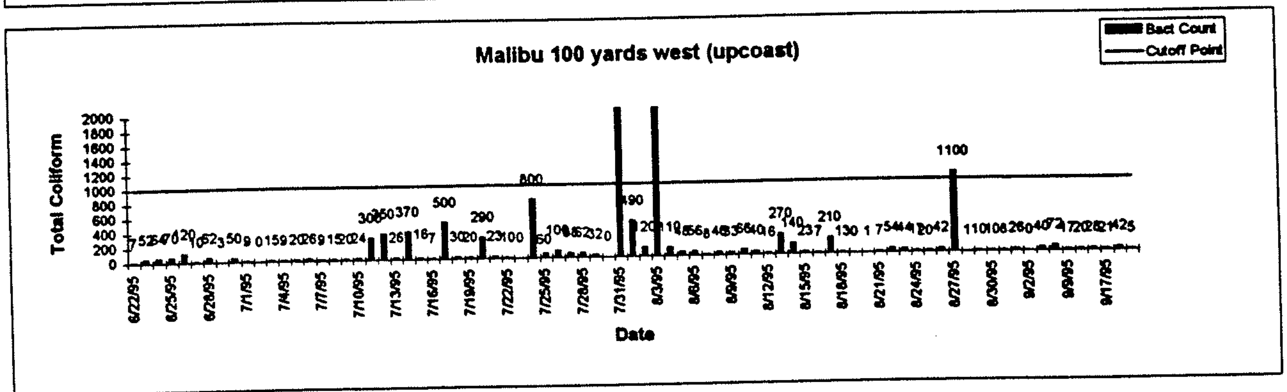
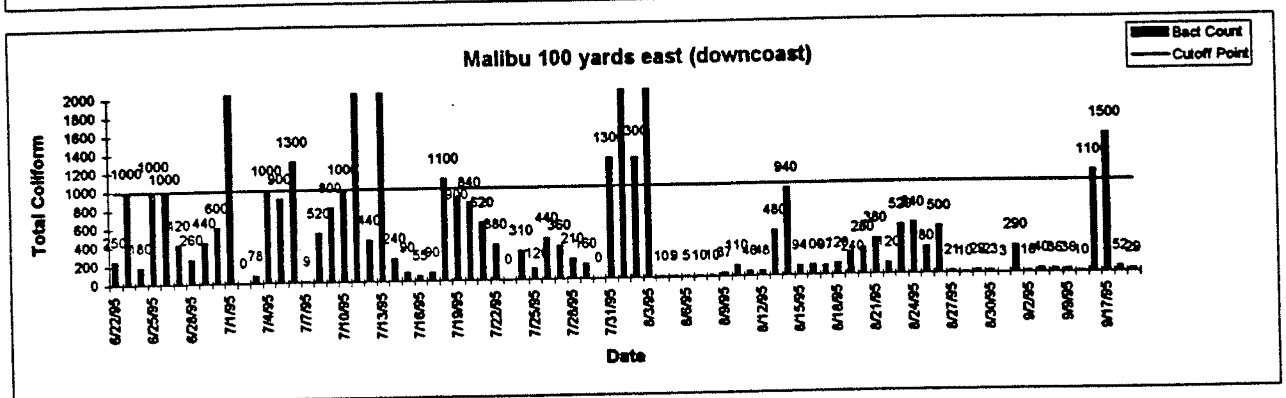


Table 6D. Daily Total Coliform Indicator Counts at Malibu Beach (Cutoff = 1000 cpu)







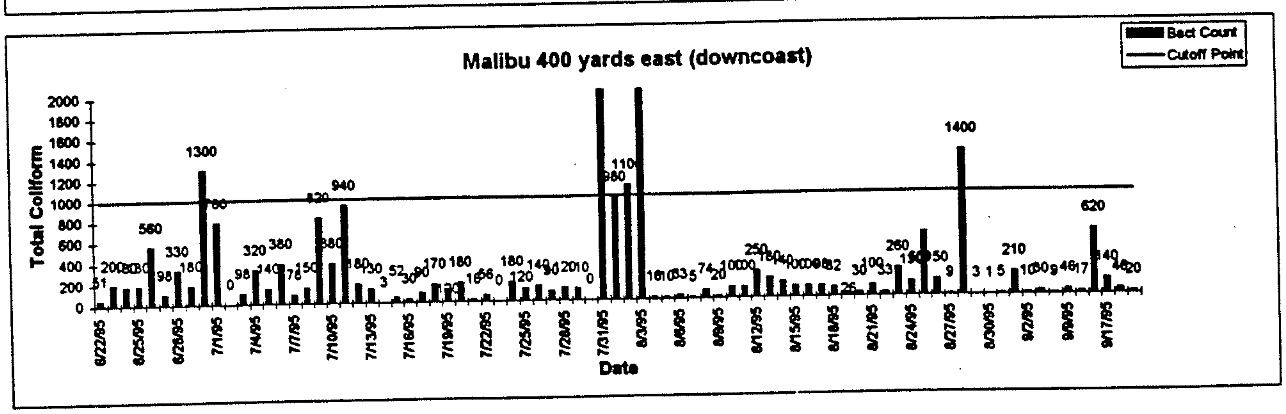


Figure 6D, cont. Daily Total Coliform Indicator Counts at Malibu Beach (Cutoff = 10,000 cpu)

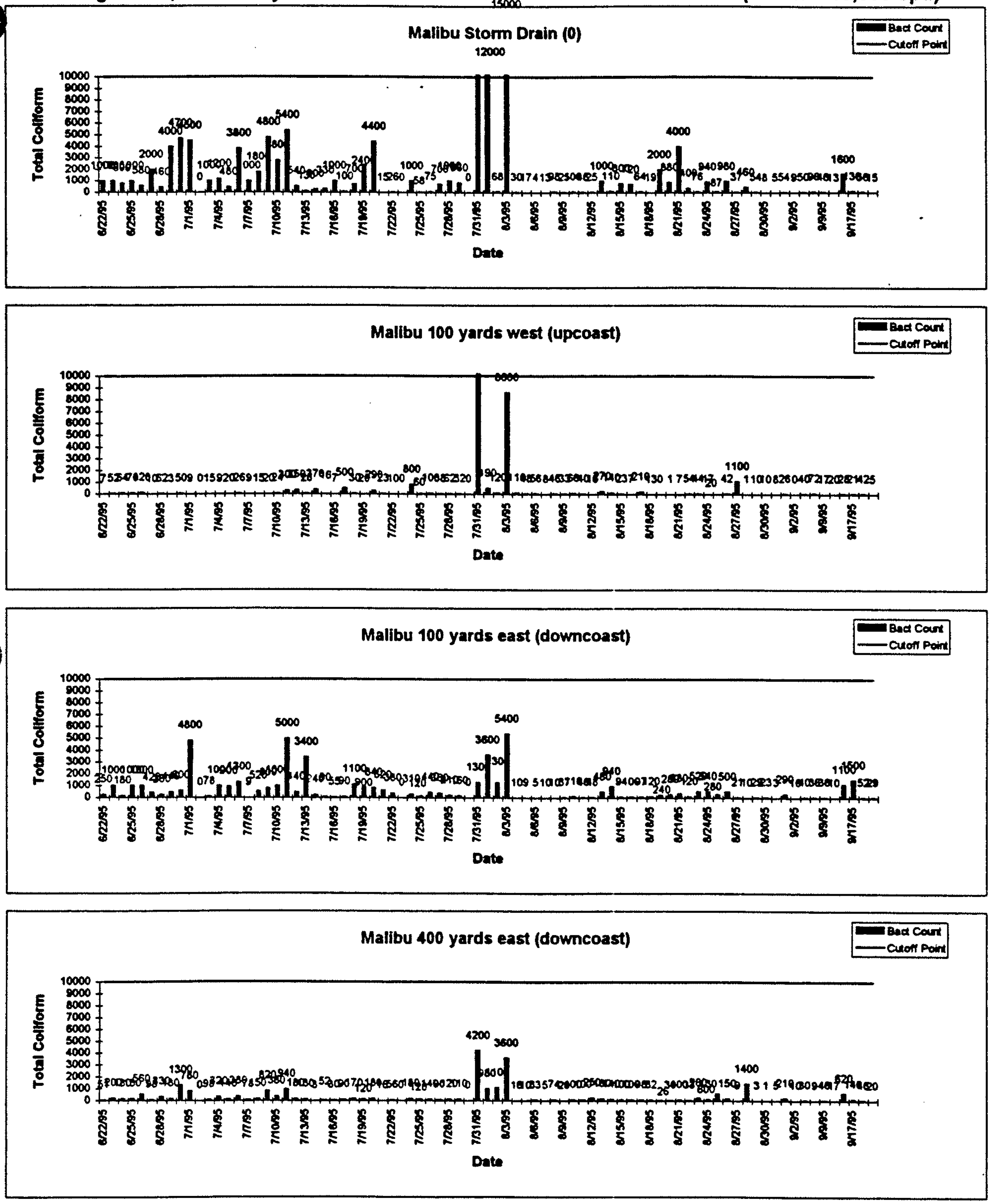


Figure 7A. Daily *E.coli* Indicator Counts at Will Rogers Beach (Cutoff = 35 cpu)

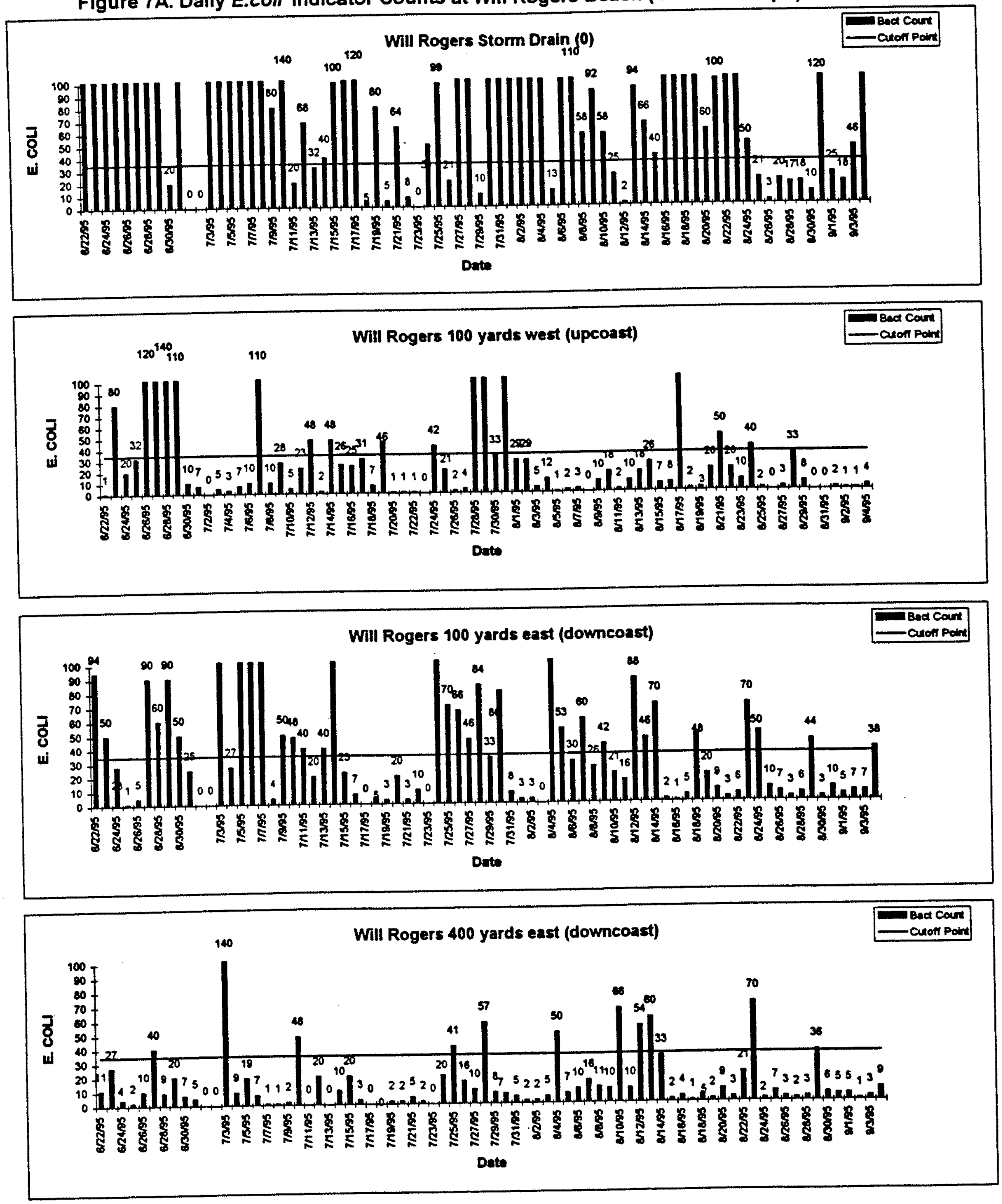


Figure 7A, cont. Daily *E.coli* Indicator Counts at Will Rogers Beach (Cutoff = 70 cpu)

