MORRO BAY

BACTERIAL STUDY

1986 - 1987

A CLEANUP AND ABATEMENT STUDY,
FUNDED BY THE
STATE WATER RESOURCES CONTROL BOARD

by

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Central Coast Region

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CHAPTER I

SUMMARY

The objective of this three-phase study was to characterize all the potential sources of bacteriological contamination of Morro Bay during wet and dry weather conditions. Sampling was scheduled for specific stations based upon tidal cycle and ocean currents. Three sampling teams were formed to complete the sampling in no more than two hours. Forty stations were sampled at prescribed depths during each two-hour sampling run. Most sampling took place from July 8, to September 12, 1986, with follow-up point source investigation continuing until November 7, 1986. Phase III, the winter wet weather sampling, was conducted March 19, to April 6, 1987.

Basic trends and localized contamination were reviewed in the resulting data. The Bay entrance channel was "clean" on every day except one during the 28 sampling days of three-study phases. Second to the very low coliform counts in the entrance of the Bay were the "almost always clean" oyster bed stations. Chorro Creek was found to be contaminated at two locations both summer and winter, but as it mixed with the Bay, coliform counts dropped. Along the Bayfront (Embarcadero), high coliform counts were found both summer and winter near locations discharging significant amounts of contaminated water. In the Back Bay, summer sampling revealed intermittent peaks of coliform contamination with consistently higher counts at drainageways by Broaderson and Pecho Roads. Winter sampling results confirmed this trend and showed high results at other South Bay stations, especially near Baywood Park pier.

CHAPTER II

INTRODUCTION

Morro Bay has been suffering ongoing bacterial contamination of Bay waters: high coliform counts have been a recurring nuisance, forcing the State Department of Health Services to close Morro Bay to commercial shellfishing. Following this, the State Department of Fish and Game closed the bay to sports shellfishing (refer to chronology in Appendix E for these and other important related dates).

Midway between the rocky headlands of Point Buchon and Point Estero lies the shallow, landlocked embayment of Morro Bay. The Bay's 3.5 square mile area is separated from Estero Bay proper by four miles of a quarter-mile wide stabilized sand dune. Morro Bay is the flooded lower portion of the Los Osos Valley, half of which is navigable. The remainder is comprised of a highly productive mudflat-saltmarsh complex within the joint delta area of Los Osos and Chorro Creeks.

Chorro Creek rises in the Los Padres National Forest about eleven miles from the coast, and its ephemeral tributaries, San Bernardo and San Luisto Creeks, drain approximately 30,110 acres of the Chorro hydrologic basin (Figure 1). Chorro Creek empties into Morro Bay approximately two miles southeast of Morro Rock. Los Osos Creek drains the Los Osos hydrologic basin, originating within the Irish Hills, and empties into Morro Bay just north of Baywood Park.

The mud flats support many species of clams, in addition to Pismo and Razor clams found on the beaches. Oysters are also commercially cultivated in Morro Bay by Qualman Oyster Farm, Inc. The Bay's tidal exchanges, with an estimated 2.2 billion gallons entering the bay on an average tidal cycle, supply nutrients and remove contaminants to aid the oyster growing process. However, the oysters have been frequently contaminated by bacteria so that harvesting has been restricted (refer to Tables 16 and 17 for oyster meat sample values, which will be discussed in detail later in this report).

Some have suggested this problem started in 1983 when the Morro Bay-Cayucos Wastewater Treatment Plant (WWTP) began discharging unchlorinated wastewater to the ocean via an extended outfall stretching 4060 feet offshore. Also, in 1985, the Regional Water Quality Control Board (RWQCB) and the U. S. Environmental Protection Agency (EPA) jointly issued the City a section 301(h) variance from the secondary treatment requirements of the Clean

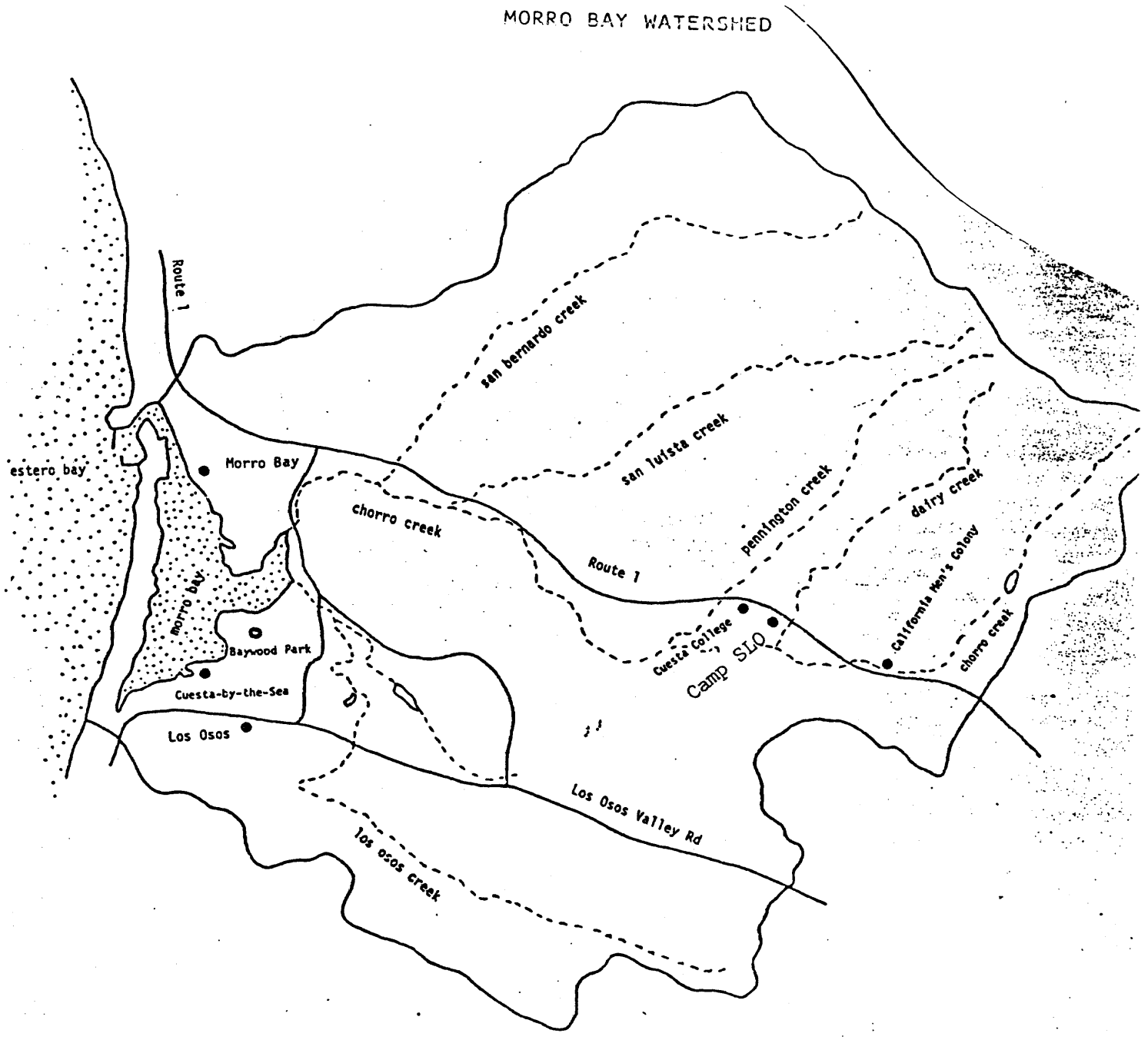

MORRO BAY WATERSHED
Route 1
san bernardo creek
san luisita creek
pennington creek
dairy creek
chorro creek
Route 1
estero bay
Morro Bay
morro bay
Baywood Park
Cuesta-by-the-Sea
Los Osos
Cuesta College
Camp SLO
California Men's Colony
chorro creek
Los Osos Valley Rd
los osos creek
NOVEMBER 1987
SAN LUIS OBISPO COUNTY
DEPARTMENT OF PLANNING & BUILDING

FIGURE 1

TABLE 16

QUALMAN'S OYSTER
MEAT SAMPLES
1984/1985

17-Sep-84	BED 13	170	130	70		
	FLOAT	230	20	100		
18-Sep-84	BED 11	31000	50	1100	<--0.16	INCH OF RAIN
	FLOAT	170	80	270		PRIOR TO SAMPLING
19-Sep-84	BED 6	80	20	100		
	FLOAT	1700	1300	570		
20-Sep-84	BED 11	490	490	210		
	FLOAT	2200	2200	190		
21-Sep-84	BED 13	490	490	260		
	FLOAT	17000	3500	160000		
28-Jan-85	BED 11	330	230	60	<--0.06	INCH OF RAIN
	FLOAT	3300	3300	200		DURING SAMPLING
29-Jan-85	BED 10	490	490	250		
	BED 13	460	330	200		
30-Jan-85	BED 12	790	330	820		
	FLOAT	1700	790	540		
31-Jan-85	BED 11	230	130	1200		
	FLOAT	3300	3300	750		
01-Feb-85	BED 12	490	230	440	<--0.05	INCH OF RAIN
	FLOAT	350000	240000	3400		AFTER SAMPLING
24-Jun-85	PARCEL#1	78	<18	-		
01-Jul-85	PARCEL#2	230	130	-		
	PARCEL#1	640	120	-		
09-Jul-85	PARCEL#1	2800	1300	-		
15-Jul-85	PARCEL#1	230	45	-		
21-Jul-85	PARCEL#1	2400	1300	-		
29-Jul-85	PARCEL#2	490	490	-		
05-Aug-85	PARCEL#1	310	130	-		
06-Aug-85	PARCEL#1	790	260	-		
12-Aug-85	PARCEL#2	230	78	-		
19-Aug-85	PARCEL#2	230	78	-		
27-Aug-85	PARCEL#2	700	230	-		
03-Sep-85	-	950	260	-		

TABLE 17

QUALMAN'S OYSTER
MEAT SAMPLES
1986

DATE	STATION NUMBER	TOTAL COLIFORM MPN/100 g	FECAL COLIFORM MPN/100 g	STD. PLATE COUNT per g at 35 C	
06-Jan-86	PARCEL#1	3500	2400	119700	
14-Jan-86	PARCEL#1	3500	3500	2800	
21-Jan-86	PARCEL#1	7000	7000	1000	
27-Jan-86	PARCEL#2	1400	2100	1260	
03-Feb-86	PARCEL#1	1200	700	3300	
10-Feb-86	PARCEL#2	2200	790	12100	
18-Feb-86	PARCEL#1	2400	2400	11200	
24-Feb-86	PARCEL#1	7000	4900	7100	
04-Mar-86	PARCEL#1	790	490	590	
11-Mar-86	PARCEL#1	35000	4600	8900	
19-Mar-86	PARCEL#1	7000	790	11900	
	CLAMS	7000	220	12100	
25-Mar-86	PARCEL#2	1700	790	1250	
15-Apr-86	PARCEL#1	130	130	4500	
27-May-86	STATION 11	130	45	290	
28-May-86	STATION 11	110	20	340	
02-Jun-86	STATION 11	700	700	950	
10-Jun-86	STATION 11	5400	5400	1000	
23-Jun-86	STATION 11	1300	490	240	
08-Jul-86	FAIRBANKS POINT	1300	1300	335	
16-Jul-86	QUALMAN DOCK	790	78	210	
22-Jul-86	ACROSS FROM DOC	790	490	270	
	WEST OF STA. 12	230	<18	190	
28-Jul-86	STATION 11	330	78	170	
29-Jul-86	STATION 11	130	<18	220	
	EFFLUENT CHLORINATION BEGINS				
04-Aug-86	STATION 11	3500	2400	300	
07-Aug-86	STATION 11	330	110	1000	
	AQUARIUM	3500	1700	440	
11-Aug-86	STATION 11	790	110	260	
18-Aug-86	STATION 12	230	230	1000	
	STATION 11	230	68	580	
21-Aug-86	STATION 11	330	330	2000	
25-Aug-86	STATION 11	130	45	320	
26-Aug-86	STATION 11	3500	2400	29000	
27-Aug-86	STATION 11	330	68	1200	
02-Sep-86	STATION 12	1700	1100	440	
	STATION 11	790	330	170	
03-Sep-86	STATION 12	110	68	100	
10-Sep-86	STATION 11	790	220	170	
11-Sep-86	STATION 11	330	110	580	
17-Sep-86	STATION 11	110	45	230	
23-Sep-86	STATION 11	1700	490	460	
24-Sep-86	STATION 11	7000	4900	2220	<-- AFTER RAIN

TABLE 17 (continued)

QUALMAN'S OYSTER
MEAT SAMPLES
1986

DATE	STATION NUMBER	TOTAL COLIFORM MPN/100 g	FECAL COLIFORM MPN/100 g	STD. PLATE COUNT per g at 35 C
29-Sep-86	STATION 12	78	45	330
30-Sep-86	STATION 11	130	130	160
06-Oct-86	STATION 11	110	18	205
14-Oct-86	STATION 11	230	45	50
15-Oct-86	STATION 11	330	170	125

Water Act. While this action served to focus additional attention on the City's ocean outfall, the contamination problem within the Bay had been occurring for quite some time prior to the new outfall's discharge. Major bacterial problems were limited to wet, rainy periods. An earlier study documenting this trend was performed in February of 1979, by the California Department of Health Services (DOHS).