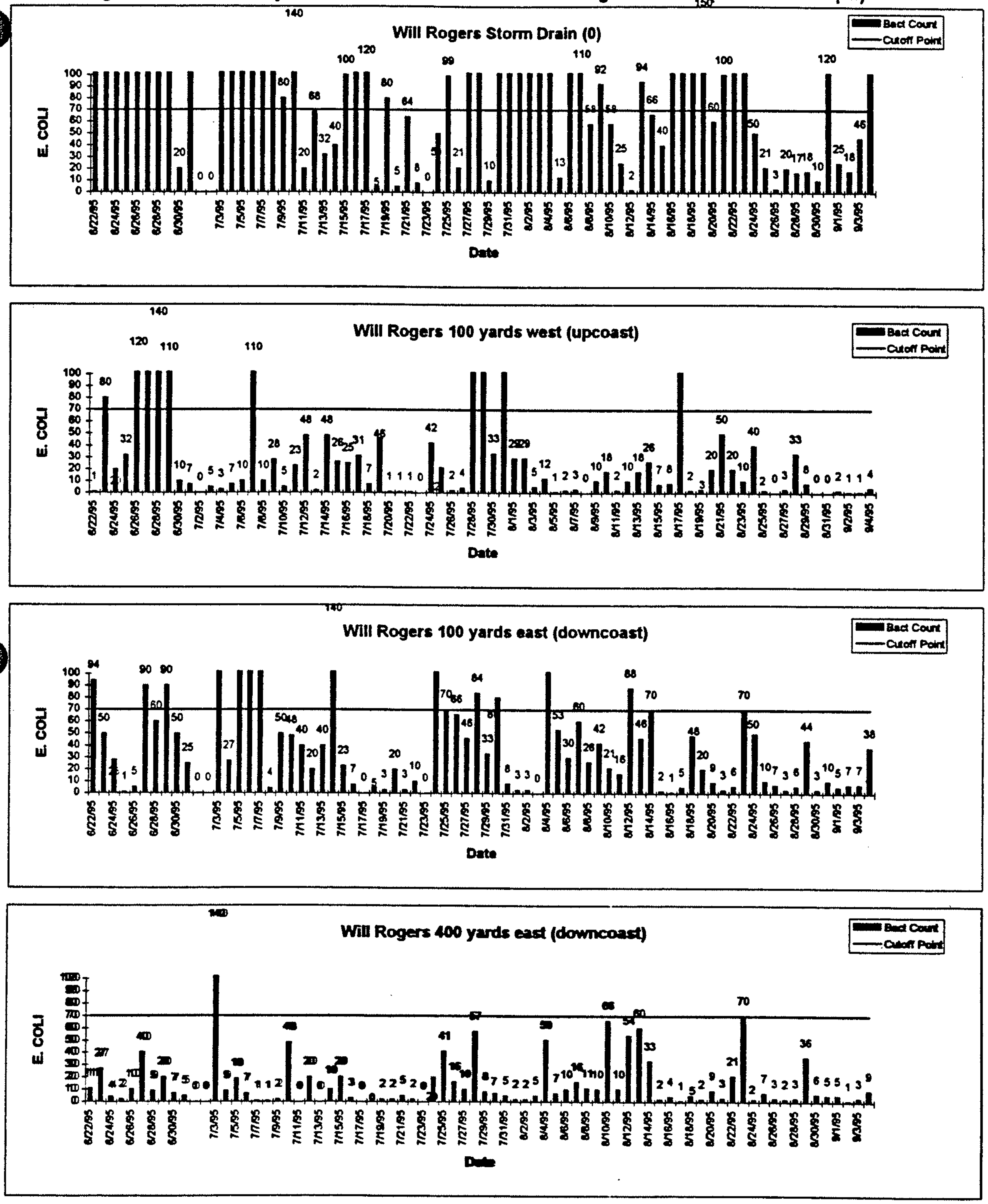
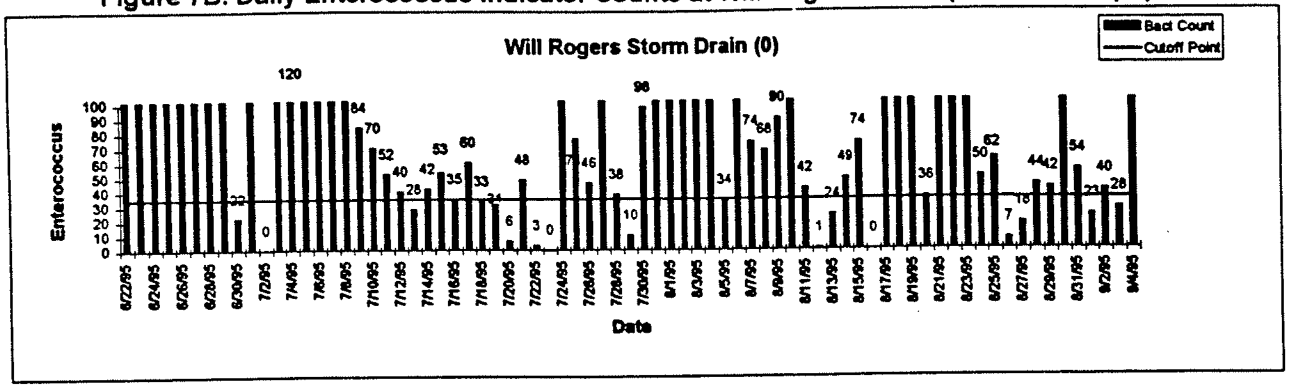
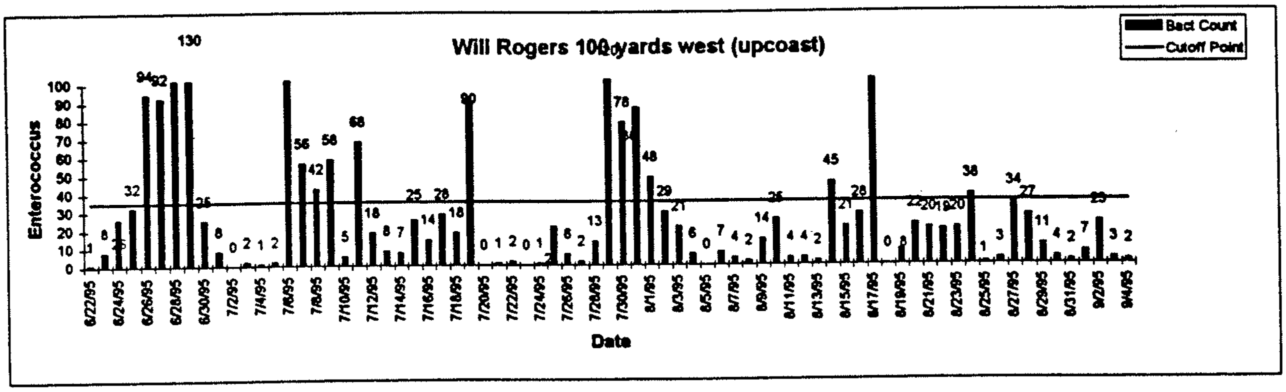
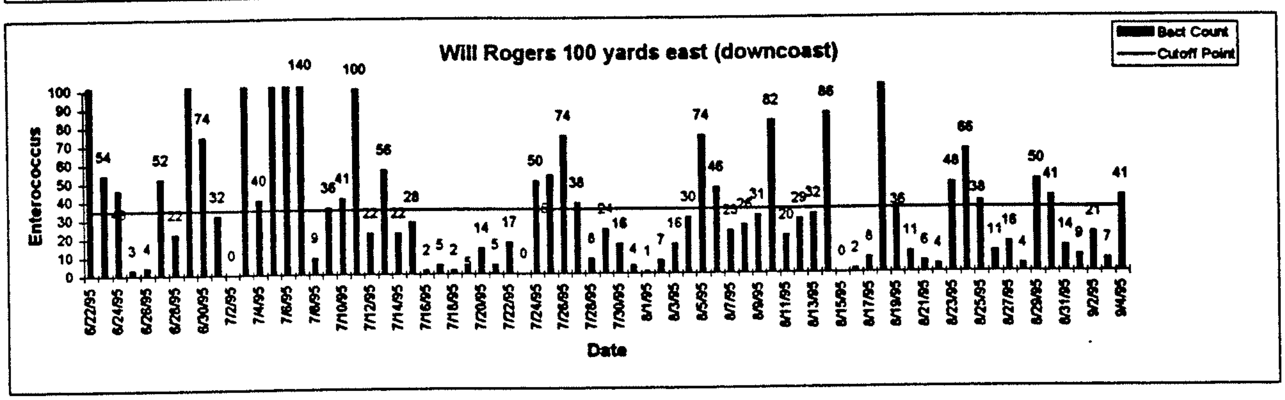


Figure 7B. Daily Enterococcus Indicator Counts at Will Rogers Beach (Cutoff = 35 cpu)







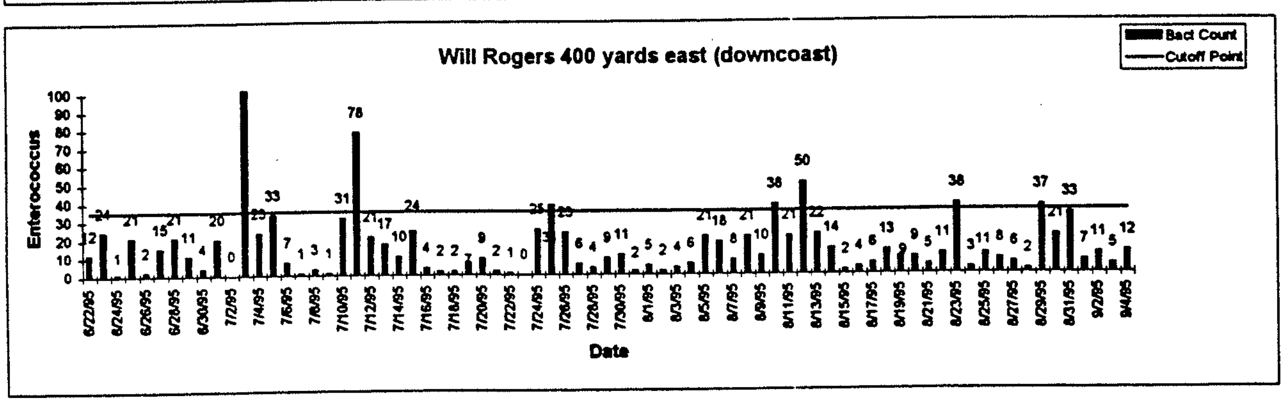


Figure 7B, cont. Daily Enterococcus Indicator Counts at Will Rogers Beach (Cutoff = 106 cpu)

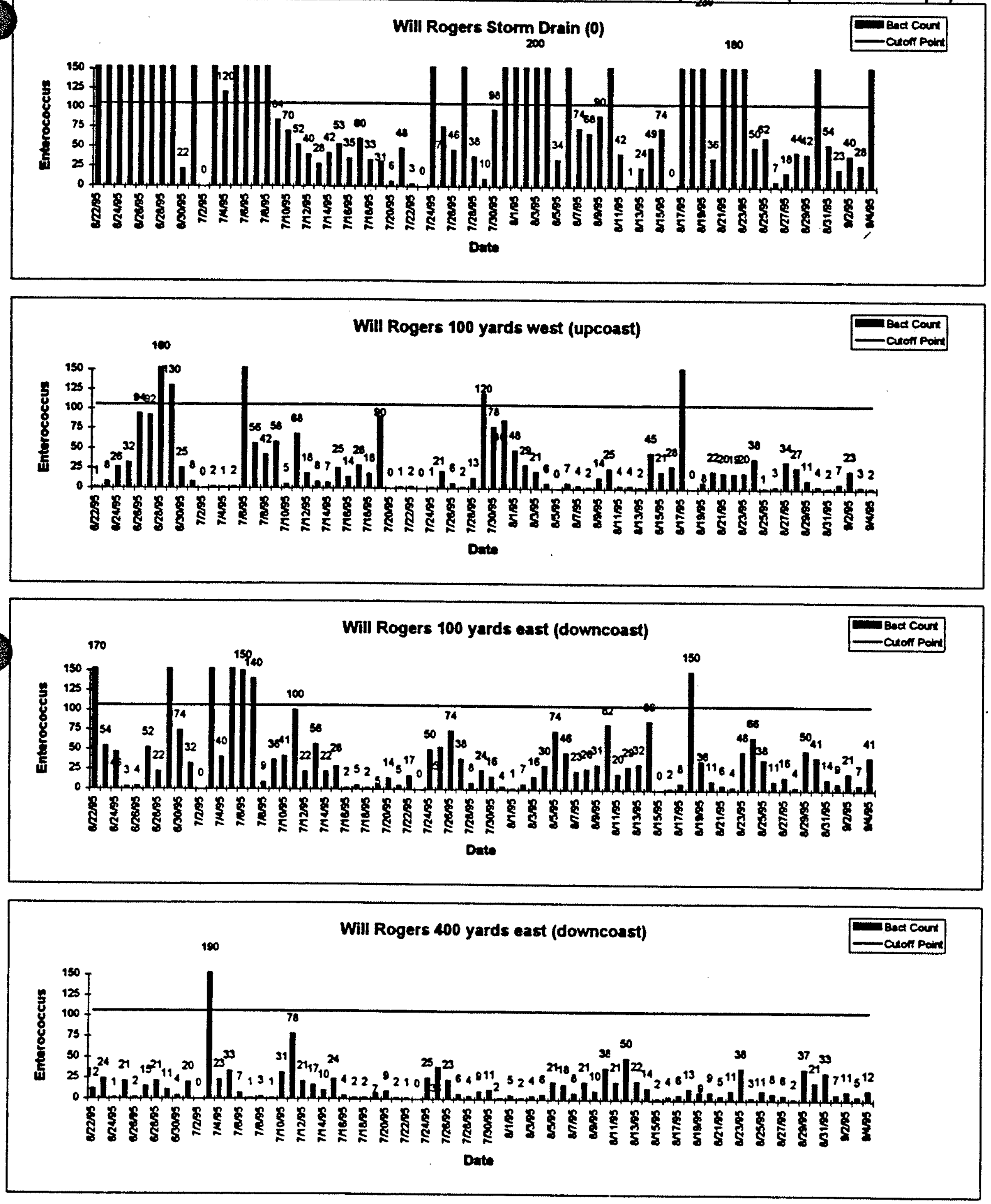
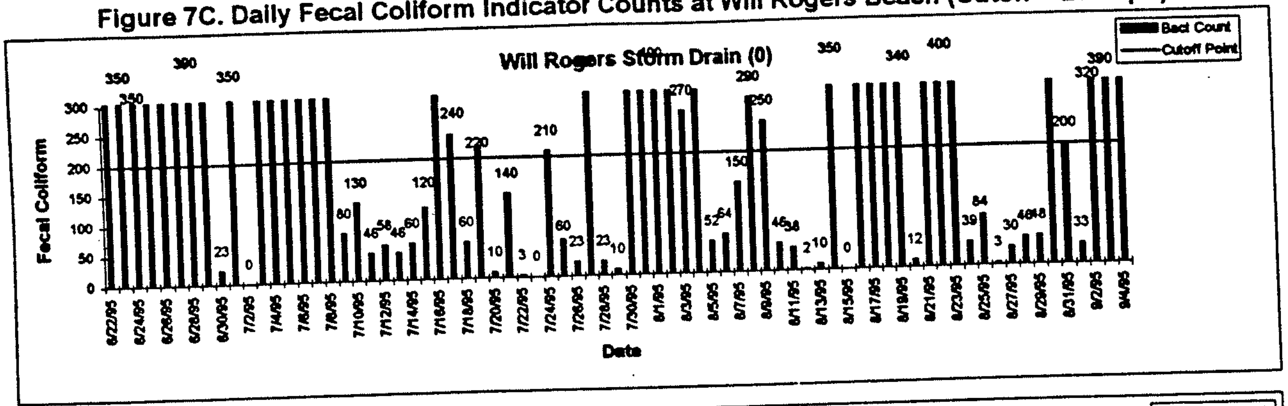
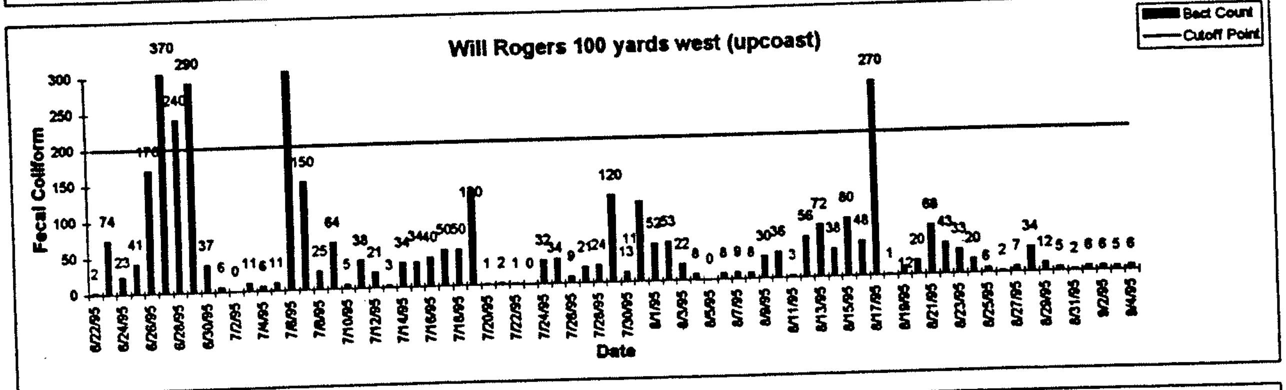
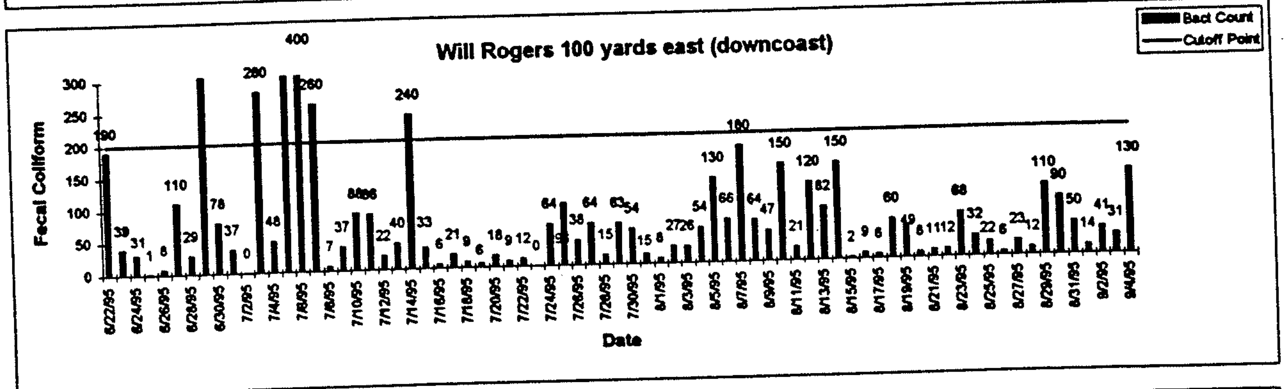


Figure 7C. Daily Fecal Coliform Indicator Counts at Will Rogers Beach (Cutoff = 200 cpu)







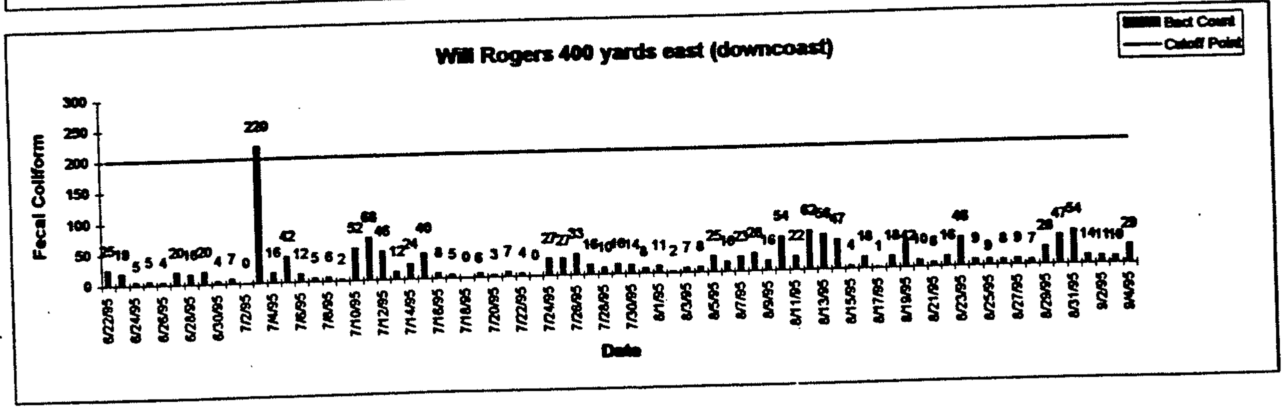


Figure 7C, cont. Daily Fecal Coliform Indicator Counts at Will Rogers Beach (Cutoff = 400 cpu)

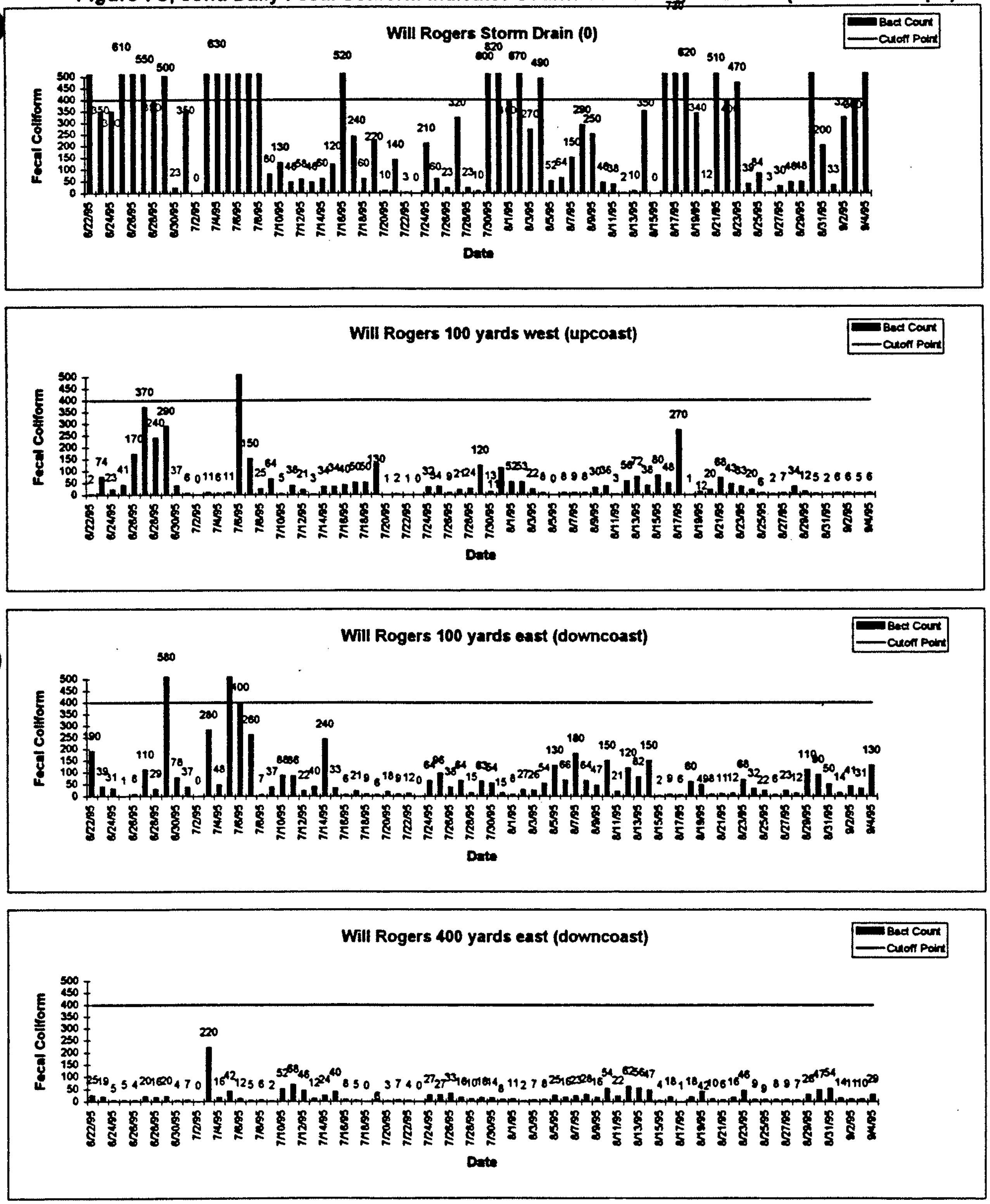


Figure 7D. Daily Total Coliform Indicator Counts at Will Rogers Beach (Cutoff = 1000 cpu)