In recent times, various State and Federal agencies, including DOHS and the U. S. Department of Health and Human Service's Food and Drug Administration (FDA), have performed studies on Morro Bay. DOHS prepares monthly sampling reports of stations within the Bay for water with one oyster meat sample collected on each run (Tables 20, 21, 22). These results over recent years indicate locations <u>within</u> the Bay as probable sources of contamination. A special two part study by DOHS was conducted in September of 1984, and January of 1985. Entitled <u>Sanitary Investigation of Shellfish and Water Quality--Morro Bay</u>. The study revealed coliform contamination in the shellfish growing areas of Morro Bay, noting increased contamination during dry weather compared to previous studies. This report concluded that contamination was possibly caused from sources <u>outside</u> of the Bay. A follow-up study by the FDA also implied that the source of contamination was <u>outside</u> of the Bay, most likely the WWTP:

> "Under conditions of southerly ocean currents, which prevailed during this study, large volumes of sewage contaminated seawater daily present themselves for conveyance into the Morro Bay on each flood tide."
>
> [p.5, Dept. of Health and Human Services-FDA, Preliminary Report, December 6, 1985]

Clearly, existing data conflicted as to the source of contamination. Was the primary source within the bay, or was it outside? While the FDA study confirmed that some effluent could travel to the Bay during southerly currents, many potential sources from within the Bay exist which could be consistent with the DOHS monthly report results and should also be considered as significant contributors to contamination. Possible sources include, but are not limited to:

1. City of Morro Bay-Cayucos Wastewater outfall
2. Live aboard and recreational boats
3. Commercial and sports fishing boats

TABLE 20

DOHS SAMPLE STATIONS
LOCATION DESCRIPTIONS

STATION NUMBER	STATION LOCATION DESCRIPTION
*******	**********
1	BUOY #3
2	BUOY #4
3	BUOY #7
4	WHARF ACROSS FROM POWER STATION
5	BREBE'S WHARF
6	3rd STORM DRAIN
7	LAUNCH RAMP
8	OYSTER GROWING SIGN ACROSS FROM RAMP
9	TRIANGLE 20 SIGN
10	NEAR 3 WOODEN PILES
11	END OF CHANNEL
12	IN CHANNEL
13	IN CHANNEL
14	IN CHANNEL OFF MUSEUM
15	AT MUSEUM
16	CHORRO CREEK AT 1st BRIDGE
17	LOS OSOS CREEK AT BRIDGE
18	CHORRO CREEK ROAD
19	SAN BERNARDO CREEK NEAR 101
20	CHORRO CREEK AT CANET ROAD
21	CHORRO CREEK 15 YDS. ABOVE CMC DISCHARGE
22	CALIFORNIA MEN'S COLONY DISCHARGE
23	PARK MARINA
30	STAR KIST OPERATION
31	QUALMAN'S DOCK
32	GOLDEN TEE MOTEL
33	CANNERY

TABLE 21
DOHS SANITARY INVESTIGATION
TOTAL COLIFORM-- in MPN/100 ml

STATION	17-Sep-84	18-Sep-84	19-Sep-84	20-Sep-84	21-Sep-84	28-Jan-85	29-Jan-85	30-Jan-85	31-Jan-85	01-Feb-85
1:	-	-	-	-	-	-	102	131	102	56
2:	-	-	-	-	-	49	79	79	110	130
3:	<2	[illegible]	2	<2	1600	35	41	105	49	33
4:	-	-	-	-	-	79	130	1300	23	23
5:	<2	>2400	23	49	>2400	1400	79	33	170	79
6:	13	>2400	13	23	>2400	330	49	33	33	449
7:	49	21	6	26	280	3500	33	33	49	13
8:	<2	130	26	17	540	490	230	170	-	-
9:	5	79	79	22	240	79	230	79	330	230
10:	17	9	540	23	240	330	13	5	-	-
11:	5	8	5	5	350	110	33	4	2	13
12:	13	8	<2	2	17	49	17	79	5	8
13:	17	49	11	5	79	130	130	23	23	5
14:	5	7	8	<2	34	49	79	49	-	-
15:	2	<2	14	14	79	33	13	13	79	23
16:	130	1600	>2400	2400	79	-	2400	330	49	330
17:	7	2	2	11	20	-	490	79	79	23
18:	-	-	-	-	-	-	-	-	-	-
19:	>2400	16000	5400	3500	3500	-	-	-	-	-
20:	>2400	330	9200	540	2400	-	-	-	-	-
21:	240	700	490	330	330	490	-	-	-	-
22:	5	<2	<2	<2	<2	<2	-	-	-	-
23:	17	9	27	17	140	140	33	13	33	33
30:	-	-	-	-	-	170	23	70	330	130
31:	-	-	-	-	-	2200	230	49	5	49
32:	-	-	-	-	-	-	79	23	23	33
(CANNERY)33:	-	-	-	-	-	-	-	-	-	-
35:	-	-	-	-	-	-	-	-	-	16000
M.B. EFFLUENT 1:	-	-	-	-	-	-	-	-	-	-
M.B. EFFLUENT 2:	-	-	-	-	-	-	-	-	-	-

TABLE 22
DOHS SANITARY INVESTIGATION
FECAL COLIFORM-- in MPN/100 ml

STATION	17-Sep-84	18-Sep-84	19-Sep-84	20-Sep-84	21-Sep-84	28-Jan-85	29-Jan-85	30-Jan-85	31-Jan-85	01-Feb-85
1:	-	-	-	-	-	-	41	32	102	21
2:	-	-	-	-	-	23	49	23	79	49
3:	<2	13	2	<2	920	16	17	90	49	33
4:	-	-	-	-	-	79	49	330	13	23
5:	<2	920	5	8	1600	1100	23	33	110	49
6:	13	>2400	8	8	1600	49	33	23	13	23
7:	33	17	4	4	79	49	33	13	33	2
8:	<2	130	21	17	540	330	130	110	-	-
9:	5	79	27	17	240	49	230	79	330	33
10:	17	7	540	23	79	330	13	5	-	-
11:	5	8	5	5	350	110	33	2	2	8
12:	13	8	<2	2	17	33	12	49	5	5
13:	17	49	5	5	79	79	130	23	23	5
14:	5	7	2	<2	34	49	49	49	-	-
15:	2	<2	11	14	17	23	5	8	13	13
16:	79	920	>2400	1300	33	-	490	330	33	170
17:	5	2	2	8	13	-	79	79	33	23
18:	-	-	-	-	-	-	-	-	-	-
19:	>2400	5400	3500	3500	790	-	-	-	-	-
20:	>2400	<20	790	790	330	-	-	-	-	-
21:	240	490	330	230	70	49	-	-	-	-
22:	<2	<2	<2	<2	<2	<2	-	-	-	-
23:	5	5	22	5	46	110	23	8	8	8
30:	-	-	-	-	-	23	13	8	23	79
31:	-	-	-	-	-	230	79	23	5	13
32:	-	-	-	-	-	-	79	13	23	8
(CANNERY)33:	-	-	-	-	-	-	-	-	-	9200
35:	-	-	-	-	-	-	-	-	-	23
M.B. EFFLUENT 1:	-	-	-	-	-	-	-	-	-	-
M.B. EFFLUENT 2:	-	-	-	-	-	-	-	-	-	-

4. Birds and marine mammals

5. Creeks entering the Bay

6. Storm drains

7. Septic systems

8. Shoreline lift stations

The objective of this study, therefore, is to characterize, quantitatively, all potential sources of bacteria to Morro Bay and to determine if major sources of bacterial contamination of oysters are inside or outside the Bay.

CHAPTER III

MATERIALS AND METHODS

This chapter gives an account of the materials and methods used to obtain a bacteriological profile of the bay. Various design factors considered in devising the sampling program are first discussed, followed by a discussion of actual sampling methods and techniques. A section on analysis follows. This chapter closes with a discussion of potential sources suspected of contributing to Morro Bay's contamination.

MATERIALS AND METHODS

DESIGN FACTORS

Station Locations

The most fundamental design factor was establishment of station locations. Figures 2 and 3 show locations of sites where samples were collected during our study, along with Table 1 which includes the location description and the agency responsible for each station. Since most of the locations were selected to coincide with DOHS' pre-existing sampling stations, their corresponding codes are also included. Each site in the Bay can be located in the field by specific landmarks in order to ensure continuity of data from one sampling run to the next.

In addition to stations corresponding to DOHS stations, extra stations were located along the Bay to fill in gaps and to determine more specific locations of suspected sources. Two mooring stations, one station by the Morro Bay Aquarium, and an East Bay station were added. Three extra stations were added along Chorro Creek during the course of the study to help define contamination found at original Station 16.

Stations A through G were also established on the shoreline of the back bay to determine whether septic tank leakage was contributing. Because these stations were to be sampled from the shore, accessibility was a key factor in location selection. Private property and impassable landscape were typical obstacles.

Tides

A second major design factor was Morro Bay's tidal exchange. Whether the water is entering the Bay or leaving it, and whether the water is quiet or rapidly moving must be considered to evaluate resulting data properly. A tide chart for the Central Coast is included as Appendix A. A time lag was observed between the figures provided and the actual times when high and low tides were observed inside the Bay. FDA indicated there was as much as a two hour lag, but observations indicated only a twenty minute lag.

Three different tidal environments were sampled during this study. The first was at slack tide preceding ebb tide, where water is moving slowly at high tide levels (Phases I and III). The second occurred at slack tide before flood tide, where water is moving slowly at low tide levels (Phases I and III).

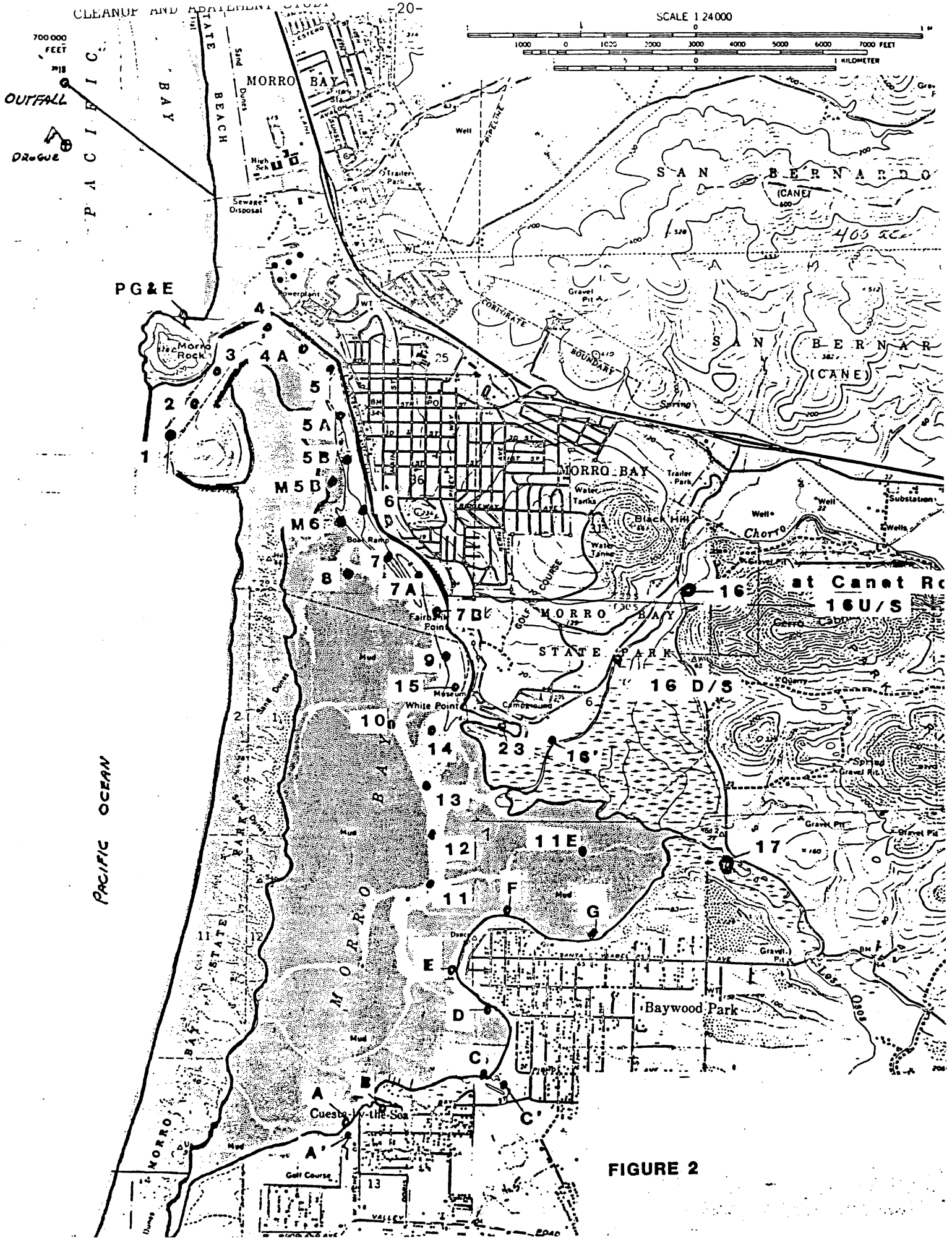

SCALE 1:24000
1000 0 1000 2000 3000 4000 5000 6000 7000 FEET
1 KILOMETER
700 000 FEET
OUTFALL
DROGUE
PACIFIC OCEAN
MORRO BAY
MORRO BAY STATE BEACH
MORRO BAY STATE PARK
Sewage Disposal
Trailer Park
Well
PIPELINE
SAN BERNARDO (CANE)
405 ac
PG&E
Morro Rock
Powerplant
Gravel Pit
FORTHRATE
BOUNDARY
Spring
MORRO BAY
Water Tanks
Black Hill
Chorro
Substation
Boat Ramp
GOLF COURSE
Fairbank Point
Museum
White Point
Campground
Quarry
Cerro Cabrillo
Baywood Park
Los Osos
Cuesta-by-the-Sea
Golf Course
1 2 3 4 4A 5 5A 5B M5B M6 6 7 7A 7B 8 9 10 11 11E 12 13 14 15 16 16' 16 D/S 16U/S 17 23 A A' B C C' D E F G