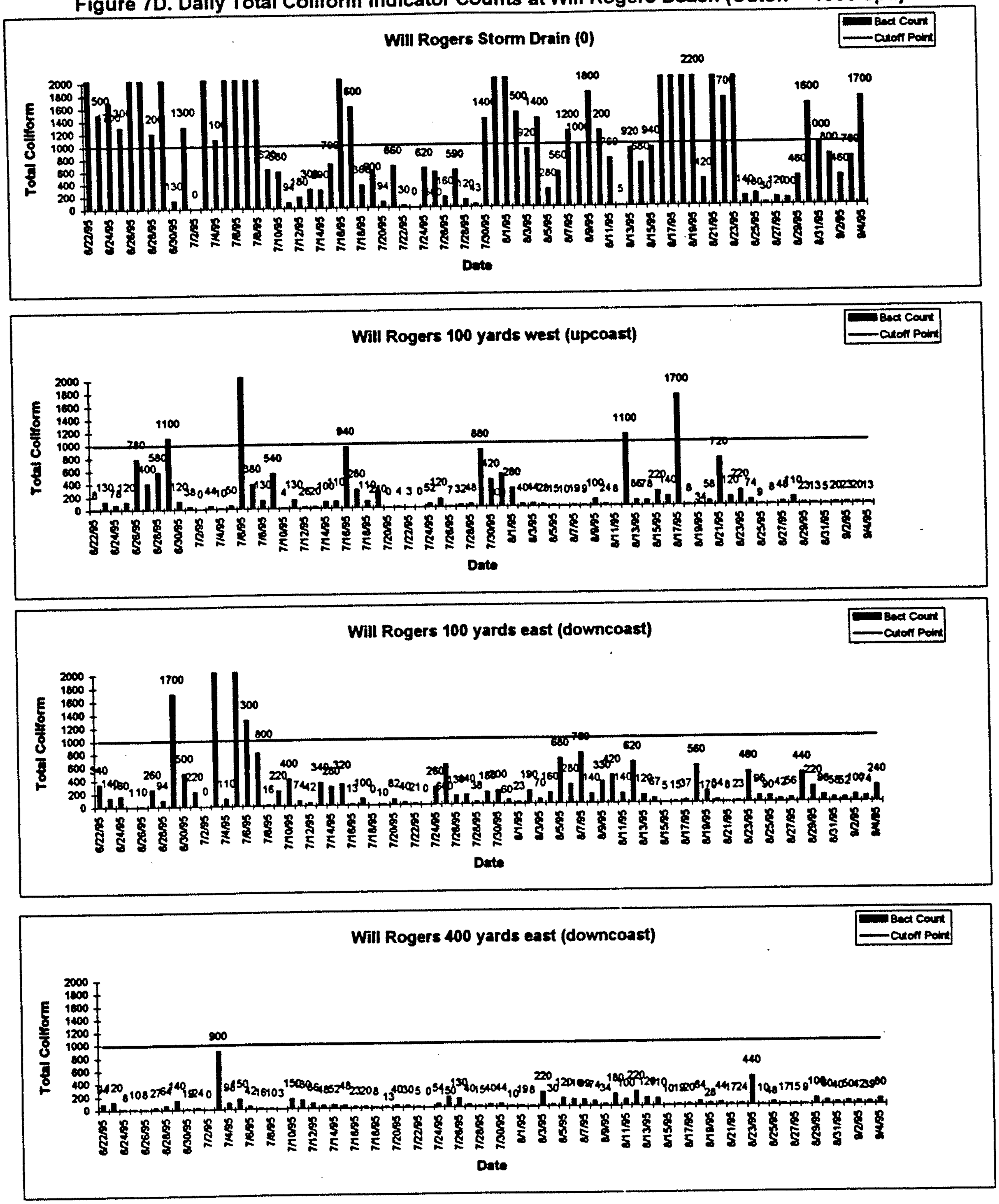
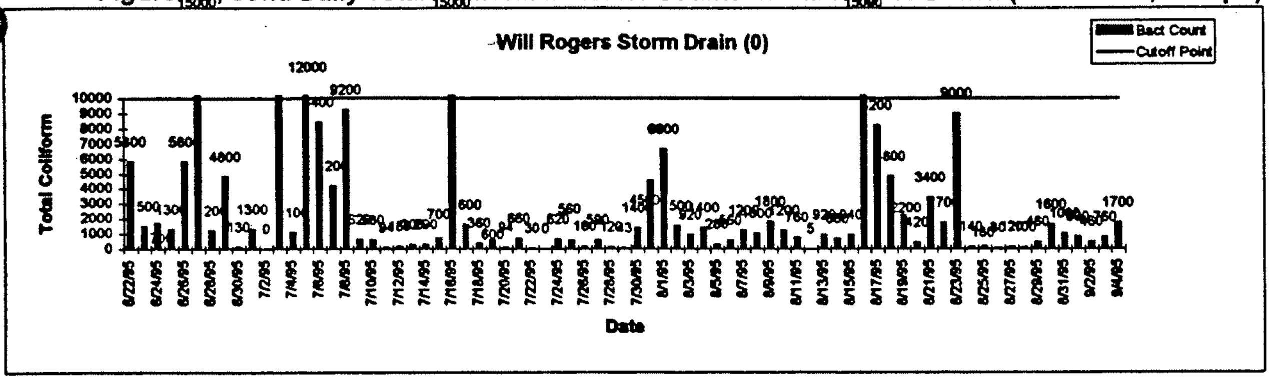
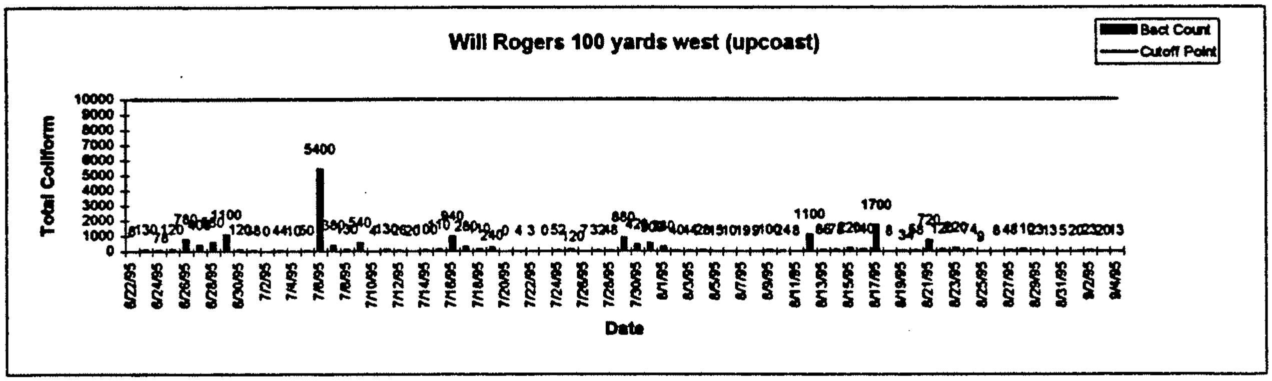
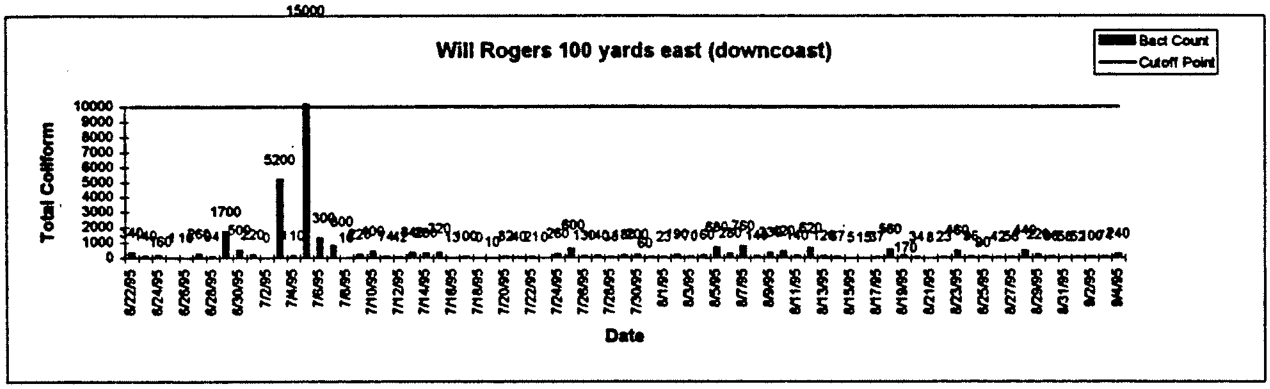


Figure 7D, cont. Daily Total Coliform Indicator Counts at Will Rogers Beach (Cutoff = 10,000 cpu)







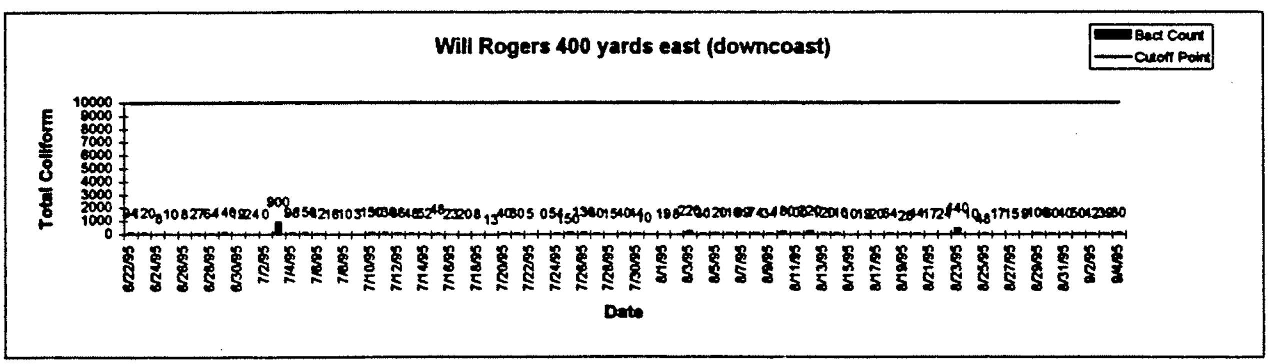


Table 17. Risks Among Swimmers at the Drain vs. Risks Among Controls

ALL BEACHES

SYMPTOMS	Total Exposed = 827		Total Unexposed = 3030				
	0 yds		400+ yds				
	Ill	Risks	Ill	Risks	RR	Lower 95%CI	Upper 95% CI
Fever*	59	0.071	138	0.046	1.57	1.17	2.10
Chills*	31	0.037	72	0.024	1.58	1.04	2.39
Eye discharge	19	0.023	61	0.020	1.14	0.69	1.90
Earache	38	0.046	116	0.038	1.20	0.84	1.72
Ear discharge*	13	0.016	21	0.007	2.27	1.14	4.51
Skin rash	4	0.005	23	0.008	0.64	0.22	1.84
Infected cut	6	0.007	17	0.006	1.29	0.51	3.27
Nausea	40	0.048	133	0.044	1.10	0.78	1.56
Vomiting*	25	0.030	57	0.019	1.61	1.01	2.56
Diarrhea	53	0.064	204	0.067	0.95	0.71	1.27
Diarrhea w/ blood	2	0.002	7	0.002	1.05	0.22	5.03
Stomach pain	61	0.074	206	0.068	1.08	0.82	1.43
Coughing	55	0.067	209	0.069	0.96	0.72	1.28
Phlegm*	39	0.047	90	0.030	1.59	1.10	2.29
Nasal congestion	74	0.089	273	0.090	0.99	0.78	1.27
Sore throat	59	0.071	190	0.063	1.14	0.86	1.51
HCGI 1	35	0.042	102	0.034	1.26	0.86	1.83
HCGI 2*	15	0.018	26	0.009	2.11	1.12	3.97
SRD*	63	0.076	139	0.046	1.66	1.25	2.21

* statistically significant at $p < 0.05$

Table 18. Risks Among Swimmers at 1-50 Yards Upcoast vs. Risks Among Controls

ALL BEACHES

	Total Exposed = 2592		Total Unexposed = 3030				
	1-50 yds		400+ yds				
SYMPTOMS	Ill	Risks	Ill	Risks	RR	Lower 95%CI	Upper 95% CI
Fever	114	0.045	138	0.046	0.99	0.78	1.26
Chills	63	0.025	72	0.024	1.05	0.75	1.46
Eye discharge	50	0.020	61	0.020	0.98	0.68	1.42
Earache	81	0.032	116	0.038	0.84	0.63	1.11
Ear discharge	19	0.008	21	0.007	1.08	0.58	2.01
Skin rash*	35	0.014	23	0.008	1.82	1.08	3.08
Infected cut	23	0.009	17	0.006	1.62	0.87	3.03
Nausea	82	0.032	133	0.044	0.74	0.56	0.97
Vomiting	36	0.014	57	0.019	0.76	0.50	1.14
Diarrhea	120	0.047	204	0.067	0.70	0.57	0.88
Diarrhea w/ blood	1	0.000	7	0.002	0.17	0.02	1.39
Stomach pain	163	0.064	206	0.068	0.95	0.78	1.16
Coughing	173	0.068	209	0.069	0.99	0.82	1.20
Phlegm	80	0.032	90	0.030	1.06	0.79	1.43
Nasal congestion	205	0.081	273	0.090	0.90	0.76	1.07
Sore throat	177	0.070	190	0.063	1.12	0.92	1.36
HCGI 1	71	0.028	102	0.034	0.83	0.62	1.12
HCGI 2	20	0.008	26	0.009	0.92	0.52	1.65
SRD	112	0.044	139	0.046	0.97	0.76	1.23

* statistically significant at $p < 0.05$

Table 19. Risks Among Swimmers at 51-100 Yards Upcoast vs. Risks Among Controls

ALL BEACHES

SYMPTOMS	Total Exposed = 2186 51-100 yds Ill	Risks	Total Unexposed = 3030 400+ yds Ill	Risks	RR	Lower 95%CI	Upper 95% CI
Fever	109.00	0.050	138	0.046	1.09	0.86	1.40
Chills	54	0.025	72	0.024	1.04	0.73	1.47
Eye discharge	45	0.021	61	0.020	1.02	0.70	1.50
Earache	81	0.037	116	0.038	0.97	0.73	1.28
Ear discharge	10	0.005	21	0.007	0.66	0.31	1.40
Skin rash	20	0.009	23	0.008	1.21	0.66	2.19
Infected cut	10	0.005	17	0.006	0.82	0.37	1.78
Nausea	75	0.034	133	0.044	0.78	0.59	1.03
Vomiting	40	0.018	57	0.019	0.97	0.65	1.45
Diarrhea	96	0.044	204	0.067	0.65	0.52	0.83
Diarrhea w/ blood	1	0.000	7	0.002	0.20	0.02	1.61
Stomach pain	126	0.058	206	0.068	0.85	0.68	1.05
Coughing	164	0.075	209	0.069	1.09	0.89	1.32
Phlegm	69	0.032	90	0.030	1.06	0.78	1.45
Nasal congestion	214	0.098	273	0.090	1.09	0.92	1.29
Sore throat	168	0.077	190	0.063	1.23	1.00	1.50
HCGI 1	63	0.029	102	0.034	0.86	0.63	1.17
HCGI 2	19	0.009	26	0.009	1.01	0.56	1.83
SRD	114	0.052	139	0.046	1.14	0.89	1.45