FIGURE 2

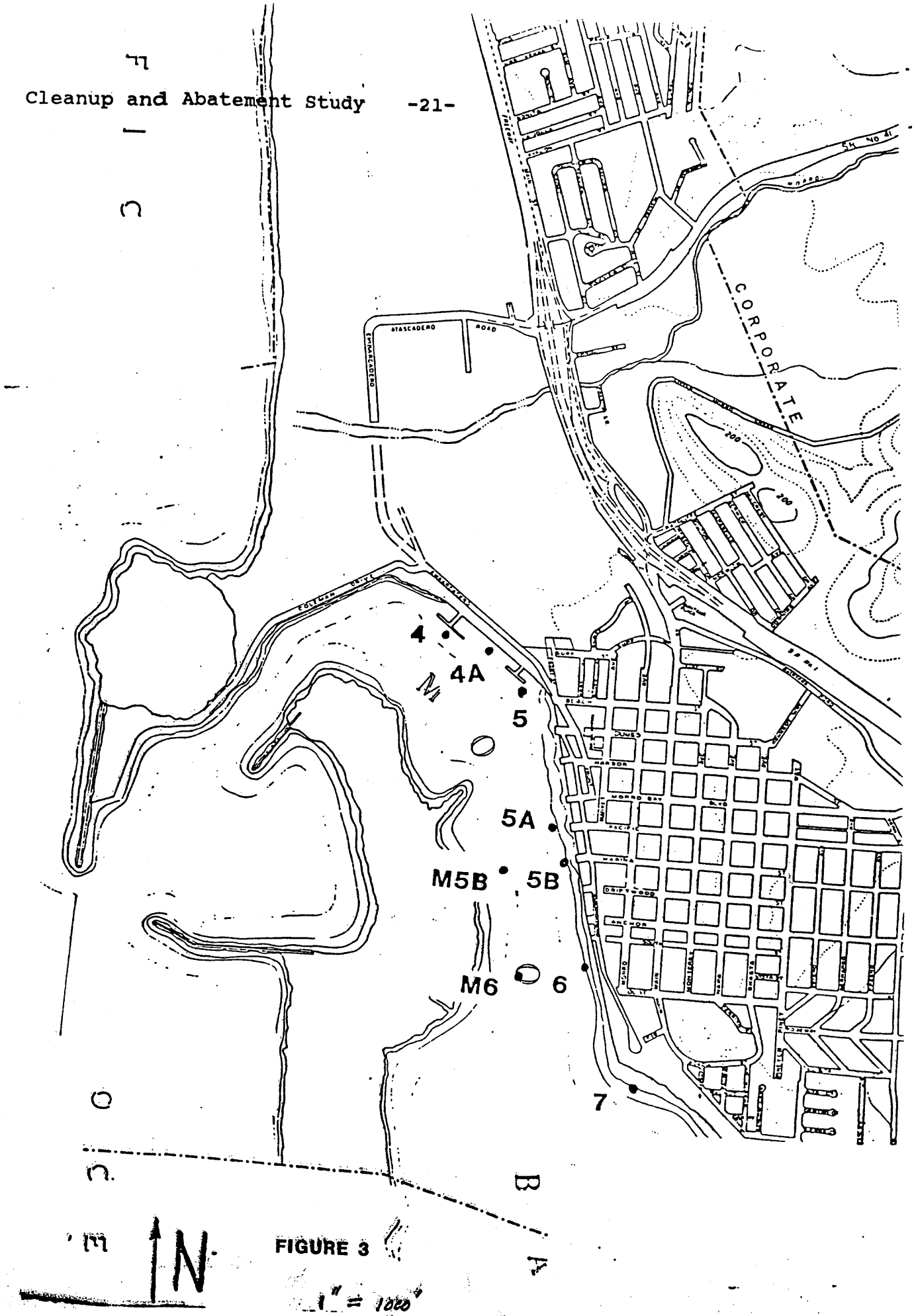

ATASCADERO ROAD
EMBARCADERO
CORPORATE
4
4A
M4
5
5A
M5B
5B
M6
6
7
N
1" = 1000'

FIGURE 3

TABLE 1
STATION LOCATIONS

STATION NUMBER	CORRESPONDING STATIONS	LOCATION DESCRIPTION	SAMPLING ASSIGNED TO: CHANNEL STATIONS	BAY STATIONS	SHORE STATIONS	CREEK STATIONS
PG&E	-	PG&E DISCHARGE CHANNEL --NORTH SIDE OF ROCK			RWQCB	
1	DOHS 1	BOUY #3	CITY			
2	DOHS 2	BUOY #4	CITY			
3	DOHS 3	BUOY #7	CITY			
4	DOHS 4	ACROSS FROM PG&E COMMERCIAL/SPORT FISH DOCK	CITY			
4-A	DOHS 30	BETWEEN TWO "T" PIERS		CO.H.D.		
5	DOHS 5	BREBE'S WHARF --BEACH/FRONT ST. STORM DRAINS		CO.H.D.		
5-A	DOHS 31	QUALMAN'S DOCK		CO.H.D.		
5-B	-	MORRO BAY AQUARIUM		CO.H.D.		
M5-B	-	CENTERLINE OF MOORED BOATS OFF SHORE STATION 5B		CO.H.D.		
6	DOHS 6	3rd STORM DRAIN FROM LAUNCH RAMP PARKING BETWEEN OLIVE AND SOUTH STREET DRAINS		CO.H.D.		
M-6	-	CENTERLINE OF MOORED BOATS OFFSHORE OF STA. 6		CO.H.D.		
7	DOHS 7	LAUNCH RAMP NEAR STORM DRAIN		CO.H.D.		
7-A	DOHS 33	MORRO BAY FUEL DOCK --STORM DRAIN & LIFT STATION		CO.H.D.		
7-B	DOHS 32	GOLDEN TEE MOTEL STORM DRAIN & LIFT STATION		CO.H.D.		
8	DOHS 8	OYSTER GROWING SIGN ACROSS FROM BOAT LAUNCH RAMP		CO.H.D.		
9	DOHS 9	TRIANGLE 20 SIGN		CO.H.D.		
10	DOHS 10	NEAR 3 PILES (DHS 24 HR. FLOAT AT THIS STA.)		CO.H.D.		
11	DOHS 11	END OF CHANNEL		CO.H.D.		
12	DOHS 12	IN CHANNEL		CO.H.D.		
13	DOHS 13	IN CHANNEL NEAR OYSTER BEDS		CO.H.D.		
14	DOHS 14	IN CHANNEL OFF MUSEUM		CO.H.D.		
15	DOHS 15	AT MUSEUM		CO.H.D.		
16	DOHS 16	CHORRO CREEK AT SOUTH BAY BLVD. CROSSING				RWQCB
16'	-	CHORRO CREEK AT MOUTH OF BAY				RWQCB
16-U/S	-	CHORRO CREEK AT CANET ROAD CROSSING				RWQCB
16-D/S	-	CHORRO CREEK BETWEEN 16 AND 16'--AT ROAD ACCESS				RWQCB
17	DOHS 17	LOS OSOS CREEK 1/4 MILE DOWN TURRI ROAD FROM SOUTH BAY BOULEVARD CROSSING				RWQCB
23	DOHS 23	PARK MARINA		CO.H.D.		
11-E	-	EAST BAY OFFSHORE OF 2 CREEKS		CO.H.D.		
A	-	DRAINAGEWAY JUNCTION WITH BAY 200 YDS. WEST OF PECHO ROAD			RWQCB	
A'	-	ABOUT 50 FEET UP-DRAINAGEWAY OF STATION A			RWQCB	
B	-	CUESTA-BY-THE-SEA INLET FROM THE END OF PECHO ROAD			RWQCB	
C	-	DRAINAGEWAY 100 YDS. EAST OF END OF BRODERSON			RWQCB	
C'	-	ABOUT 50 YARDS UP-DRAINAGEWAY OF STATION C			RWQCB	
D	-	BAYWOOD PARK PIER BY BAYWOOD PARK LODGE			RWQCB	
E	-	COASTAL ACCESS FROM PASADENA DRIVE			RWQCB	
F	-	END OF 2nd STREET BEHIND VACANT LOT			RWQCB	
G	-	END OF 7th STREET			RWQCB	
					RWQCB	

The third tidal condition sampled was during the final hour before flood tide, where the water is rapidly entering the Bay and has been doing so for several hours (Phase II).

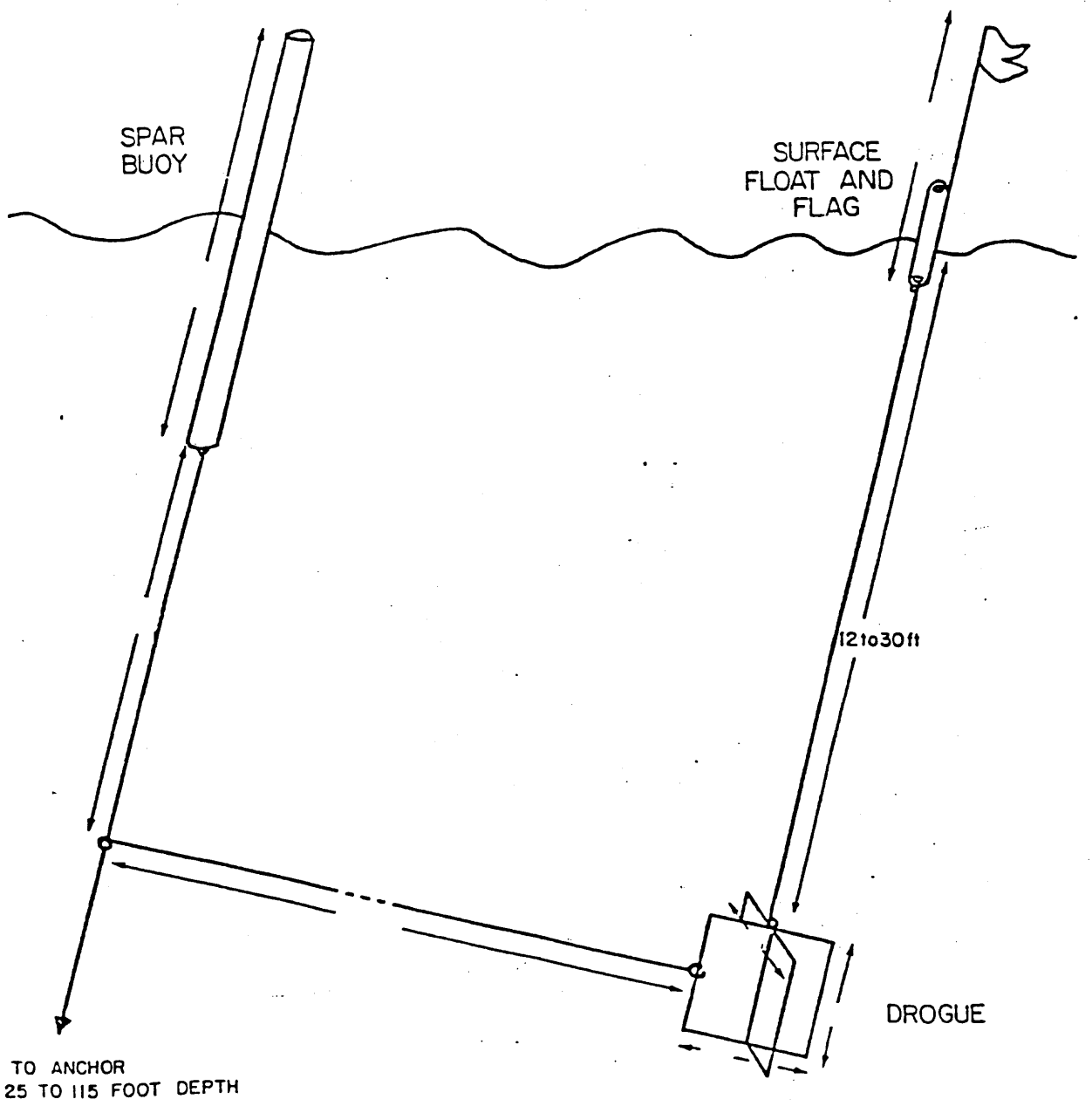
Currents

Currents were an important feature in designing the monitoring program as they were linked to determination of effects from sources outside the Bay. Contamination from Morro Bay WWTP located north of the Bay entrance was a possibility considered during southerly currents. Therefore, sampling was designed to evaluate results under the two conditions of both northerly and southerly currents to help contrast in-Bay and out-Bay sources.

Determination of the season in which these current patterns occur was essential to sampling program design. Ecomar reported on coastal waters off Morro Bay in a 1978 report entitled, Marine Environmental Investigation of Morro Bay-Cayucos Sanitary District. Ecomar concluded (page 111) that a "clearly defined single direction for each time of the year cannot be generated from either meter or drogue data." However, predominantly southward flow existed in the winter months (December through March) and bi-directional flows, north and south, existed in the fall months (September through November). FDA's study on Morro Bay indicated the same trends with similar unpredictability in the fall. Local residents note southerly currents during the end of summer or beginning of fall.

Because of predicted currents, the monitoring program was designed in two phases. Phase I ran from July into August, with northward currents expected. Phase II ran from August through September, with southward currents expected. A tethered drogue was placed in the ocean north of the Bay to make certain of the current direction (approximate location noted on Figure 2). Phase I samples were to be collected only when northerly currents existed, while Phase II samples were to be collected only with southerly currents.