Table 20. Risks Among Swimmers at 1-50 Yards Downcoast vs. Risks Among Controls

ALL BEACHES

	Total Exposed = 1926	1-50 yds	Total Unexposed = 3030	400+ yds			
SYMPTOMS	Ill	Risks	Ill	Risks	RR	Lower 95% CI	Upper 95% CI
Fever	94	0.049	138	0.046	1.07	0.83	1.38
Chills	45	0.023	72	0.024	0.98	0.68	1.42
Eye discharge	23	0.012	61	0.020	0.59	0.37	0.95
Earache	55	0.029	116	0.038	0.75	0.54	1.02
Ear discharge	6	0.003	21	0.007	0.45	0.18	1.11
Skin rash	18	0.009	23	0.008	1.23	0.67	2.28
Infected cut	14	0.007	17	0.006	1.30	0.64	2.62
Nausea	61	0.032	133	0.044	0.72	0.54	0.97
Vomiting	27	0.014	57	0.019	0.75	0.47	1.17
Diarrhea	82	0.043	204	0.067	0.63	0.49	0.81
Diarrhea w/ blood	2	0.001	7	0.002	0.45	0.09	2.16
Stomach pain	108	0.056	206	0.068	0.82	0.66	1.03
Coughing	123	0.064	209	0.069	0.93	0.75	1.15
Phlegm	63	0.033	90	0.030	1.10	0.80	1.51
Nasal congestion	166	0.086	273	0.090	0.96	0.80	1.15
Sore throat	127	0.066	190	0.063	1.05	0.85	1.31
HCGI 1	50	0.026	102	0.034	0.77	0.55	1.08
HCGI 2	12	0.006	26	0.009	0.73	0.37	1.44
SRD	93	0.048	139	0.046	1.05	0.81	1.36

Table 21. Risks Among Swimmers at 51-100 Yards Downcoast vs. Risks Among Controls

ALL BEACHES

	Total Exposed = 1125	51-100 yds	Total Unexposed = 3030	400+ yds			
SYMPTOMS	Ill	Risks	Ill	Risks	RR	Lower 95% CI	Upper 95% CI
Fever	49	0.044	138	0.046	0.96	0.70	1.32
Chills	31	0.028	72	0.024	1.16	0.77	1.76
Eye discharge	14	0.012	61	0.020	0.62	0.35	1.10
Earache	35	0.031	116	0.038	0.81	0.56	1.18
Ear discharge	9	0.008	21	0.007	1.15	0.53	2.51
Skin rash	10	0.009	23	0.008	1.17	0.56	2.45
Infected cut	6	0.005	17	0.006	0.95	0.38	2.40
Nausea	40	0.036	133	0.044	0.81	0.57	1.15
Vomiting	18	0.016	57	0.019	0.85	0.50	1.44
Diarrhea	67	0.060	204	0.067	0.88	0.68	1.16
Diarrhea w/ blood	1	0.001	7	0.002	0.38	0.05	3.12
Stomach pain	68	0.060	206	0.068	0.89	0.68	1.16
Coughing*	99	0.088	209	0.069	1.28	1.01	1.60
Phlegm	45	0.040	90	0.030	1.35	0.95	1.91
Nasal congestion*	137	0.122	273	0.090	1.35	1.11	1.64
Sore throat	76	0.068	190	0.063	1.08	0.83	1.39
HCGI_1	33	0.029	102	0.034	0.87	0.59	1.28
HCGI_2	9	0.008	26	0.009	0.93	0.44	1.98
SRD	63	0.056	139	0.046	1.22	0.91	1.63

* statistically significant at $p < 0.05$

Table 22. Risks Among Swimmers At Each Distance vs. Risks Among Controls

ALL BEACHES – downcoast

	drain (0 yds)			1 - 50 yards			51 - 100 yards		
SYMPTOMS	RR	Lower 95% CI	Upper 95% CI	RR	Lower 95% CI	Upper 95% CI	RR	Lower 95% CI	Upper 95% CI
Fever	1.57	1.17	2.10	1.07	0.83	1.38	0.96	0.70	1.32
Chills	1.58	1.04	2.39	0.98	0.68	1.42	1.16	0.77	1.76
Eye discharge	1.14	0.69	1.90	0.59	0.37	0.95	0.62	0.35	1.10
Earache	1.20	0.84	1.72	0.75	0.54	1.02	0.81	0.56	1.18
Ear discharge	2.27	1.14	4.51	0.45	0.18	1.11	1.15	0.53	2.51
Skin rash	0.64	0.22	1.84	1.23	0.67	2.28	1.17	0.56	2.45
Infected cut	1.29	0.51	3.27	1.30	0.64	2.62	0.95	0.38	2.40
Nausea	1.10	0.78	1.56	0.72	0.54	0.97	0.81	0.57	1.15
Vomiting	1.61	1.01	2.56	0.75	0.47	1.17	0.85	0.50	1.44
Diarrhea	0.95	0.71	1.27	0.63	0.49	0.81	0.88	0.68	1.16
Diarrhea w/ blood	1.05	0.22	5.03	0.45	0.09	2.16	0.38	0.05	3.12
Stomach pain	1.08	0.82	1.43	0.82	0.66	1.03	0.89	0.68	1.16
Coughing	0.96	0.72	1.28	0.93	0.75	1.15	1.28	1.01	1.60
Phlegm	1.59	1.10	2.29	1.10	0.80	1.51	1.35	0.95	1.91
Nasal congestion	0.99	0.78	1.27	0.96	0.80	1.15	1.35	1.11	1.64
Sore throat	1.14	0.86	1.51	1.05	0.85	1.31	1.08	0.83	1.39
HCGI_1	1.26	0.86	1.83	0.77	0.55	1.08	0.87	0.59	1.28
HCGI_2	2.11	1.12	3.97	0.73	0.37	1.44	0.93	0.44	1.98
SRD	1.66	1.25	2.21	1.05	0.81	1.36	1.22	0.91	1.63

Table 23. Risks Among Swimmers At Each Distance vs. Risks Among Controls

ALL BEACHES – upcoast

	drain (0 yds)			1 - 50 yards			51 - 100 yards		
SYMPTOMS	RR	Lower 95% CI	Upper 95% CI	RR	Lower 95% CI	Upper 95% CI	RR	Lower 95% CI	Upper 95% CI
Fever	1.57	1.17	2.10	0.99	0.78	1.26	1.09	0.86	1.40
Chills	1.58	1.04	2.39	1.05	0.75	1.46	1.04	0.73	1.47
Eye discharge	1.14	0.69	1.90	0.98	0.68	1.42	1.02	0.70	1.50
Earache	1.20	0.84	1.72	0.84	0.63	1.11	0.97	0.73	1.28
Ear discharge	2.27	1.14	4.51	1.08	0.58	2.01	0.66	0.31	1.40
Skin rash	0.64	0.22	1.84	1.82	1.08	3.08	1.21	0.66	2.19
Infected cut	1.29	0.51	3.27	1.62	0.87	3.03	0.82	0.37	1.78
Nausea	1.10	0.78	1.56	0.74	0.56	0.97	0.78	0.59	1.03
Vomiting	1.61	1.01	2.56	0.76	0.50	1.14	0.97	0.65	1.45
Diarrhea	0.95	0.71	1.27	0.70	0.57	0.88	0.65	0.52	0.83
Diarrhea w/ blood	1.05	0.22	5.03	0.17	0.02	1.39	0.20	0.02	1.61
Stomach pain	1.08	0.82	1.43	0.95	0.78	1.16	0.85	0.68	1.05
Coughing	0.96	0.72	1.28	0.99	0.82	1.20	1.09	0.89	1.32
Phlegm	1.59	1.10	2.29	1.06	0.79	1.43	2.60	2.03	3.34
Nasal congestion	0.99	0.78	1.27	0.90	0.76	1.07	1.09	0.92	1.29
Sore throat	1.14	0.86	1.51	1.12	0.92	1.36	1.23	1.00	1.50
HCGI_1	1.26	0.86	1.83	0.83	0.62	1.12	0.86	0.63	1.17
HCGI_2	2.11	1.12	3.97	0.92	0.52	1.65	1.01	0.56	1.83
SRD	1.66	1.25	2.21	0.97	0.76	1.23	1.14	0.89	1.45

Table 24. Risks Among Swimmers at the Drain vs. Risks Among Controls

CONTROLS EXPOSED TO TOTAL/FECAL RATIOS > 5

SYMPTOMS	Total Exposed = 827	0 yds	Total Unexposed = 624	400+ yds			
	Ill	Risks	Ill	Risks	RR	Lower 95%CI	Upper 95% CI
Fever*	59	0.071	27	0.043	1.65	1.06	2.57
Chills*	31	0.037	11	0.018	2.13	1.08	4.20
Eye discharge	19	0.023	19	0.030	0.75	0.40	1.41
Earache	38	0.046	26	0.042	1.10	0.68	1.80
Ear discharge	13	0.016	4	0.006	2.45	0.80	7.48
Skin rash	4	0.005	3	0.005	1.01	0.23	4.48
Infected cut	6	0.007	1	0.002	4.53	0.55	37.51
Nausea	40	0.048	27	0.043	1.12	0.69	1.80
Vomiting	25	0.030	10	0.016	1.89	0.91	3.90
Diarrhea	53	0.064	36	0.058	1.11	0.74	1.67
Diarrhea w/ blood	2	0.002	0	0.000	–	–	–
Stomach pain	61	0.074	44	0.071	1.05	0.72	1.52
Coughing	55	0.067	34	0.054	1.22	0.81	1.85
Phlegm*	39	0.047	11	0.018	2.68	1.38	5.18
Nasal congestion	74	0.089	46	0.074	1.21	0.85	1.73
Sore throat	59	0.071	33	0.053	1.35	0.89	2.04
HCGI 1	35	0.042	23	0.037	1.15	0.69	1.92
HCGI 2*	15	0.018	2	0.003	5.66	1.30	24.66
SRD*	63	0.076	17	0.027	2.80	1.65	4.73

* statistically significant at $p < 0.05$

Table 25. Risks Among Swimmers at 1-50 Yards Upcoast vs. Risks Among Controls

CONTROLS EXPOSED TO TOTAL/FECAL RATIOS > 5

	Total Exposed = 2592		Total Unexposed = 624				
	1-50 yds		400+ yds				
SYMPTOMS	Ill	Risks	Ill	Risks	RR	Lower 95%CI	Upper 95% CI
Fever	114	0.045	27	0.043	1.04	0.69	1.57
Chills	63	0.025	11	0.018	1.41	0.75	2.67
Eye discharge	50	0.020	19	0.030	0.65	0.39	1.09
Earache	81	0.032	26	0.042	0.77	0.50	1.19
Ear discharge	19	0.008	4	0.006	1.17	0.40	3.43
Skin rash	35	0.014	3	0.005	2.88	0.89	9.33
Infected cut	23	0.009	1	0.002	5.67	0.77	41.94
Nausea	82	0.032	27	0.043	0.75	0.49	1.15
Vomiting	36	0.014	10	0.016	0.89	0.44	1.78
Diarrhea	120	0.047	36	0.058	0.82	0.57	1.18
Diarrhea w/ blood	1	0.000	0	0.000	–	–	–
Stomach pain	163	0.064	163	0.261	0.25	0.20	0.30
Coughing	173	0.068	34	0.054	1.26	0.88	1.79
Phlegm	80	0.032	11	0.018	1.79	0.96	3.35
Nasal congestion	205	0.081	46	0.074	1.10	0.81	1.50
Sore throat	177	0.070	33	0.053	1.32	0.92	1.90
HCGI 1	71	0.028	23	0.037	0.76	0.48	1.21
HCGI 2	20	0.008	2	0.003	2.47	0.58	10.53
SRD	112	0.044	17	0.027	1.63	0.98	2.69

Table 26. Risks Among Swimmers at 51-100 Yards Upcoast vs. Risks Among Controls

CONTROLS EXPOSED TO TOTAL/FECAL RATIOS > 5

	Total Exposed = 2186		Total Unexposed = 624				
	51-100 yds		400+ yds				
SYMPTOMS	Ill	Risks	Ill	Risks	RR	Lower 95%CI	Upper 95% CI
Fever	109	0.050	27	0.043	1.15	0.76	1.74
Chills	54	0.025	11	0.018	1.40	0.74	2.66
Eye discharge	45	0.021	19	0.030	0.68	0.40	1.15
Earache	81	0.037	26	0.042	0.89	0.58	1.37
Ear discharge	10	0.005	4	0.006	0.71	0.22	2.27
Skin rash	20	0.009	3	0.005	1.90	0.57	6.38
Infected cut	10	0.005	1	0.002	2.85	0.37	22.26
Nausea	75	0.034	27	0.043	0.79	0.52	1.22
Vomiting	40	0.018	10	0.016	1.14	0.57	2.27
Diarrhea	96	0.044	36	0.058	0.76	0.52	1.10
Diarrhea w/ blood	1	0.000	0	0.000	–	–	–
Stomach pain	126	0.058	44	0.071	0.82	0.59	1.14
Coughing	164	0.075	34	0.054	1.38	0.96	1.97
Phlegm	69	0.032	11	0.018	1.79	0.95	3.36
Nasal congestion	214	0.098	46	0.074	1.33	0.98	1.80
Sore throat*	168	0.077	33	0.053	1.45	1.01	2.09
HCGI 1	63	0.029	23	0.037	0.78	0.49	1.25
HCGI 2	19	0.009	21	0.034	0.26	0.14	0.48
SRD*	114	0.052	17	0.027	1.91	1.16	3.16