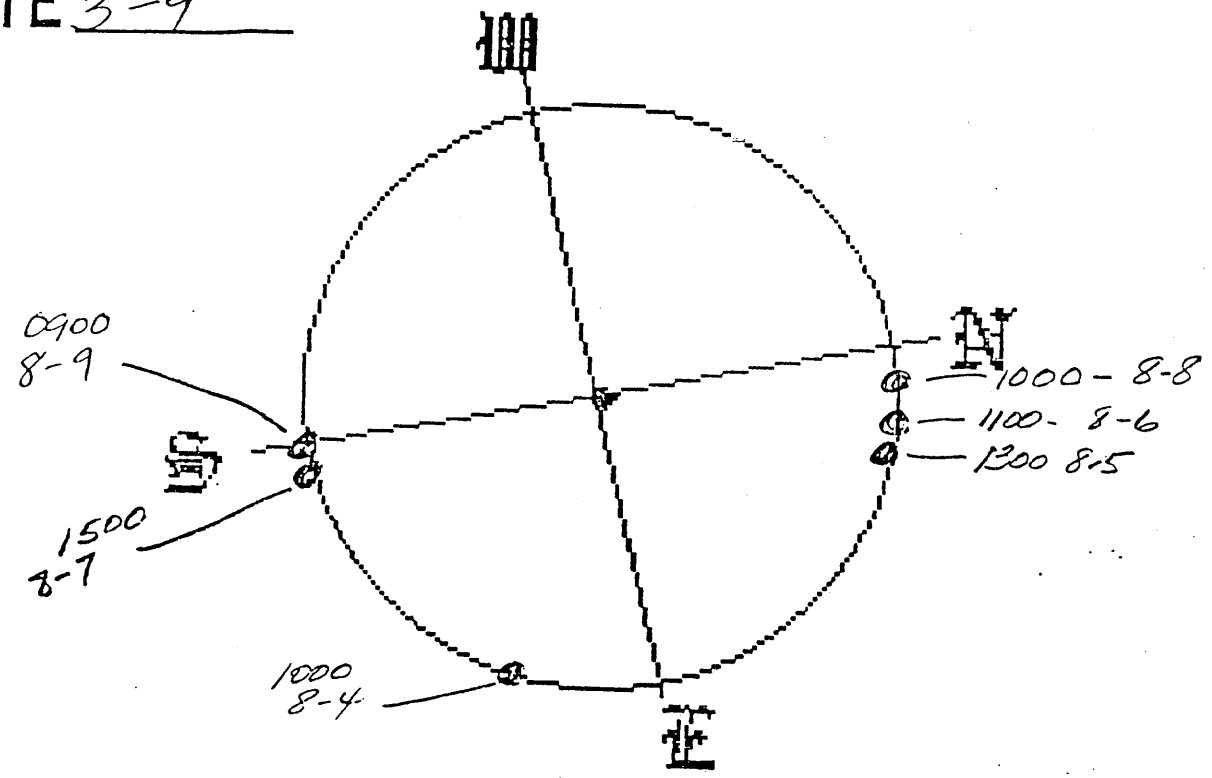
The drogue consisted of a bottom anchored spar buoy with a two-foot crosscurrent drogue tethered off at mid-depth supported with a surface float. A schematic of the drogue is presented in Figure 4. Measurements of the surface float relative to the anchored spar buoy were taken with telescope from the WWTP to discern current direction. An example of the sheet used to record direction readings is shown in Figure 5.



Tethered Drogue Schematic

FIGURE 4

DATE Aug 3-9



NAME Darrock OCEAN CONDITION _____

WIND _____ OBSERVATION POINT Plant

All week no wind, ocean calm mostly fog every morn.

FIGURE 5

Creek Flow

Because potential contamination could be carried by creeks into the Bay, creek flow was considered in sampling program design. DOHS indicated that historically, no water had been flowing in Chorro and Los Osos Creeks during Phase I and II sampling seasons. Since upstream contamination from dairies and the California Men's Colony and numerous non-point sources was possible, any creek flow was noted and sampled. Phase III Winter Sampling design anticipated large creek flows.

Effluent Chlorination/Nonchlorination

Program design also depended on the City's wastewater treatment plant changing from nonchlorination of effluent (in early Phase II), to chlorination of effluent (in late Phase II). By completing this portion of the study, conclusions could be reached as to whether the treatment plant's unchlorinated effluent is actually a bacterial contaminator of the bay.

Unfortunately, EPA ordered chlorination to begin on August 1, 1986, a deadline which was met by the Morro Bay-Cayucos Wastewater Treatment Plant. This order allowed completion of the chlorination portion of Phase II. The Regional Board requested EPA to allow the WWTP to discontinue chlorination for the final portion of the bacteriological study. EPA's September 12, 1986, reply refused to suspend the order for the necessary two weeks (see chronology, Appendix E for additional correspondence on this issue). Consequently, the condition of southward current with nonchlorination designed to detect any contamination entering the Bay from the WWTP could not be completed. However, sampling resources from this cancelled phase were redirected to complete a short Phase III winter study.

Weekday vs Weekend

Another feature of the design is week-round sampling; included so that weekends would be represented in sampling results. Some sources of pollution may become more prevalent during the weekend. Vacationers staying at the Marina, for example, could cause higher coliform counts which could only be detected on weekends.

Presampling Meetings

Before all phases, meetings were scheduled to review proposed sampling times and to discuss proper procedures and, before Phase II, to review Phase I results. Representatives from all of the agencies involved in study conduct Attended the meetings, including, the State of California Regional Water Quality Control

Board (RWQCB), San Luis Obispo County Health Department, State Department of Health Services (DOHS), California Department of Fish and Game (DFG), and City of Morro Bay representatives.

In addition to discussion at these meetings, comments and suggestions about sampling design were requested from various agencies given workplans to critique. Those who responded included the City of Morro Bay, U. S. Environmental Protection Agency (EPA), and FDA.

MATERIALS AND METHODS

SAMPLING

Samples were collected at stations shown in Figures 2 and 3 as follows:

Frequency

Phase I In this phase, from July 8 to August 3, 1986, samples were collected from each station every other day (fourteen sample days). Seven flood and seven ebb tides were sampled as prescribed. Sampling began at the time of high or low tide scheduled on the tide table. Taking tidal delay into account, all of this phase's samples were taken at slack tide. Each sampling team completed sampling its stations within two hours. The majority of Phase I samples were collected when water velocities were slow and pollutants were near their sources. All ocean currents should have been flowing upcoast to eliminate the possibility of contamination from the treatment plant located north of the Bay entrance. However, drogues were not in place until the middle of the phase, thus no current direction readings were available before July 22, 1986.

Phase II Samples were collected every other day with the exception of a six day period because of boat repair for fourteen days (seven sample days) from August 21, to September 12, 1986. With a southerly current, sampling began one hour before high tide, and finished within one hour after high tide. Water was entering the Bay rapidly. The treatment plant was already chlorinating its effluent in this phase and no contamination was expected at the Bay entrance.

Phase III This phase evaluated winter conditions and replaced the cancelled second half of Phase II. Phase III included seven sampling days, March 19 through April 6, 1987. Four low tides and three high tides were sampled during slack tide conditions.

Depth

Bay station samples were all collected at two depths, surface and middle. Channel station samples, 1 through 4, were collected at these two depths plus a third depth at two meters above the bottom of the channel. Back Bay stations, A through G, creek stations, 16 and 17, and the PG&E station were sampled only at the surface.

Locations

Sampling stations, as mentioned previously, are located on the maps in Figures 2 and 3 and are described by Table 1. There are four channel stations, twenty Bay stations, ten shoreline stations and five creek stations. Responsibility for these stations is broken into three sampling teams:

4 Channel Stations	- City of Morro Bay Personnel
20 Bay Stations	- San Luis Obispo County Health Department (Contracted)
10 Shoreline + 5 Creek Stations	- Regional Water Quality Control Board

The team concept allowed all work to be done simultaneously within a two hour period.

Sample Type

All collected samples were analyzed for both total and fecal coliform. In addition, on two days in Phase I (July 14 and July 28), and one day in Phase II (August 25), extra samples were taken for fecal streptococcus analysis.

Number of Samples Taken

Table 2 contains a breakdown of the total number of samples collected for analysis. On some days shown on Table 2, samples could not be collected for various reasons: on low tides, there would frequently be no water in the back Bay; extra Chorro Creek stations were not added until sampling had begun; lack of vision, particularly due to fog, prevented the boat crew from collecting samples on some occasions.

Observation Sheets

In order to evaluate sampling results, observations were made during the course of sampling. The following, plus any miscellaneous observations, were recorded for each station on each sampling run:

1. Time sample was taken.

2. Presence/absence of birds or mammals.

3. Surface current.

4. Discharges in the vicinity.

TABLE 2

NUMBER OF SAMPLES

PHASE	NUMBER OF STATIONS	DEPTHS	TOTAL STATIONS (per day)	NUMBER OF DAYS	TOTAL SCHEDULED	NUMBER OF "NO SAMPLES"	TOTAL TAKEN
I	39	4 @ 3 20 @ 2 15 @ 1	67	14	938	48	890
II	39	4 @ 3 20 @ 2 15 @ 1	67	7	469	8	461
supplamental fecal streptococcus	39	4 @ 3 20 @ 2 15 @ 1	67	3	201	8	193
III	39	4 @ 3 20 @ 2 15 @ 1	67	7	459	10	459
							*****
					TOTAL NUMBER OF SAMPLES		2003

5. Creek flow.

6. Algae presence.

7. Live aboards in the vicinity.

For each sampling day, tide height and cycle were noted, as well as weather conditions. Once the drogue was in place, a separate set of observations was kept by the City of Morro Bay-Cayucos WWTP for current directions.

Collection and Transportation

Samples were collected and preserved in accordance with Standard Methods for the Examination of Water and Wastewater, 1985, 16th edition, Sections 906A and B, pages 856 - 859. Pre-sterilized plastic sampling cups were supplied by the San Luis Obispo County Health Department Laboratory. Photograph 1 shows the sampling cups.

Two different devices were used to collect water samples. For surface depths, sampling poles with rings fitted to the end were used to hold the cups securely and to avoid possible contamination of water being sampled. The cup was placed in the ring and water was scooped into the cup via the pole (see Photograph 2). For the middle and bottom depths, a Kemmerer Sampler was used. Water passed completely through the column until the test desired depth was reached; then a weight was dropped along the support rope, triggering the device to close the top and bottom openings, sealing the test water within the column. Care was taken not to contaminate either the sampling cup or the lid. If the inside of the lid or cup was touched, that entire container was discarded and a new one used.

After each sample was collected, it was placed on ice until that day's sampling run was complete. All of the samples were assembled at the Fish and Game dock and placed in one ice chest to be taken to the lab by the County Health sample crew. Chain of Custody forms were signed and dated by each team, and kept with the samples until they reached the lab.

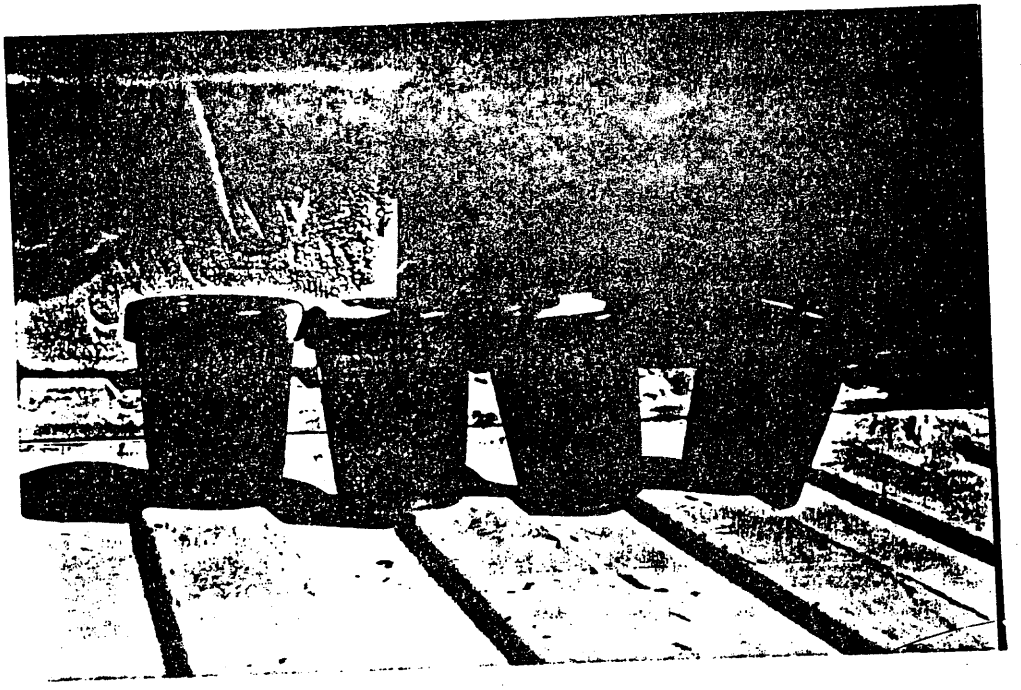


PHOTO 1

PHOTO 2

MATERIALS AND METHODS

ANALYSIS

The contract for laboratory services of all water samples was awarded to the San Luis Obispo County Health Department Laboratory.

All water samples were analyzed for total and fecal coliform. Total coliform tests detect all forms of coliform present; fecal coliform tests are run specifically for fecal members of the coliform group, those typically found in the gut and feces of warm blooded animals. Differentiation between these two is essential because non-fecal members of the coliform group tend to survive longer periods of time in unfavorable water environments as compared to fecal members (Standard Methods, p. 828).

Additional samples were collected on three different days to test for fecal streptococcus. This test helps determine whether the source of contamination is human or animal. If the fecal coliform to fecal streptococcus ratio (FC/FS) is greater than four, the source is more likely to be human contamination; if FC/FS is less than about 0.7, the source is more likely to be animal contamination. In either case, the FC/FS ratio can only be used reliably when fecal streptococcus counts are greater than 100 per 100 ml.