* statistically significant at $p < 0.05$

Table 27. Risks Among Swimmers at 1-50 Yards Downcoast vs. Risks Among Controls

CONTROLS EXPOSED TO TOTAL/FECAL RATIOS > 5

	Total Exposed = 1926		Total Unexposed = 624				
	1-50 yds		400+ yds				
SYMPTOMS	Ill	Risks	Ill	Risks	RR	Lower 95% CI	Upper 95% CI
Fever	94	0.049	27	0.043	1.13	0.74	1.71
Chills	45	0.023	11	0.018	1.33	0.69	2.55
Eye discharge	23	0.012	19	0.030	0.39	0.22	0.72
Earache	55	0.029	26	0.042	0.69	0.43	1.08
Ear discharge	6	0.003	4	0.006	0.49	0.14	1.72
Skin rash	18	0.009	3	0.005	1.94	0.57	6.58
Infected cut	14	0.007	1	0.002	4.54	0.60	34.43
Nausea	61	0.032	27	0.043	0.73	0.47	1.14
Vomiting	27	0.014	10	0.016	0.87	0.43	1.80
Diarrhea	82	0.043	36	0.058	0.74	0.50	1.08
Diarrhea w/ blood	2	0.001	0	0.000	–	–	–
Stomach pain	108	0.056	44	0.071	0.80	0.57	1.12
Coughing	123	0.064	34	0.054	1.17	0.81	1.69
Phlegm	63	0.033	11	0.018	1.86	0.98	3.50
Nasal congestion	166	0.086	46	0.074	1.17	0.85	1.60
Sore throat	127	0.066	33	0.053	1.25	0.86	1.81
HCGI 1	50	0.026	23	0.037	0.70	0.43	1.14
HCGI 2	12	0.006	2	0.003	1.94	0.44	8.66
SRD*	93	0.048	17	0.027	1.77	1.07	2.95

* statistically significant at $p < 0.05$

Table 28. Risks Among Swimmers at 51-100 Yards Downcoast vs. Risks Among Controls

CONTROLS EXPOSED TO TOTAL/FECAL RATIOS > 5

	Total Exposed	= 1125	Total Unexposed	= 624			
		51-100 yds		400+ yds			
SYMPTOMS	Ill	Risks	Ill	Risks	RR	Lower 95% CI	Upper 95% CI
Fever	49	0.044	27	0.043	1.01	0.64	1.59
Chills	31	0.028	11	0.018	1.56	0.79	3.09
Eye discharge	14	0.012	19	0.030	0.41	0.21	0.81
Earache	35	0.031	26	0.042	0.75	0.45	1.23
Ear discharge	9	0.008	4	0.006	1.25	0.39	4.04
Skin rash	10	0.009	3	0.005	1.85	0.51	6.69
Infected cut	6	0.005	1	0.002	3.33	0.40	27.58
Nausea	40	0.036	27	0.043	0.82	0.51	1.33
Vomiting	18	0.016	10	0.016	1.00	0.46	2.15
Diarrhea	67	0.060	36	0.058	1.03	0.70	1.53
Diarrhea w/ blood	1	0.001	0	0.000	–	–	–
Stomach pain	68	0.060	44	0.071	0.86	0.59	1.24
Coughing*	99	0.088	34	0.054	1.62	1.11	2.35
Phlegm*	45	0.040	11	0.018	2.27	1.18	4.36
Nasal congestion*	137	0.122	46	0.074	1.65	1.20	2.27
Sore throat	76	0.068	33	0.053	1.28	0.86	1.90
HCGI_1	33	0.029	23	0.037	0.80	0.47	1.34
HCGI_2	9	0.008	2	0.003	2.50	0.54	11.52
SRD*	63	0.056	17	0.027	2.06	1.21	3.48

* statistically significant at $p < 0.05$

Table 29. Risks Among Swimmers At Each Distance vs. Risks Among Controls

CONTROLS EXPOSED TO TOTAL/FECAL RATIOS > 5 – downcoast

	drain (0 yds)			1 - 50 yards			51 - 100 yards		
SYMPTOMS	RR	Lower 95% CI	Upper 95% CI	RR	Lower 95% CI	Upper 95% CI	RR	Lower 95% CI	Upper 95% CI
Fever	1.65	1.06	2.57	1.13	0.74	1.71	1.01	0.64	1.59
Chills	2.13	1.08	4.20	1.33	0.69	2.55	1.56	0.79	3.09
Eye discharge	0.75	0.40	1.41	0.39	0.22	0.72	0.41	0.21	0.81
Earache	1.10	0.68	1.80	0.69	0.43	1.08	0.75	0.45	1.23
Ear discharge	2.45	0.80	7.48	0.49	0.14	1.72	1.25	0.39	4.04
Skin rash	1.01	0.23	4.48	1.94	0.57	6.58	1.85	0.51	6.69
Infected cut	4.53	0.55	37.51	4.54	0.60	34.43	3.33	0.40	27.58
Nausea	1.12	0.69	1.80	0.73	0.47	1.14	0.82	0.51	1.33
Vomiting	1.89	0.91	3.90	0.87	0.43	1.80	1.00	0.46	2.15
Diarrhea	1.11	0.74	1.67	0.74	0.50	1.08	1.03	0.70	1.53
Diarrhea w/ blood	--	--	--	--	--	--	--	--	--
Stomach pain	1.05	0.72	1.52	0.80	0.57	1.12	0.86	0.59	1.24
Coughing	1.22	0.81	1.85	1.17	0.81	1.69	1.62	1.11	2.35
Phlegm	2.68	1.38	5.18	1.86	0.98	3.50	2.27	1.18	4.36
Nasal congestion	1.21	0.85	1.73	1.17	0.85	1.60	1.65	1.20	2.27
Sore throat	1.35	0.89	2.04	1.25	0.86	1.81	1.28	0.86	1.90
HCGI_1	1.15	0.69	1.92	0.70	0.43	1.14	0.80	0.47	1.34
HCGI_2	5.66	1.30	24.66	1.94	0.44	8.66	2.50	0.54	11.52
SRD	2.80	1.65	4.73	1.77	1.07	2.95	2.06	1.21	3.48

Table 30. Risks Among Swimmers At Each Distance vs. Risks Among Controls

CONTROLS EXPOSED TO TOTAL/FECAL RATIOS > 5 – upcoast

	drain (0 yds)			1 - 50 yards			51 - 100 yards		
SYMPTOMS	RR	Lower 95% CI	Upper 95% CI	RR	Lower 95% CI	Upper 95% CI	RR	Lower 95% CI	Upper 95% CI
Fever	1.65	1.06	2.57	1.04	0.69	1.57	1.15	0.76	1.74
Chills	2.13	1.08	4.20	1.41	0.75	2.67	1.40	0.74	2.66
Eye discharge	0.75	0.40	1.41	0.65	0.39	1.09	0.68	0.40	1.15
Earache	1.10	0.68	1.80	0.77	0.50	1.19	0.89	0.58	1.37
Ear discharge	2.45	0.80	7.48	1.17	0.40	3.43	0.71	0.22	2.27
Skin rash	1.01	0.23	4.48	2.88	0.89	9.33	1.90	0.57	6.38
Infected cut	4.53	0.55	37.51	5.67	0.77	41.94	2.85	0.37	22.26
Nausea	1.12	0.69	1.80	0.75	0.49	1.15	0.79	0.52	1.22
Vomiting	1.89	0.91	3.90	0.89	0.44	1.78	1.14	0.57	2.27
Diarrhea	1.11	0.74	1.67	0.82	0.57	1.18	0.76	0.52	1.10
Diarrhea w/ blood	--	--	--	--	--	--	--	--	--
Stomach pain	1.05	0.72	1.52	0.25	0.20	0.30	0.82	0.59	1.14
Coughing	1.22	0.81	1.85	1.26	0.88	1.79	1.38	0.96	1.97
Phlegm	2.68	1.38	5.18	1.79	0.96	3.35	1.79	0.95	3.36
Nasal congestion	1.21	0.85	1.73	1.10	0.81	1.50	1.33	0.98	1.80
Sore throat	1.35	0.89	2.04	1.32	0.92	1.90	1.45	1.01	2.09
HCGI_1	1.15	0.69	1.92	0.76	0.48	1.21	0.78	0.49	1.25
HCGI_2	5.66	1.30	24.66	2.47	0.58	10.53	0.26	0.14	0.48
SRD	2.80	1.65	4.73	1.63	0.98	2.69	1.91	1.16	3.16

Table 31. Adjusted Odds Ratios and 95% Confidence Intervals for Outcomes of Interest by Distance from Drain.†

	Distance from drain (in yards)				
	400	100-50	50-1	0	trend P
# exposed:	3030	3311	4518	827	
Fever *	138 1.00	158 1.06 0.83-1.34	208 1.04 0.84-1.30	59 1.53 1.10-2.12	0.10
Chills	72 1.00	85 1.06 0.77-1.46	108 1.03 0.76-1.40	31 1.54 0.99-2.40	0.24
Eye discharge	61 1.00	59 0.88 0.61-1.27	73 0.79 0.56-1.12	19 1.20 0.70-2.06	0.61
Earache	116 1.00	116 0.89 0.68-1.16	136 0.80 0.62-1.03	38 1.32 0.89-1.94	0.70
Ear discharge *	21 1.00	19 0.78 0.42-1.46	25 0.82 0.46-1.47	13 2.28 1.10-4.71	0.26
Skin rash	23 1.00	30 1.15 0.66-1.98	53 1.51 0.92-2.47	4 0.62 0.21-1.83	0.41
Infected cut	17 1.00	16 0.80 0.40-1.59	37 1.50 0.84-2.68	6 1.55 0.59-4.05	0.08
Nausea	133 1.00	115 0.77 0.60-1.00	143 0.74 0.58-0.94	40 1.10 0.75-1.60	0.22
Vomiting	57 1.00	58 0.97 0.67-1.40	63 0.76 0.53-1.09	25 1.40 0.85-2.31	0.86
Diarrhea	204 1.00	163 0.70 0.57-0.87	202 0.67 0.55-0.82	53 0.95 0.69-1.32	0.01
Diarrhea with blood	7 1.00	2 0.26 0.05-1.23	3 0.26 0.07-1.02	2 0.80 0.15-4.20	0.19
Stomach pain	206 1.00	194 0.85 0.70-1.05	271 0.91 0.75-1.09	61 1.06 0.78-1.43	0.78
Cough	209 1.00	263 1.18 0.97-1.42	296 0.97 0.81-1.17	55 0.99 0.72-1.35	0.53
Cough & phlegm *	90 1.00	114 1.15 0.87-1.53	143 1.08 0.82-1.41	39 1.65 1.11-2.46	0.11

Table 31 (continued)

Runny nose	273 1.00	351 1.18 1.00-1.40	371 0.92 0.78-1.09	74 1.04 0.79-1.38	0.33
Sore throat	190 1.00	244 1.17 0.96-1.42	304 1.09 0.90-1.32	59 1.19 0.87-1.63	0.33
HCGI 1*	102 1.00	188 1.03 0.83-1.28	239 0.97 0.79-1.19	69 1.48 1.09-2.00	0.23
HCGI 2	26 1.00	28 1.03 0.60-1.76	32 0.88 0.52-1.49	15 1.58 0.81-3.08	0.57
Signif.* resp. disease	161 1.00	198 1.12 0.90-1.39	239 1.01 0.82-1.24	67 1.64 1.21-2.23	0.10

* Statistically significant at p<05.

† All results adjusted for: age, beach, gender, race, tourist versus local residence, socioeconomic status, and worry about potential hazards of swimming in the Santa Monica Bay. The number of diseased subjects are given on the first line for each outcome. Trend P is from a linear model.

Table 32. Crude Odds Ratios and 95% Confidence Intervals for Outcomes of Interest by Distance from Drain Among Swimmers at Ashland Beach.†

	Distance from drain (in yards)				
	400	100-50	50-1	0	trend P
# exposed:	1523	1667	2534	154	
Fever	71 1.00	77 0.99 0.71-1.38	111 0.94 0.69-1.27	11 1.57 0.81-3.04	0.92
Chills*	27 1.00	42 1.43 0.88-2.33	57 1.28 0.80-2.02	7 2.64 1.13-6.16	0.15
Eye discharge*	38 1.00	32 0.76 0.48-1.23	39 0.61 0.39-0.96	11 3.01 1.50-6.01	0.67
Earache	66 1.00	57 0.78 0.54-1.12	62 0.55 0.39-0.79	7 1.05 0.47-2.33	0.01
Ear discharge	8 1.00	8 0.91 0.34-2.44	13 0.98 0.40-2.36	1 1.24 0.15-9.96	0.95
Skin rash	12 1.00	13 0.99 0.45-2.18	34 1.71 0.88-3.32	1 0.82 0.11-6.37	0.11
Infected cut	6 1.00	8 1.22 0.42-3.52	16 1.61 0.63-4.11	0 0.00 0.00-+INF	0.49
Nausea	66 1.00	57 0.78 0.54-1.12	67 0.60 0.42-0.85	4 0.59 0.21-1.64	0.00
Vomiting	34 1.00	32 0.86 0.53-1.40	35 0.61 0.38-0.99	3 0.87 0.26-2.87	0.06
Diarrhea	94 1.00	60 0.57 0.41-0.79	103 0.64 0.48-0.86	5 0.51 0.20-1.27	0.00
Diarrhea with blood	5 1.00	1 0.18 0.02-1.56	1 0.12 0.01-1.03	0 0.00 0.00-+INF	0.03
Stomach pain	93 1.00	90 0.88 0.65-1.18	144 0.93 0.71-1.21	6 0.62 0.27-1.45	0.44
Cough	111 1.00	133 1.10 0.85-1.43	176 0.95 0.74-1.21	9 0.79 0.39-1.59	0.44
Cough & phlegm	47 1.00	57 1.11 0.75-1.65	86 1.10 0.77-1.58	5 1.05 0.41-2.69	0.66

Table 32 (continued)

Runny nose	140 1.00	169 1.11 0.88-1.41	200 0.85 0.68-1.06	12 0.83 0.45-1.54	0.08
Sore throat	99 1.00	127 1.19 0.90-1.56	156 0.94 0.73-1.22	6 0.58 0.25-1.35	0.27
HCGI 1	54 1.00	50 0.84 0.57-1.24	63 0.69 0.48-1.00	5 0.91 0.36-2.32	0.08
HCGI 2	13 1.00	14 0.98 0.46-2.10	16 0.74 0.35-1.54	0 0.00 0.00-+INF	0.24
Signif. resp. disease	84 1.00	99 1.08 0.80-1.46	140 1.00 0.76-1.32	10 1.19 0.60-2.34	0.93

* Statistically significant at p<.05

† The number of diseased subjects are given on the first line for each outcome. Trend P is from a linear model.