For coliform counts, membrane filter tests, with results reported as colonies per 100 ml, were used (as opposed to multiple tube fermentation tests, with values reported as MPN (Most Probable Number) per 100 ml). According to Standard Methods, the statistical reliability of the membrane filter technique is greater than that of the MPN procedure (page 812). As expected, some statistical variation and a 95% confidence limit exists. These membrane filter tests were performed in accordance with Standard Methods 909A for total coliform, 909C for fecal coliform, and 910 for fecal streptococcus.

Data resulting from these tests were evaluated against water quality criteria. Limits for these criteria are included as Appendix B.

MATERIALS AND METHODS

POTENTIAL SOURCES INVESTIGATION

In addition to the regular sample locations, various possible point sources were to be specifically investigated as follows:

Tiger's Folly

This recreational tour boat cruises the Bay several times a day during the summer. Significant quantities of wastewater from crew and passengers represent a potential source of bacteria and pollution.

Live Aboards and Pump-out Stations

Waste disposal practices of those living on board their boats within the Bay were investigated along with an investigation of the frequency of usage of available pump-out stations.

Lift Stations

The City of Morro Bay's lift stations could discharge raw sewage into the Bay if they are not operating properly. These stations were identified and labeled for later investigation (See Appendix C).

Storm Drains

Storm drains entering the Bay were to be located for quick reference so that any discharges from drains could be noted during the sampling program.

Birds and Mammals

Waste from birds and mammals can contribute greatly to bacteriological contamination of the Bay. Their location and numbers were noted during sampling runs.

Pacific Gas & Electric Company

Water is taken in by PG&E from the entrance of the bay at Station 4 and discharged at Station "PG&E" for use as once through cooling water for a fossil-fueled power plant in Morro Bay. If Station 4 and/or PG&E's discharge was contaminated, and

southerly currents prevailed, the discharge would travel around Morro Rock into the Bay again, recycling and reintroducing coliform to the Bay. This could greatly confuse interpretation of the entrance channel station results. This possibility was investigated.

CHAPTER IV

RESULTS AND DISCUSSION

This chapter provides compilations of results obtained by this study. The first section discusses findings of the potential sources investigation. Following are discussions of Phase I, Phase II, and Phase III results. Due to preliminary findings in the prescribed phases, follow-up studies were performed; a discussion of these results closes this chapter.

RESULTS AND DISCUSSION

POTENTIAL SOURCES RESULTS

Potential point sources were investigated separately from the regular sampling program, either before the program began, between phases, or on non-sampling days. Results of these investigations follow.

Tiger's Folly

A sewer line connected to the Harbor Hut Restaurant is used to pump waste from the Tiger's Folly directly to the City's sewer system. At each pumping, approximately 300 gallons are transferred. During the summer months, pumping occurs about twice a week; during the winter, once to twice a month is all that is necessary. It was revealed by the operators that if tanks become too full, wastewater backs up into the boat itself, something the operators will naturally try to avoid by timely pump-outs. As long as this pump-out is accomplished without leakage, there is no reason to suspect the Tiger's Folly in the contamination of the Bay.

Live Aboards and Pump-out Stations

A preliminary investigation on this subject examined the usage of pump-out stations. Three stations exist. Two are free to public use, and one has a minimal charge. The two free-of-charge pump stations are rarely used. The WASTOP at the end of the North T-Pier (in front of the Harbor Patrol Office) has been used less than two dozen times in its ten years, and the K Pump at the South T-Pier (by Great American Fish Company) has never been used. The third pump station is located at the Morro Bay Marina by the Exxon fuel dock. There is a three dollar user's fee to those not registered at the Marina. Otherwise, it is free. However, the station is used only about two times per month. According to a worker at the Marina, most of the live-aboards use port-a-potties in which waste is carried to bathrooms on shore and disposed. However, it can be easily assumed that the practice of pumping tanks directly into the Bay, certainly more convenient than either method above, is also likely to occur. In fact, State Park Marina residents who have no pump-out station, readily admitted to discharging holding tank waste for want of a suitable alternative (this is discussed in detail later). Station 23 was located to quantify this impact.

Lift Stations

In 1985, lift stations in Morro Bay were investigated by the RWQCB. One station was found to be discharging raw sewage into the Bay, but the problem has since been corrected. Larger pumps, improved alarm systems, and new lines were all installed last year, thus, greatly reducing the threat of contamination due to these sources. A map of the lift stations can be found in Appendix C.

Storm Drains

Storm drains flowing into Morro Bay may be a significant source of bacteriological contamination. Figure 3, identifies locations of these drains as they enter the Bay. Any discharges from these areas were to be noted during each sampling run.

Birds and Mammals

Waste from birds and mammals contributes to bacteriological contamination of the Bay. Morro Bay is a bird sanctuary and this contamination could be significant. In addition to birds, there are other warm blooded animals inhabiting the Bay.

Determining the impact of bacteria from birds and mammals is difficult. Samplers noted the presence and approximate number of such animals during sampling, and correlations were drawn later from population and pollution levels.

Pacific Gas & Electric Company

Sampling results were to be monitored to note any recycling trend around Morro Rock, from PG&E's outlet to the Morro Bay entrance. If high counts were found at Station 4 and at the PG&E station, stations outside of the bay and around the rock would be established to monitor this cycle. However, the PG&E discharge was always free of coliform throughout the program. No further investigation of this site was considered necessary.

RESULTS AND DISCUSSIONS

PHASE I

Results from the first phase of the study are presented in tabular form in Tables 3, 4, and 5, for total coliform, fecal coliform, and fecal streptococcus, respectively. Included as data for each sampling day is information on the time sampling began, the tidal level at that time, the current direction (when available), and the day and date of sampling. Included for each station is the arithmetic mean, the log mean, the maximum coliform count, and, for total and fecal coliform, the numbers and percentages of times that shellfish growing water limits are exceeded. A graph of the log means of total and fecal coliform results are shown in Figures 6 and 7.

Several trends in the raw data are notable. First, July 18th, showed high counts, both total and fecal, in the Bay entrance and halfway down the harbor. These stand out from every other sampling day, as a majority of entrance channel stations typically average 10 (per 100 ml), or less than 10, on any other occasion. To view this graphically, compare the total coliform results from July 18th to July 22nd, a day of typical coliform counts in Figures 8 and 9. For a comparison of these same two days' fecal results, compare Figures 10 with 11.

Notice secondly, the consistency of results of a given station throughout the phase (with the above stated exception of July 18th). If a station is low in coliform count on a few days, it is likely that it is low for each day sampled; likewise for high counts. This consistency is a significant finding as it allows more confidence in drawing general conclusions from the data. Exceptions to this rule occur at stations where non-constant discharges were noted by samplers at the time of sampling.

Various stations showed consistently high results. Briefly, these stations include Station 5, Central Coast Seafood; Station 5B, the Morro Bay Aquarium; Stations C, C', A and A' from the back Bay; and Station 16, Chorro Creek. The Marina, Station 23, also had a few days of high coliform counts.

Before discussing the significance of these results, the conditions of this phase should be briefly renumerated: (1) slack water is moving slowly, so that detected contamination will be close to its source, and (2) no contamination should be entering the Bay from the WWTP because currents are generally northerly. (This second presumption is supported by the fact that entrance channel stations were generally the cleanest in the survey).

entral Coast Regional
later Quality Control Board

TABLE 3

TOTAL COLIFORM

MORRO BAY COLIFORM SAMPLING -- PHASE ONE

STATION	TUE HIGH(3.6) 12:59 08-Jul	THURS HIGH(3.8) 14:08 10-Jul	SAT LOW(0.3) 08:26 12-Jul	MON LOW(1.2) 09:44 14-Jul	WED LOW(2.1) 11:32 16-Jul	FRI HIGH(3.5) 09:36 18-Jul	SUN LOW(2.2) 15:35 20-Jul	TUE HIGH(4.3) 12:31 22-Jul	THUR HIGH(4.5) 13:52 24-Jul	SAT LOW(0.7) 08:33 26-Jul	MON LOW(1.9) 09:50 28-Jul	WED HIGH(3.0) 08:22 30-Jul	FRI LOW(2.9) 13:53 01-Aug	SUN HIGH(3.7) 10:57 03-Aug	Log Mean	Percent of Samples Exceeding 230	Percent Samples Exceedin 70
PG&E TOP: PG&E-1	30	30	<10	10	10	30	<10	<10	20	20	<10	40	10	20	11.9	0.0 %	0.0
CHANNEL ENT. TOP: 1-1	<10	<10	80	40	<10	480	<10	<10	<10	10	30	30	10	<10	14.0	7.1 %	14.3
CHANNEL ENT. MID: 1-2	<10	<10	30	10	<10	640	<10	<10	<10	50	20	70	<10	<10	13.3	7.1 %	7.1
CHANNEL ENT. BOT: 1-3	<10	<10	<10	30	<10	320	<10	<10	<10	50	30	40	<10	<10	11.9	7.1 %	7.1
CHANNEL TOP: 2-1	<10	<10	30	40	<10	380	<10	<10	<10	10	20	20	10	<10	12.1	7.1 %	7.1
CHANNEL MID: 2-2	<10	<10	10	<10	<10	490	10	<10	<10	30	30	<10	10	<10	10.4	7.1 %	7.1
CHANNEL BOT: 2-3	<10	<10	30	40	40	500	10	<10	30	20	30	<10	10	<10	16.7	7.1 %	7.1
CHANNEL TOP: 3-1	<10	<10	30	10	<10	260	10	<10	<10	20	40	<10	<10	<10	10.7	7.1 %	7.1
CHANNEL MID: 3-2	<10	<10	30	10	10	290	<10	<10	<10	20	30	20	30	<10	13.2	7.1 %	7.1
CHANNEL BOT: 3-3	<10	<10	10	10	40	370	10	<10	<10	30	80	10	70	10	16.9	7.1 %	14.3
CHANNEL PG&E TOP: 4-1	<10	<10	20	<10	20	170	10	10	<10	20	50	10	<10	<10	11.8	0.0 %	7.1
CHANNEL PG&E MID: 4-2	10	<10	<10	30	10	140	10	<10	<10	40	30	<10	20	<10	12.2	0.0 %	7.1
CHANNEL PG&E BOT: 4-3	<10	<10	30	20	<10	460	<10	<10	<10	20	40	<10	30	<10	12.6	7.1 %	7.1
STARKIST TOP: 4A-1	20	<10	10	40	80	540	40	10	10	400	60	200	70	<10	37.7	14.3 %	28.6
STARKIST MID: 4A-2	<10	20	30	40	80	570	60	10	30	120	620	30	30	10	42.7	14.3 %	28.6
C.COAST SEAFOOD TOP: 5-1	20	20	140	tntc	940	790	20	40	10	20	1420	740	40	40	109.0	35.7 %	42.9
C.COAST SEAFOOD MID: 5-2	10	<10	60	tntc	100	500	30	70	<10	40	200	30	100	20	54.9	14.3 %	35.7
QUALMAN'S TOP: 5A-1	10	40	140	160	10	310	<10	150	<10	<10	170	630	<10	20	35.8	14.3 %	42.9
QUALMAN'S MID: 5A-2	<10	<10	70	40	<10	340	40	140	<10	40	130	90	<10	40	29.1	7.1 %	28.6
AQUARIUM TOP: 5B-1	110	230	1140	120	100	370	<10	2720	2060	10	1360	520	810	1750	294.0	64.3 %	85.7
AQUARIUM MID: 5B-2	730	<10	500	100	60	400	<10	970	80	<10	400	520	120	70	102.9	42.9 %	64.3
BOATS OFF 5B TOP: M5B-1	<10	<10	30	<10	<10	220	<10	10	<10	30	20	10	10	<10	10.8	0.0 %	7.1
BOATS OFF 5B MID: M5B-2	<10	<10	30	10	10	160	<10	<10	<10	20	<10	10	<10	<10	9.3	0.0 %	14.3
OLIVE & SOUTH TOP: 6-1	20	<10	30	140	20	60	<10	30	40	70	50	30	<10	10	23.5	0.0 %	7.1
OLIVE & SOUTH MID: 6-2	10	10	20	160	30	200	<10	70	10	10	50	310	10	20	28.3	7.1 %	21.4
BOATS OFF 6 TOP: M6-1	<10	<10	<10	<10	<10	100	<10	<10	<10	20	20	30	<10	<10	8.6	0.0 %	7.1
BOATS OFF 6 MID: M6-2	<10	<10	<10	<10	30	160	<10	<10	<10	<10	20	30	<10	<10	9.1	0.0 %	7.1
OYSTER SIGN TOP: 8-1	<10	<10	10	<10	10	20	<10	10	<10	10	50	230	<10	<10	9.4	0.0 %	7.1
OYSTER SIGN MID: 8-2	20	<10	40	10	10	30	<10	<10	<10	60	60	200	60	<10	17.8	0.0 %	7.1
LAUNCH RAMP TOP: 7-1	90	20	10	90	10	340	<10	<10	13	30	110	230	30	240	37.2	14.3 %	42.9
LAUNCH RAMP MID: 7-2	210	80	150	100	40	380	<10	10	110	30	70	140	30	520	71.8	14.3 %	57.1
TRIANGLE 20 MID: 9-2	<10	10	10	10	<10	210	<10	<10	10	40	10	20	30	<10	12.2	0.0 %	7.1
MUSEUM TOP: 15-1	<10	<10	30	<10	<10	<10	10	10	10	<10	<10	30	<10	50	8.8	0.0 %	0.0
MUSEUM MID: 15-2	10	<10	10	10	<10	50	<10	20	10	100	<10	10	20	40	13.2	0.0 %	7.1
NEAR 3 PILES TOP: 10-1	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	10	<10	5.3	0.0 %	0.0
NEAR 3 PILES MID: 10-2	<10	<10	<10	<10	<10	20	<10	10	<10	10	<10	<10	<10	<10	6.1	0.0 %	0.0
CHANNEL/MUSEUM TOP:14-1	<10	<10	<10	<10	10	40	<10	<10	<10	20	10	40	<10	20	9.1	0.0 %	0.0
CHANNEL/MUSEUM MID:14-2	<10	<10	<10	<10	20	20	<10	<10	<10	<10	<10	20	50	50	9.4	0.0 %	0.0
PARK MARINA TOP: 23-1	10	30	460	180	70	100	50	<10	<10	<10	50	20	80	1220	44.1	14.3 %	28.6
PARK MARINA MID: 23-2	20	20	190	10	20	10	60	30	<10	20	140	60	180	1740	42.9	7.1 %	28.6
OYSTER BEDS TOP: 13-1	<10	<10	10	<10	10	<10	<10	<10	<10	10	10	<10	40	<10	7.4	0.0 %	0.0
OYSTER BEDS MID: 13-2	<10	<10	10	20	<10	40	<10	<10	<10	10	10	20	<10	20	9.1	0.0 %	0.0
IN CHANNEL TOP: 12-1	<10	<10	10	<10	<10	<10	10	<10	<10	<10	<10	20	<10	20	6.7	0.0 %	0.0
IN CHANNEL MID: 12-2	<10	10	<10	<10	<10	50	<10	<10	<10	10	<10	<10	20	70	8.7	0.0 %	0.0
END OF CHANNEL TOP: 11-1	<10	<10	<10	10	10	<10	<10	10	<10	10	<10	<10	<10	<10	6.1	0.0 %	0.0
END OF CHANNEL TOP: 11-2	<10	<10	10	<10	<10	50	<10	20	<10	<10	<10	60	20	30	10.2	0.0 %	0.0
EAST BAY TOP: 11E-1	<10	<10	10	<10	<10	10	<10	<10	<10	30	<10	20	<10	10	7.3	0.0 %	0.0
EAST BAY MID: 11E-2	10	<10	30	<10	<10	10	10	<10	<10	10	10	40	<10	20	8.3	0.0 %	0.0
xxxoyster meat CoHD: 11	-	-	-	-	-	-	-	-	-	-	330	330	-	-	330.0	100.0 %	100.0
xxxouster meat CoHD:misc	1300	-	-	-	790	-	-	377	-	-	-	-	-	-	545.7	100.0 %	100.0

TABLE 3 (continued)

MORRO BAY COLIFORM SAMPLING -- PHASE ONE

STATION	TUE HIGH(3.6) 12:59 08-Jul	THURS HIGH(3.8) 14:08 10-Jul	SAT LOW(0.3) 08:26 12-Jul	MON LOW(1.2) 09:44 14-Jul	WED LOW(2.1) 11:32 16-Jul	FRI HIGH(3.5) 09:36 18-Jul	SUN LOW(2.2) 15:35 20-Jul	TUE HIGH(4.3) 12:31 22-Jul	THUR HIGH(4.5) 13:52 24-Jul	SAT LOW(0.7) 08:33 26-Jul	MON LOW(1.3) 09:50 28-Jul	WED HIGH(3.0) 08:22 30-Jul	FRI LOW(2.9) 13:55 01-Aug	SUN HIGH(3.7) 10:57 03-Aug	Log Mean	Percent of Samples Exceeding 230	Percent Samples Exceedi 70
UP CHANNEL OF C TOP:C'-1	120	60	260	230	260	250	150	370	40	400	380	290	290	260	203.3	57.1 %	85.7
CUESTA-BY-THE-SEA TOP:B-1	<10	10	30	10	<10	10	10	<10	<10	<10	10	60	10	30	10.4	0.0 %	0.0
W. OF PECHO TOP: A-1	<10	<10	62	180	10	10	20	50	10	tntc	110	1240	120	50	40.1	14.3 %	35.7
UP CHANNEL OF A TOP:A'-1	<10	no samp	no samp	no samp	620	190	410	750	<10	tntc	tntc	tntc	tntc	120	88.3	63.6 %	81.8
LOS OSOS CK. TOP: 17-1	20	20	40	10	<10	10	<10	80	70	20	<10	180	<10	10	17.2	0.0 %	14.3
CANET RD. TOP:16U/S-1	no samp	no samp	no samp	no samp	no samp	no samp	no samp	no samp	no samp	no samp	no samp	no samp	120	80	98.0	0.0 %	14.3
CHORRO CK. TOP: 16-1	150	130	280	130	270	140	180	390	60	160	120	140	60	60	139.8	21.4 %	78.6
DOWNSTREAM 16 TOP:16D/S-1	no samp	no samp	no samp	no samp	no samp	no samp	no samp	no samp	no samp	no samp	no samp	no samp	<10	10	7.1	0.0 %	0.0
MOUTH OF 16 TOP:16'-1	no samp	no samp	no samp	no samp	no samp	10	<10	10	<10	<10	10	10	<10	<10	6.8	0.0 %	0.0

*NOTE: FOR MEANS, (a)"<10" ARE FIGURED AT "5"
(b)"tntc" ARE FIGURED AT "3000"
(c)"confluent" ARE FIGURED AT "5000"

***NOTE: OYSTER MEAT SAMPLING WAS PERFORMED INDEPENDENTLY BY THE COUNTY HEALTH DEPARTMENT

no samp= no sample taken tntc= too numerous to count

Central Coast Regional
Water Quality Control Board

TABLE 4

FECAL COLIFORM

MORRO BAY COLIFORM SAMPLING -- PHASE ONE

STATION	TUE HIGH(3.6) 12:59 08-Jul	THURS HIGH(3.8) 14:09 10-Jul	SAT LOW(0.3) 08:26 12-Jul	MON LOW(1.2) 09:44 14-Jul	WED LOW(2.1) 11:32 16-Jul	FRI HIGH(3.5) 09:36 18-Jul	SUN LOW(2.2) 15:35 20-Jul	TUE HIGH(4.3) 12:31 22-Jul	THUR HIGH(4.5) 13:52 24-Jul	SAT LOW(0.7) 08:33 26-Jul	MON LOW(1.9) 09:50 28-Jul	WED HIGH(3.0) 08:22 30-Jul	FRI LOW(2.9) 13:53 01-Aug	SUN HIGH(3.7) 10:57 03-Aug	Log Mean	Percent of Samples Exceeding 43	Percent Sample Exceedi 14
PG&E TOP: PG&E-1	<5	<5	<5	<5	15	5	5	<5	5	5	5	20	<5	<5	4.2	0.0 %	14.3
CHANNEL ENT. TOP: 1-1	<5	<5	<5	5	<5	67	<5	<5	<5	5	<5	10	<5	<5	3.9	7.1 %	7.1
CHANNEL ENT. MID: 1-2	<5	<5	<5	<5	<5	45	<5	<5	<5	5	10	10	<5	<5	3.9	7.1 %	7.1
CHANNEL ENT. BOT: 1-3	<5	<5	<5	<5	5	68	<5	<5	<5	<5	<5	10	<5	<5	3.7	7.1 %	7.1
CHANNEL TOP: 2-1	<5	<5	<5	5	<5	35	<5	<5	<5	25	<5	<5	<5	<5	3.7	0.0 %	7.1
CHANNEL MID: 2-2	<5	<5	10	5	5	50	<5	<5	<5	<5	5	<5	<5	<5	4.0	7.1 %	7.1
CHANNEL BOT: 2-3	<5	<5	10	<5	<5	84	5	<5	<5	<5	5	<5	<5	<5	3.9	7.1 %	7.1
CHANNEL TOP: 3-1	<5	<5	20	<5	<5	25	5	<5	<5	5	5	<5	<5	<5	4.0	0.0 %	14.3
CHANNEL MID: 3-2	<5	<5	<5	5	5	35	<5	<5	<5	<5	5	<5	<5	<5	3.5	0.0 %	7.1
CHANNEL BOT: 3-3	<5	<5	5	10	20	20	<5	<5	<5	5	<5	<5	<5	<5	4.1	0.0 %	14.3
CHANNEL PG&E TOP: 4-1	<5	<5	<5	<5	<5	5	<5	<5	<5	5	20	<5	5	<5	3.4	0.0 %	7.1
CHANNEL PG&E MID: 4-2	<5	<5	<5	5	5	5	<5	<5	<5	5	10	5	<5	<5	3.5	0.0 %	0.0
CHANNEL PG&E BOT: 4-3	<5	<5	10	<5	10	25	<5	<5	<5	5	5	<5	<5	<5	4.0	0.0 %	7.1
STARKIST TOP: 4A-1	5	<5	<5	10	5	45	<5	<5	5	225	15	5	5	<5	6.8	14.3 %	21.4
STARKIST MID: 4A-2	<5	<5	5	5	10	65	5	<5	10	55	45	<5	5	<5	7.2	21.4 %	21.4
C.COAST SEAFOOD TOP: 5-1	<5	<5	10	15	5	40	15	<5	3	5	90	25	<5	20	8.5	7.1 %	42.9
C.COAST SEAFOOD MID: 5-2	<5	<5	<5	20	<5	44	15	<5	<5	5	105	10	20	<5	7.1	14.3 %	35.7
QUALMAN'S TOP: 5A-1	<5	5	5	<5	<5	52	<5	10	5	5	60	10	<5	<5	5.8	14.3 %	14.3
QUALMAN'S MID: 5A-2	<5	10	<5	<5	<5	30	5	5	5	5	110	5	5	5	6.1	7.1 %	14.3
AQUARIUM TOP: 5B-1	10	95	795	10	50	81	<5	1870	1200	<5	1010	40	705	1510	104.5	64.3 %	71.4
AQUARIUM MID: 5B-2	505	10	480	10	70	30	<5	880	45	<5	360	10	45	60	44.6	57.1 %	64.3
BOATS OFF 5B TOP: M5B-1	<5	<5	<5	<5	<5	10	<5	<5	<5	<5	<5	<5	<5	<5	2.8	0.0 %	0.0
BOATS OFF 5B MID: M5B-2	<5	<5	<5	<5	<5	20	<5	<5	<5	10	<5	<5	<5	<5	3.2	0.0 %	7.1
OLIVE & SOUTH TOP: 6-1	<5	<5	<5	<5	<5	5	<5	10	5	10	5	5	<5	<5	3.9	0.0 %	0.0
OLIVE & SOUTH MID: 6-2	<5	<5	<5	<5	<5	30	<5	5	10	<5	10	<5	<5	<5	3.8	0.0 %	7.1
BOATS OFF 6 TOP: M6-1	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	10	5	<5	<5	2.9	0.0 %	0.0
BOATS OFF 6 MID: M6-2	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	2.5	0.0 %	0.0
OYSTER SIGN TOP: 8-1	<5	<5	<5	<5	<5	<5	<5	5	<5	5	10	5	<5	<5	3.2	0.0 %	0.0
OYSTER SIGN MID: 8-2	<5	<5	<5	10	<5	<5	<5	<5	<5	5	5	5	<5	<5	3.2	0.0 %	0.0
LAUNCH RAMP TOP: 7-1	20	<5	<5	<5	<5	14	<5	5	10	5	55	120	10	180	8.9	21.4 %	28.6
LAUNCH RAMP MID: 7-2	5	<5	<5	<5	<5	70	<5	5	<5	5	65	85	15	395	9.7	28.6 %	35.7
TRIANGLE 20 MID: 9-2	<5	<5	5	<5	<5	5	<5	5	<5	15	<5	<5	5	<5	3.5	0.0 %	7.1
MUSEUM TOP: 15-1	<5	<5	5	5	<5	5	<5	<5	5	<5	<5	5	5	25	4.0	0.0 %	7.1
MUSEUM MID: 15-2	<5	<5	5	<5	5	<5	<5	<5	<5	30	<5	5	30	50	5.1	7.1 %	21.4
NEAR 3 PILES TOP: 10-1	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	10	5	5	3.0	0.0 %	0.0
NEAR 3 PILES MID: 10-2	<5	<5	<5	<5	5	<5	<5	<5	<5	<5	10	15	20	<5	3.6	0.0 %	14.3
CHANNEL/MUSEUM TOP:14-1	<5	<5	<5	<5	<5	<5	5	<5	<5	5	5	<5	5	5	3.2	0.0 %	0.0
CHANNEL/MUSEUM MID:14-2	<5	<5	15	<5	<5	10	<5	<5	<5	<5	5	10	<5	<5	3.6	0.0 %	7.1
PARK MARINA TOP: 23-1	<5	<5	<5	5	<5	10	5	<5	<5	<5	5	5	10	5	3.9	0.0 %	0.0
PARK MARINA MID: 23-2	<5	<5	<5	5	<5	5	10	5	<5	<5	<5	10	60	20	5.1	7.1 %	14.3
OYSTER BEDS TOP: 13-1	<5	<5	15	<5	5	<5	<5	<5	10	5	<5	10	<5	<5	3.8	0.0 %	7.1
OYSTER BEDS MID: 13-2	<5	<5	5	<5	5	15	<5	<5	<5	<5	5	5	10	25	4.5	0.0 %	14.3
IN CHANNEL TOP: 12-1	<5	<5	<5	<5	10	<5	<5	<5	<5	5	<5	10	<5	5	3.4	0.0 %	0.0
IN CHANNEL MID: 12-2	<5	<5	<5	5	<5	10	<5	<5	<5	<5	<5	<5	15	10	3.6	0.0 %	7.1
END OF CHANNEL TOP: 11-1	<5	<5	5	5	<5	5	<5	<5	<5	<5	<5	5	<5	10	3.4	0.0 %	0.0
END OF CHANNEL TOP: 11-2	<5	<5	<5	<5	5	<5	<5	5	<5	5	<5	10	5	20	3.9	0.0 %	7.1
EAST BAY TOP: 11E-1	<5	<5	50	<5	5	<5	<5	<5	<5	40	<5	40	<5	10	5.3	7.1 %	21.4
EAST BAY MID: 11E-2	<5	<5	40	<5	<5	<5	10	<5	<5	10	<5	35	<5	5	4.7	0.0 %	14.3
xxxoyster meat CoHD: 11	-	-	-	-	-	-	-	-	-	-	78	78	-	-	78.0	100.0 %	100.0
xxxoyster meat CoHD:misc	1300	-	-	-	78	-	-	180	-	-	-	-	-	-	118.5	100.0 %	100.0