Table 33. Crude Odds Ratios and 95% Confidence Intervals for Outcomes of Interest by Distance from Drain Among Swimmers at Malibu Beach.†

	Distance from drain (in yards)				
	400	100-50	50-1	0	trend P
# exposed:	1013	1012	1399	587	
Fever*	48 1.00	45 0.94 0.62-1.42	61 0.92 0.62-1.35	42 1.55 1.01-2.38	0.14
Chills	37 1.00	23 0.61 0.36-1.04	37 0.72 0.45-1.14	21 0.98 0.57-1.69	0.72
Eye discharge	15 1.00	14 0.93 0.45-1.94	24 1.16 0.61-2.23	7 0.80 0.33-1.98	0.97
Earache*	26 1.00	35 1.36 0.81-2.28	49 1.38 0.85-2.23	30 2.04 1.20-3.49	0.02
Ear discharge*	7 1.00	4 0.57 0.17-1.95	11 1.14 0.44-2.95	12 3.00 1.17-7.66	0.01
Skin rash	6 1.00	6 1.00 0.32-3.11	12 1.45 0.54-3.88	3 0.86 0.21-3.46	0.78
Infected cut	7 1.00	4 0.57 0.17-1.95	14 1.45 0.58-3.61	6 1.48 0.50-4.44	0.22
Nausea	46 1.00	36 0.78 0.50-1.21	53 0.83 0.55-1.24	34 1.29 0.82-2.04	0.47
Vomiting*	17 1.00	16 0.94 0.47-1.87	21 0.89 0.47-1.70	22 2.28 1.20-4.33	0.04
Diarrhea	67 1.00	61 0.91 0.63-1.30	67 0.71 0.50-1.01	48 1.26 0.86-1.85	0.92
Diarrhea with blood	2 1.00	1 0.50 0.05-5.52	1 0.36 0.03-3.99	2 1.73 0.24-12.30	0.79
Stomach pain	7 1.00	65 0.91 0.64-1.29	95 0.97 0.70-1.33	52 1.29 0.89-1.87	0.28
Cough	61 1.00	79 1.32 0.93-1.87	88 1.05 0.75-1.47	40 1.14 0.76-1.72	0.86
Cough & phlegm*	25 1.00	38 1.54 0.92-2.57	41 1.19 0.72-1.98	29 2.05 1.19-3.54	0.05

Table 33 (continued)

Runny nose	88 1.00	103 1.19 0.88-1.61	122 1.00 0.75-1.34	58 1.15 0.81-1.63	0.76
Sore throat	59 1.00	76 1.31 0.92-1.87	100 1.24 0.89-1.74	44 1.31 0.87-1.96	0.21
HCGI 1	33 1.00	27 0.81 0.49-1.36	41 0.90 0.56-1.43	28 1.49 0.89-2.49	0.22
HCGI-2*	10 1.00	10 1.00 0.41-2.42	9 0.65 0.26-1.60	15 2.63 1.17-5.89	0.08
Signif. resp. disease*	49 1.00	63 1.31 0.89-1.92	70 1.04 0.71-1.51	49 1.79 1.19-2.70	0.05

* Statistically significant at $p<.05$.

† The number of diseased subjects are given on the first line for each outcome. Trend P is from a linear model.

Table 34. Crude Odds Ratios and 95% Confidence Intervals for Outcomes of Interest by Distance from Drain Among Swimmers at Will Roger's Beach.†

	Distance from drain (in yards)				
	400	100-50	50-1	0	trend P
# exposed:	494	632	585	86	
Fever	19 1.00	36 1.51 0.86-2.67	36 1.64 0.93-2.90	6 1.87 0.73-4.84	0.08
Chills	8 1.00	20 1.99 0.87-4.55	14 1.49 0.62-3.58	3 2.20 0.57-8.44	0.35
Eye discharge	8 1.00	13 1.28 0.52-3.10	10 1.06 0.41-2.70	1 0.71 0.09-5.78	0.89
Earache	24 1.00	24 0.77 0.43-1.38	25 0.87 0.49-1.55	1 0.23 0.03-1.73	0.29
Ear discharge	6 1.00	7 0.91 0.30-2.73	1 0.14 0.02-1.16	0 0.00 0.00-+INF	0.04
Skin rash	5 1.00	11 1.73 0.60-5.02	7 1.18 0.37-3.76	0 0.00 0.00-+INF	0.74
Infected cut	4 1.00	4 0.78 0.19-3.14	7 1.48 0.43-5.10	0 0.00 0.00-+INF	0.81
Nausea	21 1.00	22 0.81 0.44-1.49	23 0.92 0.50-1.69	2 0.54 0.12-2.33	0.58
Vomiting	6 1.00	10 1.31 0.47-3.62	7 0.99 0.33-2.95	0 0.00 0.00-+INF	0.57
Diarrhea	43 1.00	42 0.75 0.48-1.16	32 0.61 0.38-0.98	0 0.00 0.00-+INF	0.00
Stomach pain	42 1.00	39 0.71 0.45-1.11	32 0.62 0.39-1.00	3 0.39 0.12-1.28	0.02
Cough	37 1.00	51 1.08 0.70-1.68	32 0.71 0.44-1.17	6 0.93 0.38-2.27	0.23
Cough & phlegm	18 1.00	19 0.82 0.43-1.58	16 0.74 0.38-1.47	5 1.63 0.59-4.52	0.94

Table 34 (continued)

Runny nose	45 1.00	79 1.43 0.97-2.10	49 0.91 0.60-1.39	4 0.49 0.17-1.39	0.21
Sore throat	32 1.00	41 1.00 0.62-1.62	48 1.29 0.81-2.05	9 1.69 0.78-3.67	0.12
HCGI 1	15 1.00	19 0.99 0.50-1.97	17 0.96 0.47-1.93	2 0.76 0.17-3.39	0.78
HCGI 2	3 1.00	4 1.04 0.23-4.68	7 1.98 0.51-7.71	0 0.00 0.00-+INF	0.55
Signif. resp. disease	28 1.00	36 1.01 0.60-1.67	29 0.87 0.51-1.48	8 1.71 0.75-3.88	0.80

* Statistically significant at $p<.05$.

† The number of diseased subjects are given on the first line for each outcome. Trend P is from a linear model.

Table 35. Crude Odds Ratios and 95% Confidence Intervals for Outcomes of Interest by Distance from Drain Among Children Under 12 Years Old.†

	Distance from drain (in yards)				
	400	100-50	50-1	0	trend P
# exposed:	1551	1470	2079	514	
Fever*	86 1.00	78 0.95 0.70-1.31	113 0.98 0.73-1.31	42 1.52 1.03-2.22	0.18
Chills	38 1.00	37 1.03 0.65-1.63	44 0.86 0.55-1.34	20 1.61 0.93-2.80	0.51
Eye discharge	43 1.00	27 0.66 0.40-1.07	36 0.62 0.39-0.97	12 0.84 0.44-1.60	0.13
Earache	54 1.00	50 0.98 0.66-1.44	58 0.80 0.55-1.16	22 1.24 0.75-2.06	0.82
Ear discharge*	8 1.00	6 0.79 0.27-2.28	7 0.65 0.24-1.80	7 2.66 0.96-7.38	0.31
Skin rash	13 1.00	14 1.14 0.53-2.43	26 1.50 0.77-2.93	2 0.46 0.10-2.05	0.81
Infected cut	6 1.00	5 0.88 0.27-2.89	8 0.99 0.34-2.87	2 1.01 0.20-5.00	0.97
Nausea	75 1.00	45 0.62 0.43-0.91	61 0.59 0.42-0.84	25 1.01 0.63-1.60	0.12
Vomiting*	42 1.00	31 0.77 0.48-1.24	47 0.83 0.55-1.27	23 1.68 1.00-2.83	0.32
Diarrhea	110 1.00	69 0.65 0.47-0.88	85 0.56 0.42-0.75	38 1.05 0.71-1.53	0.05
Diarrhea with blood	2 1.00	1 0.53 0.05-5.82	2 0.75 0.10-5.30	2 3.03 0.43-21.53	0.42
Stomach pain	114 1.00	81 0.74 0.55-0.99	133 0.86 0.66-1.12	39 1.03 0.71-1.51	0.79
Cough	127 1.00	137 1.15 0.90-1.48	139 0.80 0.63-1.03	40 0.95 0.65-1.37	0.12
Cough & phlegm*	54 1.00	56 1.10 0.75-1.61	53 0.73 0.49-1.07	28 1.60 1.00-2.55	0.88

Table 35 (continued)

Runny nose	146 1.00	148 1.08 0.85-1.37	152 0.76 0.60-0.96	48 0.99 0.70-1.40	0.09
Sore throat	100 1.00	102 1.08 0.81-1.44	106 0.78 0.59-1.03	37 1.13 0.76-1.66	0.37
HCGI 1	71 1.00	50 0.73 0.51-1.06	72 0.75 0.54-1.04	29 1.25 0.80-1.94	0.86
HCGI 2	22 1.00	14 0.67 0.34-1.31	26 0.88 0.50-1.56	14 1.95 0.99-3.83	0.19
Signif. resp. disease*	86 1.00	88 1.08 0.80-1.47	88 0.75 0.56-1.02	47 1.71 1.18-2.48	0.53

* Statistically significant at $p<.05$.

† The number of diseased subjects are given on the first line for each outcome. Trend P is from a linear model.

Table 36. Crude Odds Ratios and 95% Confidence Intervals for Outcomes of Interest by Distance from Drain Among Swimmers Aged 12-25 Years Old.†

	Distance from drain (in yards)				
	400	100-50	50-1	0	trend P
# exposed:	739	892	1188	163	
Fever*	25 1.00	39 1.31 0.78-2.18	46 1.15 0.70-1.89	11 2.07 1.00-4.29	0.23
Chills	14 1.00	22 1.31 0.67-2.58	28 1.25 0.65-2.39	6 1.98 0.75-5.23	0.29
Eye discharge	7 1.00	14 1.67 0.67-4.15	15 1.34 0.54-3.30	3 1.96 0.50-7.66	0.49
Earache	33 1.00	38 0.95 0.59-1.53	38 0.71 0.44-1.14	10 1.40 0.67-2.90	0.53
Ear discharge	7 1.00	6 0.71 0.24-2.12	12 1.07 0.42-2.72	2 1.30 0.27-6.31	0.67
Skin rash	5 1.00	3 0.50 0.12-2.08	13 1.62 0.58-4.57	0 0.00 0.00-+INF	0.53
Infected cut	8 1.00	6 0.62 0.21-1.79	15 1.17 0.49-2.77	2 1.14 0.24-5.40	0.55
Nausea	25 1.00	40 1.34 0.81-2.23	34 0.84 0.50-1.42	7 1.28 0.54-3.02	0.61
Vomiting	7 1.00	19 2.28 0.95-5.44	5 0.44 0.14-1.40	2 1.30 0.27-6.31	0.20
Diarrhea	43 1.00	31 0.58 0.36-0.93	46 0.65 0.43-1.00	10 1.06 0.52-2.15	0.28
Diarrhea with blood	3 1.00	1 0.28 0.03-2.65	0 0.00 0.00-+INF	0 0.00 0.00-+INF	0.07
Stomach pain	52 1.00	54 0.85 0.57-1.26	77 0.92 0.64-1.32	11 0.96 0.49-1.88	0.78
Cough	43 1.00	71 1.40 0.95-2.07	87 1.28 0.88-1.87	13 1.40 0.74-2.67	0.25
Cough & phlegm*	21 1.00	32 1.27 0.73-2.23	48 1.44 0.85-2.42	10 2.23 1.03-4.84	0.05

Table 36 (continued)

Runny nose	72 1.00 0.87-1.65	102 1.20 0.74-1.37	116 1.00 0.62-1.88	17 1.08	0.90
Sore throat	46 1.00	67 1.22 0.83-1.80	105 1.46 1.02-2.09	15 1.53 0.83-2.81	0.03
HCGI 1	16 1.00	24 1.25 0.66-2.37	21 0.81 0.42-1.57	4 1.14 0.38-3.45	0.58
HCGI 2	1 1.00	10 8.37 1.07-65.51	3 1.87 0.19-17.99	1 4.56 0.28-73.21	0.98
Signif. resp. disease	46 1.00	55 0.99 0.66-1.48	81 1.10 0.76-1.60	16 1.64 0.90-2.98	0.20

* Statistically significant at p<.05.