Central Coast Regional
Water Quality Control Board

FECAL COLIFORM

TABLE 4 (continued)

MORRO BAY COLIFORM SAMPLING --PHASE ONE

STATION	TUE HIGH(3.6) 12:59 08-Jul	THURS HIGH(3.8) 14:09 10-Jul	SAT LOW(0.3) 08:26 12-Jul	MON LOW(1.2) 09:44 14-Jul	WED LOW(2.1) 11:32 16-Jul	FRI HIGH(3.5) 09:36 18-Jul	SUN LOW(2.2) 15:35 20-Jul	TUE HIGH(4.3) 12:31 22-Jul	THUR HIGH(4.5) 13:52 24-Jul	SAT LOW(0.7) 08:33 26-Jul	MON LOW(1.9) 09:50 28-Jul	WED HIGH(3.0) 08:22 30-Jul	FRI LOW(2.9) 13:53 01-Aug	SUN HIGH(3.7) 10:57 03-Aug	Log Mean	Percent of Samples Exceeding 43	Percent Sampl Exceed 14
LOS OSOS CK. TOP: 17-1	55	25	30	50	10	10	10	30	110	25	<5	45	<5	10	18.3	28.6 %	57.1
CAMET RD. TOP:16U/S-1	no samp	no samp	no samp	no samp	no samp	no samp	no samp	no samp	no samp	no samp	no samp	no samp	15	15	15.0	0.0 %	100.0
CHORRO CK. TOP: 16-1	140	115	185	130	190	162	115	435	110	55	40	121	30	55	107.8	85.7 %	100.0
DOWNSTREAM 16 TOP:16D/S-1	no samp	no samp	no samp	no samp	no samp	no samp	no samp	no samp	no samp	no samp	no samp	no samp	<5	15	6.1	0.0 %	50.0
MOUTH OF 16 TOP:16'-1	no samp	no samp	no samp	no samp	no samp	no samp	no samp	15	<5	10	5	10	10	<5	6.5	0.0 %	14.3

TABLE 5

Central Coast Regional
Water Quality Control Board FECAL STREPTOCOCCUS

STATION	MON LOW(1.2) 09:44 14-Jul STREP	F.C./S.C. 14-Jul	MON LOW(1.9) 09:50 28-Jul STREP	F.C./S.C. 28-Jul
PG&E TOP: PG&E-1	2	1	1	5
CHANNEL ENT. TOP: 1-1	2	3	1	3
CHANNEL ENT. MID: 1-2	2	1	2	5
CHANNEL ENT. BOT: 1-3	1	3	2	1
CHANNEL TOP: 2-1	1	5	2	1
CHANNEL MID: 2-2	2	3	2	3
CHANNEL BOT: 2-3	2	1	2	3
CHANNEL TOP: 3-1	1	3	1	5
CHANNEL MID: 3-2	2	3	4	1
CHANNEL BOT: 3-3	1	10	1	3
CHANNEL PG&E TOP: 4-1	2	1	2	10
CHANNEL PG&E MID: 4-2	6	1	6	2
CHANNEL PG&E BOT: 4-3	2	1	4	1
STARKIST TOP: 4A-1	6	2	6	3
STARKIST MID: 4A-2	12	0	6	8
C.COAST SEAFOOD TOP: 5-1	18	1	36	3
C.COAST SEAFOOD MID: 5-2	16	1	14	8
QUALMAN'S TOP: 5A-1	6	0	10	6
QUALMAN'S MID: 5A-2	8	0	6	18
AQUARIUM TOP: 5B-1	48	0	44	23
AQUARIUM MID: 5B-2	64	0	52	7
BOATS OFF 5B TOP: M5B-1	4	1	1	3
BOATS OFF 5B MID: M5B-2	2	1	1	3
OLIVE & SOUTH TOP: 6-1	54	0	1	10
OLIVE & SOUTH MID: 6-2	50	0	6	2
BOATS OFF 6 TOP: M6-1	2	1	4	3
BOATS OFF 6 MID: M6-2	2	1	1	3
OYSTER SIGN TOP: 8-1	1	3	1	10
OYSTER SIGN MID: 8-2	1	10	4	1
LAUNCH RAMP TOP: 7-1	27	0	4	14
LAUNCH RAMP MID: 7-2	34	0	2	33
TRIANGLE 20 MID: 9-2	1	3	1	3
MUSEUM TOP: 15-1	1	5	1	3
MUSEUM MID: 15-2	1	3	1	3
NEAR 3 PILES TOP: 10-1	1	3	1	3
NEAR 3 PILES MID: 10-2	2	1	1	10
CHANNEL/MUSEUM TOP:14-1	1	3	1	5
CHANNEL/MUSEUM MID:14-2	1	3	10	1
PARK MARINA TOP: 23-1	2	3	1	5
PARK MARINA MID: 23-2	2	3	44	0
OYSTER BEDS TOP: 13-1	1	3	2	1
OYSTER BEDS MID: 13-2	1	3	1	5

TABLE 5 (continued)

Central Coast Regional
Water Quality Control Board

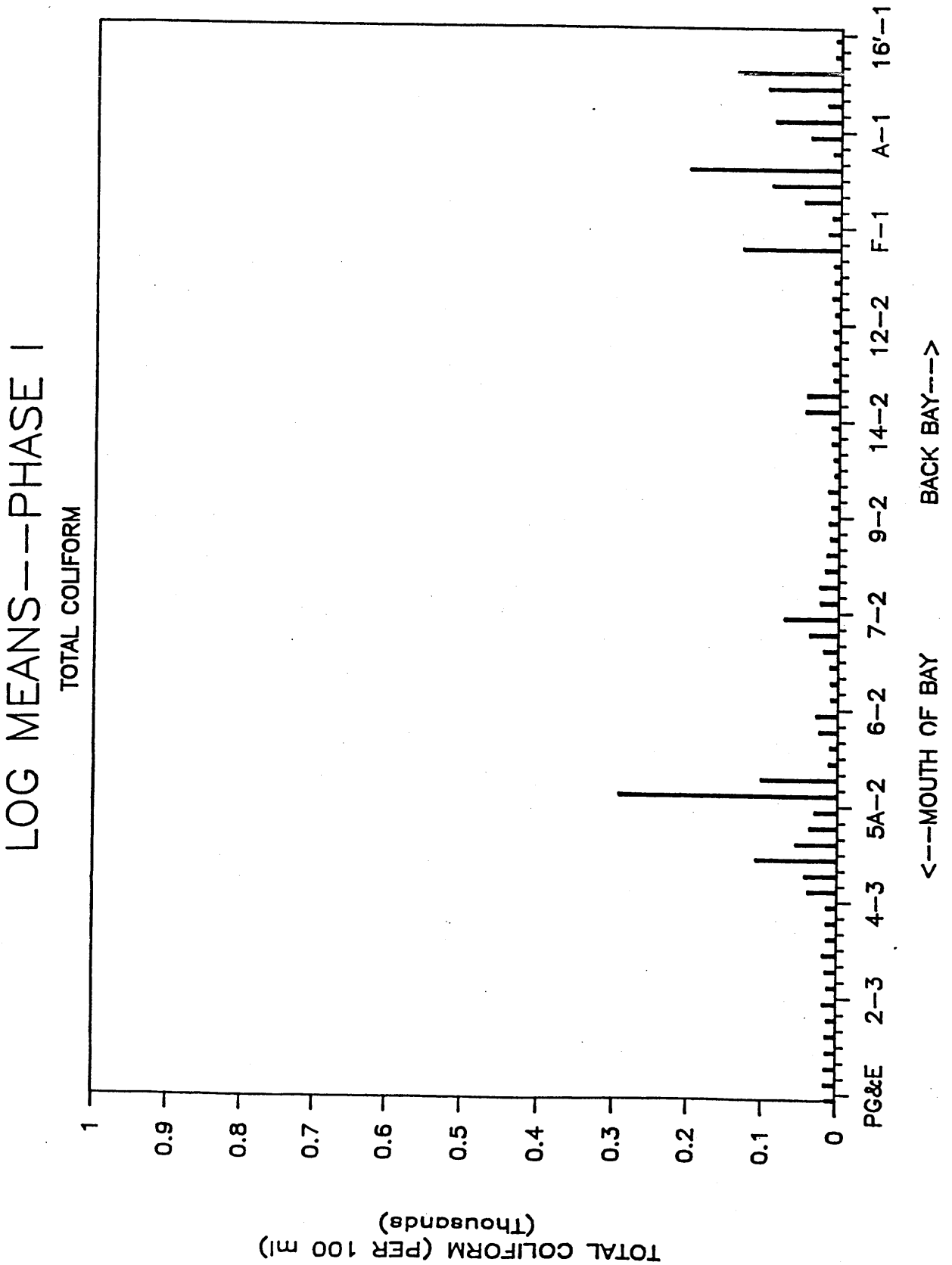
FECAL STREPTOCOCCUS

STATION	MON LOW(1.2) 09:44 14-Jul STREP ‡‡‡‡‡‡‡‡	F.C./S.C. ‡‡‡ 14-Jul ‡‡‡‡‡‡‡‡	MON LOW(1.9) 09:50 28-Jul STREP ‡‡‡‡‡‡‡‡	F.C./S.C. ‡‡‡ 28-Jul ‡‡‡‡‡‡‡‡
LOS OSOS CK. TOP: 17-1	18	3	1	3
CANET RD. TOP:16U/S-1	no samp	no samp	no samp	no samp
CHORRO CK. TOP: 16-1	17	8	32	1
DOWNSTREAM 16 TOP:16D/S-1	no samp	no samp	no samp	no samp
MOUTH OF 16 TOP:16'-1	no samp	no samp	1	5

‡NOTE: FOR MEANS, (a)"<10" ARE FIGURED AT "5"
(b)"tntc" ARE FIGURED AT "3000"
(c)"confluent" ARE FIGURED AT "3000"

‡‡‡NOTE: OYSTER MEAT SAMPLING WAS PERFORMED INDEPENDENTLY BY THE COUNTY

no samp= no sample taken


LOG MEANS---PHASE I
TOTAL COLIFORM
TOTAL COLIFORM (PER 100 ml)
(Thousands)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
PG&E
2-3
4-3
5A-2
6-2
7-2
9-2
14-2
12-2
F-1
A-1
16'-1
<---MOUTH OF BAY
BACK BAY--->
FIGURE 6

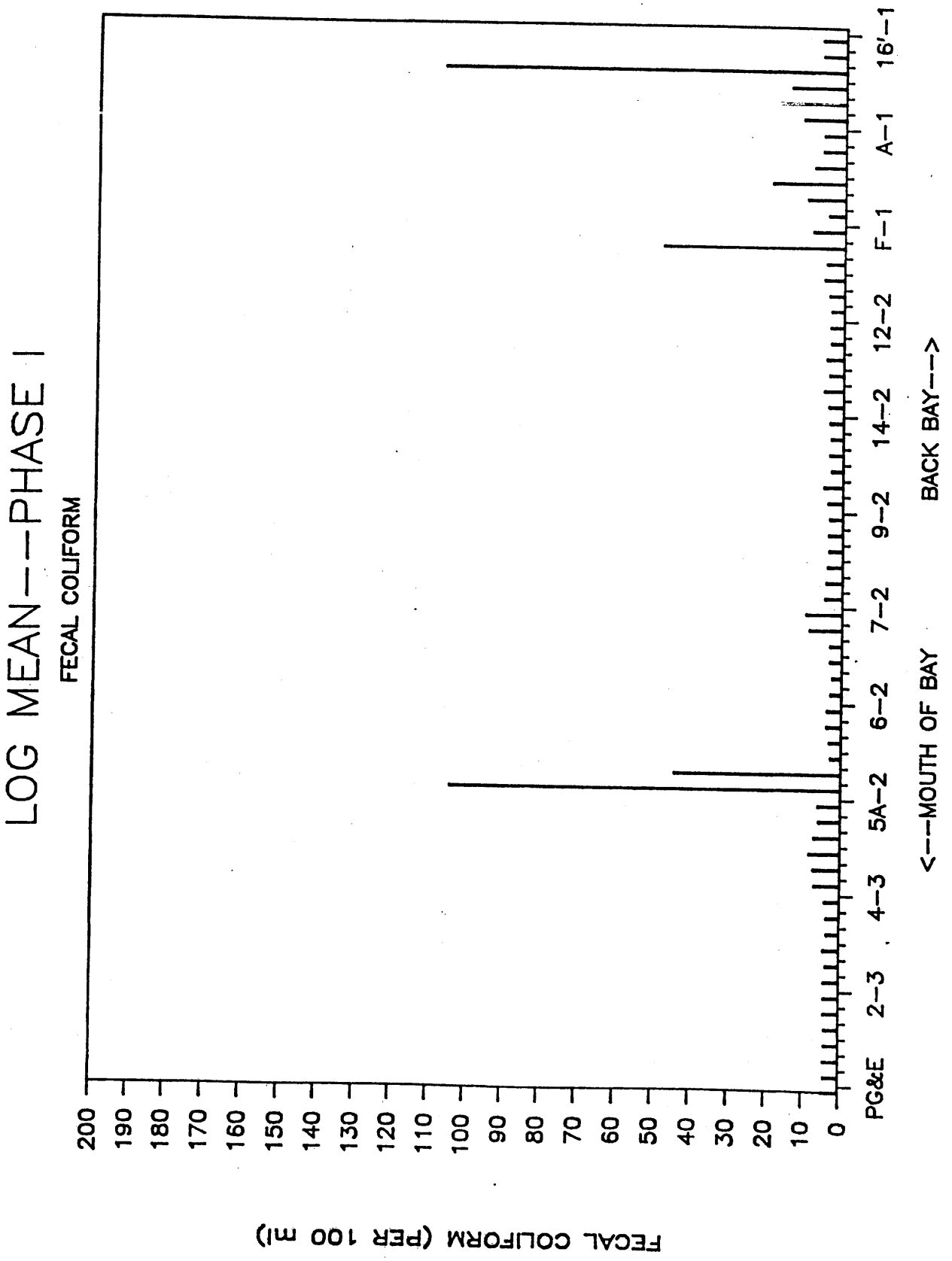

LOG MEAN---PHASE I
FECAL COLIFORM
FECAL COLIFORM (PER 100 ml)
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
PG&E
2-3
4-3
5A-2
6-2
7-2
9-2
14-2
12-2
F-1
A-1
16'-1
<---MOUTH OF BAY
BACK BAY--->
FECAL COLIFORM (PER 100 ml)