† The number of diseased subjects are given on the first line for each outcome. Trend P is from a linear model.

Table 37. Crude Odds Ratios and 95% Confidence Intervals for Outcomes of Interest by Distance from Drain Among Adults Over 25 Years Old.†

	Distance from drain (in yards)				
	400	100-50	50-1	0	trend P
# exposed:	740	949	1251	150	
Fever	27 1.00	41 1.19 0.73-1.96	49 1.08 0.67-1.74	6 1.10 0.45-2.71	0.86
Chills	20 1.00	26 1.01 0.56-1.83	36 1.07 0.61-1.86	5 1.24 0.46-3.36	0.69
Eye discharge	11 1.00	18 1.28 0.60-2.73	22 1.19 0.57-2.46	4 1.82 0.57-5.78	0.48
Earache	29 1.00	28 0.75 0.44-1.26	40 0.81 0.50-1.32	6 1.02 0.42-2.51	0.65
Ear discharge	6 1.00	7 0.91 0.30-2.72	6 0.59 0.19-1.83	4 3.35 0.93-12.02	0.64
Skin rash	5 1.00	13 2.04 0.72-5.75	14 1.66 0.60-4.64	2 1.99 0.38-10.34	0.42
Infected cut	3 1.00	5 1.30 0.31-5.46	14 2.78 0.80-9.71	2 3.32 0.55-20.04	0.04
Nausea	33 1.00	30 0.70 0.42-1.16	48 0.85 0.54-1.34	8 1.21 0.55-2.67	0.98
Vomiting	8 1.00	8 0.78 0.29-2.08	11 0.81 0.32-2.03	0 0.00 0.00-+INF	0.37
Diarrhea	51 1.00	63 0.96 0.66-1.41	71 0.81 0.56-1.18	5 0.47 0.18-1.19	0.09
Diarrhea with blood	2 1.00	0 0.00 0.00-+INF	1 0.30 0.03-3.26	0 0.00 0.00-+INF	0.26
Stomach pain	40 1.00	59 1.16 0.77-1.75	61 0.90 0.60-1.35	11 1.38 0.69-2.77	0.87
Cough	39 1.00	55 1.11 0.73-1.69	70 1.07 0.71-1.59	2 0.24 0.06-1.02	0.44
Cough & phlegm	15 1.00	26 1.36 0.72-2.59	42 1.68 0.92-3.05	1 0.32 0.04-2.47	0.38
Runny nose	55 1.00	101 1.48 1.05-2.09	103 1.12 0.79-1.57	9 0.79 0.38-1.65	0.75

Table 37 (continued)

Sore throat	44 1.00	75 1.36 0.92-2.00	93 1.27 0.88-1.84	7 0.77 0.34-1.75	0.66
HCGI 1	15 1.00	22 1.15 0.59-2.23	28 1.11 0.59-2.09	2 0.65 0.15-2.89	0.93
HCGI 2	3 1.00	4 1.04 0.23-4.66	3 0.59 0.12-2.93	0 0.00 0.00-+INF	0.35
Signif. resp. disease	29 1.00	55 1.51 0.95-2.39	70 1.45 0.93-2.26	4 0.67 0.23-1.94	0.48

* Statistically significant at $p<.05$.

† The number of diseased subjects are given on the first line for each outcome. Trend P is from a linear model.

Table 38. Risks For High vs. Low E.Coli Indicator Counts

ALL BEACHES

	Total Exposed = 2654		Total Unexposed = 7724				
	> 70 cfu		≤ 70 cfu				
SYMPTOMS	Ill	Risks	Ill	Risks	RR	Lower 95% CI	Upper 95% CI
Fever	135	0.051	363	0.047	1.08	0.89	1.31
Chills	68	0.026	186	0.024	1.06	0.81	1.40
Eye discharge	43	0.016	146	0.019	0.86	0.61	1.20
Earache	98	0.037	259	0.034	1.10	0.88	1.38
Ear discharge	17	0.006	50	0.006	0.99	0.57	1.71
Skin rash	28	0.011	72	0.009	1.13	0.73	1.75
Infected cut	15	0.006	49	0.006	0.89	0.50	1.59
Nausea	94	0.035	290	0.038	0.94	0.75	1.19
Vomiting	44	0.017	138	0.018	0.93	0.66	1.30
Diarrhea	144	0.054	411	0.053	1.02	0.85	1.23
Diarrhea w/ blood	3	0.001	8	0.001	1.09	0.29	4.11
Stomach pain	171	0.064	477	0.062	1.04	0.88	1.24
Coughing	197	0.074	540	0.070	1.06	0.91	1.24
Phlegm	88	0.033	267	0.035	0.96	0.76	1.22
Nasal congestion	251	0.095	702	0.091	1.04	0.91	1.19
Sore throat	186	0.070	516	0.067	1.05	0.89	1.23
HCGI_1	83	0.031	234	0.030	1.03	0.81	1.32
HCGI_2	24	0.009	69	0.009	1.01	0.64	1.61
SRD	135	0.051	390	0.050	1.01	0.83	1.22

Table 39. Risks For High vs. Low Bacterial Indicators

E. coli

	> 35 cfu		> 70 cfu	
Symptoms	RR	95% CI	RR	95% CI
Fever	1.16	0.98, 1.38	1.07	0.89 , 1.30
Chills	1.07	0.84, 1.37	1.06	0.80 , 1.39
Eye discharge	0.89	0.67, 1.20	0.85	0.61 , 1.19
Earache	0.94	0.77, 1.16	1.09	0.87 , 1.37
Ear discharge	0.83	0.51, 1.35	0.96	0.56 , 1.67
Skin rash	1.07	0.72, 1.59	1.13	0.73 , 1.74
Infected cut	0.74	0.44, 1.24	0.89	0.50 , 1.58
Nausea	1.10	0.90, 1.34	0.93	0.74 , 1.17
Vomiting	1.01	0.75, 1.35	0.92	0.65 , 1.28
Diarrhea	1.12	0.95, 1.31	1.00	0.83 , 1.21
Diarrhea w/ blood	1.70	0.52, 5.58	1.08	0.29 , 4.09
Stomach pain	1.18	1.01, 1.37	1.03	0.87 , 1.22
Coughing	0.94	0.81, 1.08	1.06	0.91 , 1.24
Phlegm	0.82	0.66, 1.01	0.97	0.77 , 1.22
Nasal congestion	0.97	0.86, 1.10	1.04	0.91 , 1.19
Sore throat	0.97	0.83, 1.12	1.04	0.89 , 1.22
HCGI_1	1.05	0.84, 1.30	1.02	0.80 , 1.31
HCGI_2	1.34	0.89 , 2.01	1.01	0.64 , 1.61
SRD	0.93	0.78, 1.10	1.01	0.83 , 1.22

Table 40. Odds Ratios and 95% Confidence Intervals for <u>E. Coli</u> Dichotomized First at 160 cfu, then at 320 cfu. The Number of Diseased Subjects are Given on the First Line for Each Outcome.

	Cutpoint	
	160 cfu	320 cfu
# exposed:	1509	991
Fever	74.00 1.03 0.80-1.32	45.00 0.94 0.69-1.28
Chills	40.00 1.10 0.78-1.55	22.00 0.90 0.58-1.39
Eye discharge	29.00 1.07 0.72-1.59	23.00 1.32 0.85-2.05
Earache*	65.00 1.32 1.00-1.74*	47.00 1.46 1.06-2.00*
Ear discharge	12.00 1.28 0.69-2.40	6.00 0.93 0.40-2.16
Skinrash	21.00 1.57 0.97-2.55	15.00 1.68 0.97-2.92
Infected cut	12.00 1.36 0.72-2.55	9.00 1.56 9.77-3.16
Nausea	60.00 1.09 0.82-1.45	42.00 1.17 0.84-1.62
Vomiting	28.00 1.07 0.71-1.61	20.00 1.17 0.73-1.88
Diarrhea	81.00 1.00 0.79-1.28	56.00 1.07 0.80-1.42
Diarrhea with blood	2.00 1.31 0.28-6.05	0.00 0.00 0.00-+INF
Stomache pain	101.00 1.09 0.88-1.36	70.00 1.16 0.90-1.50
Cough	111.00 1.05 0.85-1.29	82.00 1.20 0.95-1.53
Cough & phlegm	54.00 1.06 0.79-1.42	43.00 1.32 0.95-1.83

Table 40 (continued)

Runny nose*	146.00 1.07 0.89-1.29	108.00 1.24 1.00-1.53*
Sorethroat	104.00 1.02 0.83-1.27	75.00 1.14 0.89-1.47
HCGI-1	53.00 1.19 0.88-1.60	36.00 1.22 0.86-1.74
HCGI-2	16.00 1.22 0.71-2.10	10.00 1.14 0.59-2.21
Signif. resp. disease	83.00 0.95 0.75-1.21	61.00 1.09 0.83-1.44

* Statistically significant at $p<.05$.

Table 41. Crude Odds Ratios and 95% Confidence Intervals for E. Coli by Quintiles and from a Linear Model.†

	Quintile (cfu)					linear model
	1	2	3	4	5	
midpoints: # exposed:	2.00 2122	7.50 2096	23.00 2141	56.00 2052	310.00 2082	
Fever	99 1.00	104 1.07 0.80-1.41	85 0.84 0.63-1.14	119 1.26 0.96-1.65	98 1.01 0.76-1.34	0.99 0.94-1.04
Chills	56 1.00	48 0.86 0.59-1.28	48 0.85 0.57-1.25	56 1.04 0.71-1.51	50 0.91 0.62-1.34	0.99 0.92-1.07
Eye discharge	36 1.00	43 1.21 0.78-1.90	41 1.13 0.72-1.78	33 0.95 0.59-1.52	37 1.05 0.66-1.67	1.04 0.98-1.10
Earache	83 1.00	67 0.81 0.58-1.13	71 0.84 0.61-1.16	57 0.70 0.50-0.99	82 1.01 0.74-1.38	1.03 0.98-1.08
Ear discharge	16 1.00	14 0.89 0.43-1.82	16 0.99 0.49-1.99	9 0.58 0.26-1.32	14 0.89 0.43-1.83	0.98 0.84-1.14
Skin rash*	16 1.00	18 1.14 0.58-2.24	25 1.56 0.83-2.92	18 1.16 0.59-2.29	23 1.47 0.77-2.79	1.07 1.01-1.14
Infected cut	1 1.00	13 1.20 0.54-2.68	19 1.72 0.82-3.62	7 0.66 0.25-1.70	14 1.30 0.59-2.87	1.02 0.91-1.15
Nausea*	85 1.00	68 0.80 0.58-1.11	72 0.83 0.61-1.15	78 0.95 0.69-1.30	82 0.98 0.72-1.34	1.04 1.00-1.08
Vomiting	47 1.00	30 0.64 0.40-1.02	33 0.69 0.44-1.08	36 0.79 0.51-1.22	36 0.78 0.50-1.20	1.02 0.95-1.10
Diarrhea	125 1.00	86 1.17 0.90-1.53	122 0.77 0.58-1.03	115 1.17 0.89-1.52	1.08 0.82-1.41	1.03 0.99-1.07
Diarrhea with blood	2 1.00	1 0.51 0.05-5.58	2 0.99 0.14-7.04	3 1.55 0.26-9.30	3 1.53 0.26-9.16	0.85 0.38-1.87
Stomach pain*	141 1.00	119 0.85 0.66-1.09	109 0.75 0.58-0.98	145 1.07 0.84-1.36	135 0.97 0.76-1.24	1.04 1.00-1.07
Cough	150 1.00	157 1.06 0.84-1.34	140 0.92 0.72-1.17	141 0.97 0.76-1.23	149 1.01 0.80-1.28	1.02 0.98-1.06
Cough & phlegm	67 1.00	91 1.39 1.01-1.92	69 1.02 0.73-1.44	61 0.94 0.66-1.34	67 1.02 0.72-1.44	1.02 0.97-1.07

Table 41 (continued)

Runny nose	197 1.00	204 1.05 0.86-1.29	173 0.86 0.69-1.06	189 0.99 0.80-1.22	192 0.99 0.81-1.22	1.02 0.99-1.06
Sore throat	145 1.00	154 1.08 0.85-1.37	131 0.89 0.70-1.13	138 0.98 0.77-1.25	139 0.98 0.77-1.24	1.01 0.97-1.05
HCGI 1	83 1.00	56 0.67 0.48-0.95	48 0.56 0.39-0.81	66 0.82 0.59-1.13	64 0.78 0.56-1.09	1.02 0.97-1.08
HCGI 2	22 1.00	14 0.64 0.33-1.26	14 0.63 0.32-1.23	24 1.13 0.63-2.02	19 0.88 0.47-1.63	1.02 0.93-1.12
Signif. resp. disease	114 1.00	147 1.33 1.03-1.71	113 0.98 0.75-1.28	116 1.06 0.81-1.38	107 0.95 0.73-1.25	1.01 0.97-1.06

* Statistically significant at $p<.05$.

† Linear results correspond to an increase in the exposure equal to the difference between the 90th and 10th percentiles. The number of subjects with each outcome are given on the first line.