FIGURE 7

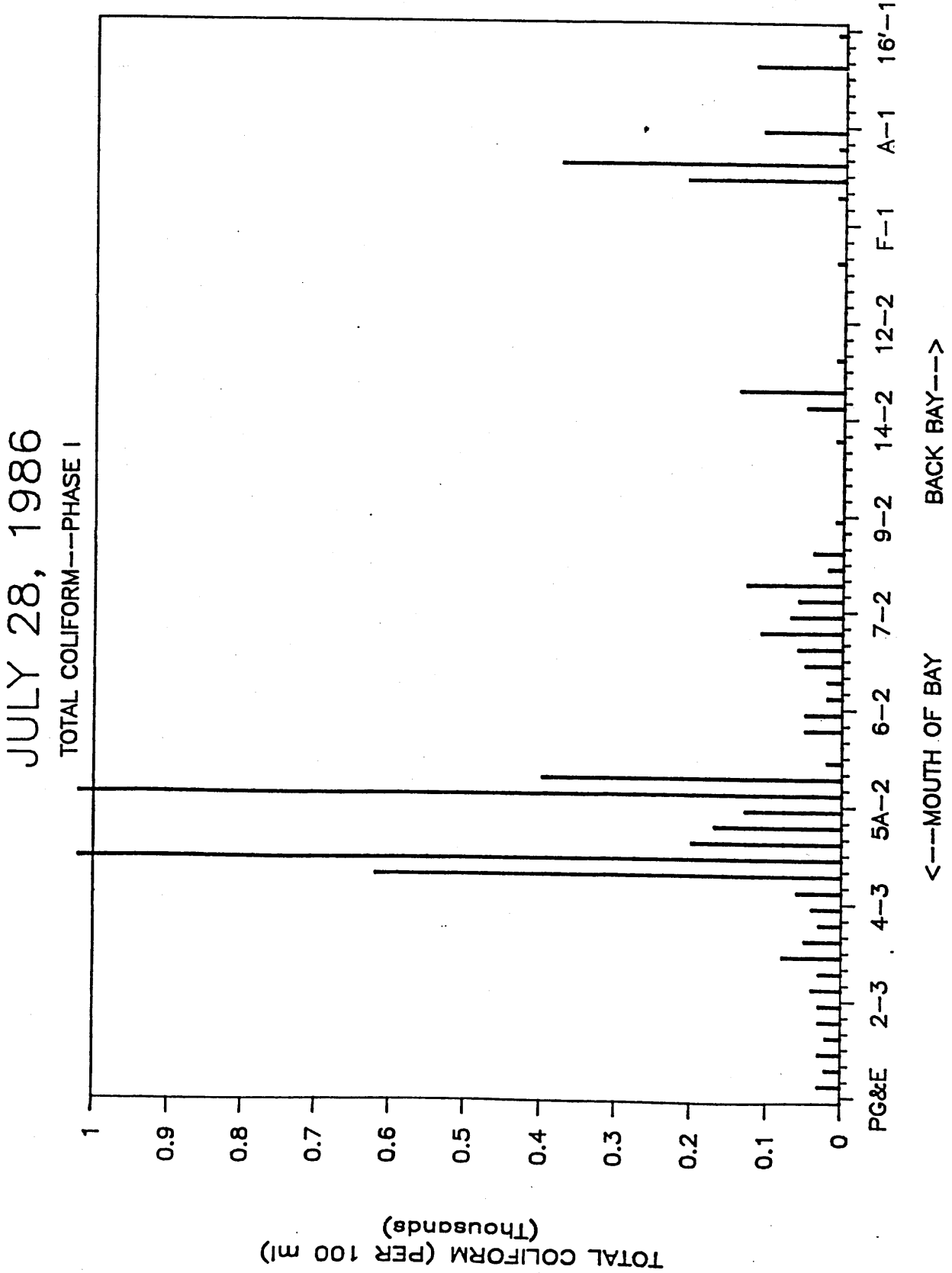
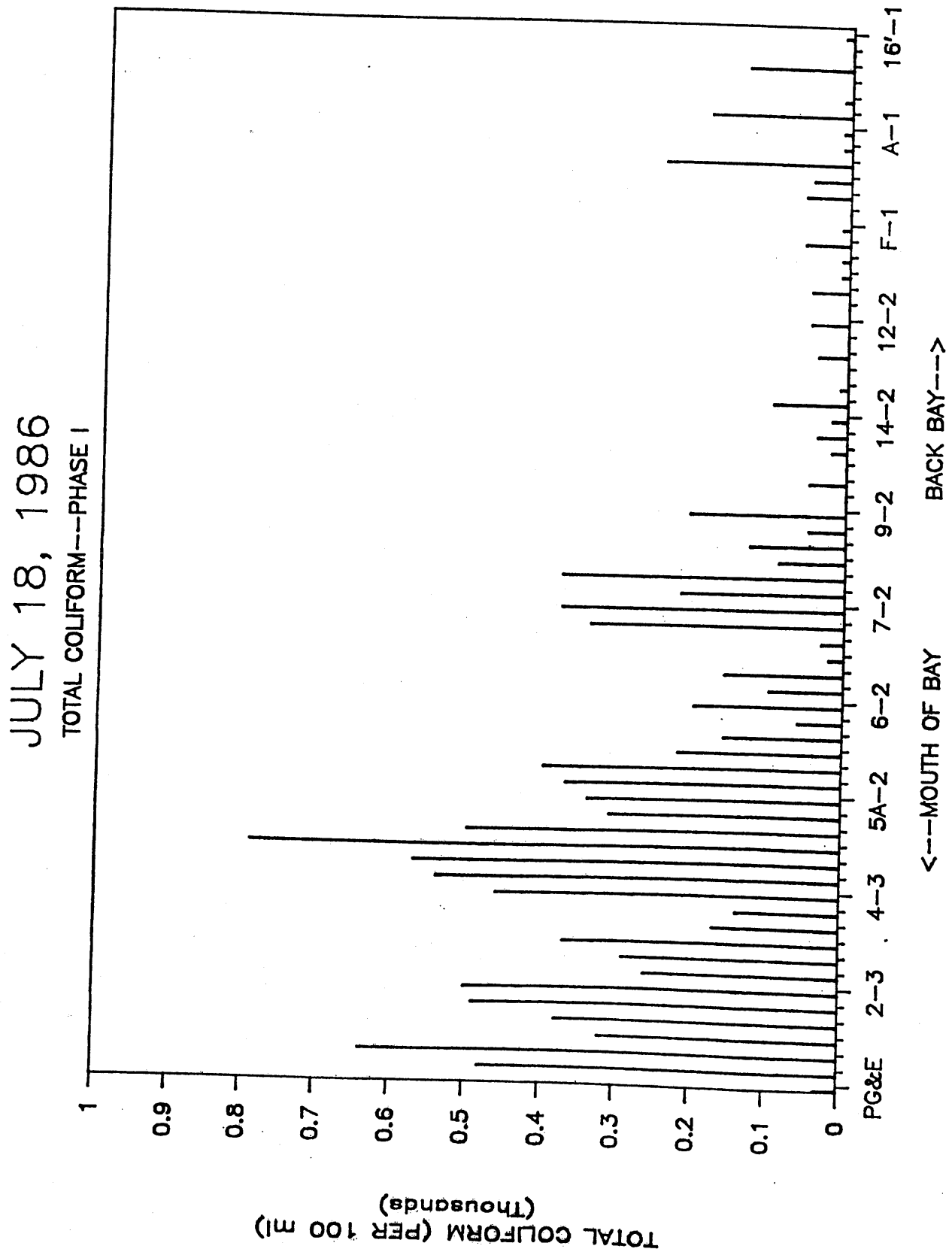

JULY 28, 1986
TOTAL COLIFORM--PHASE I
TOTAL COLIFORM (PER 100 ml)
(Thousands)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
PG&E
2-3
4-3
5A-2
6-2
7-2
9-2
14-2
12-2
F-1
A-1
16'-1
<--MOUTH OF BAY
BACK BAY-->

FIGURE 8


JULY 18, 1986
TOTAL COLIFORM--PHASE I
TOTAL COLIFORM (PER 100 ml)
(Thousands)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
PG&E
2-3
4-3
5A-2
6-2
7-2
9-2
14-2
12-2
F-1
A-1
16'-1
<---MOUTH OF BAY
BACK BAY--->
FIGURE 9

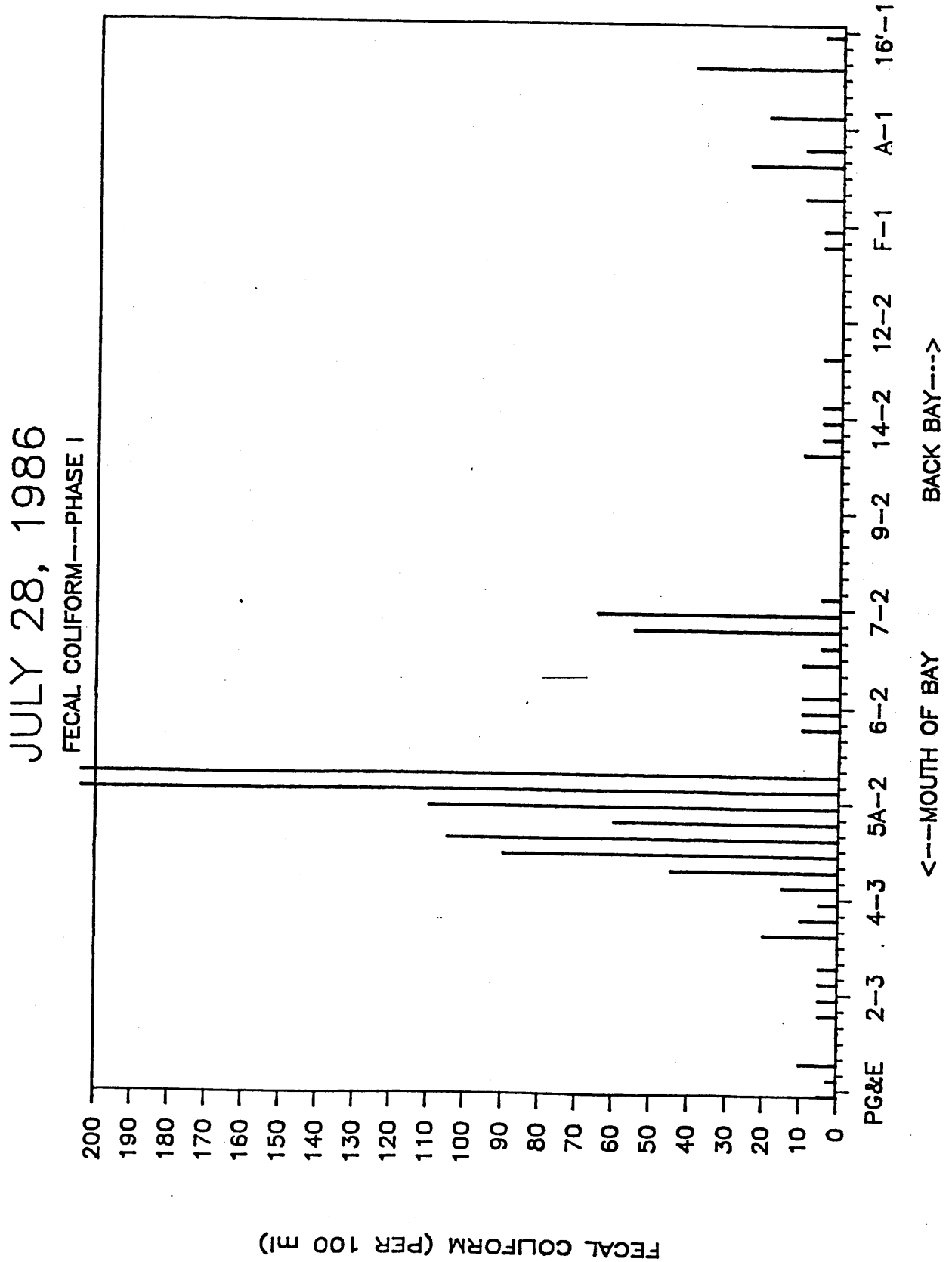

JULY 28, 1986
FECAL COLIFORM---PHASE I
FECAL COLIFORM (PER 100 ml)
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
PG&E
2-3
4-3
5A-2
6-2
7-2
9-2
14-2
12-2
F-1
A-1
16'-1
<---MOUTH OF BAY
BACK BAY--->

FIGURE 10

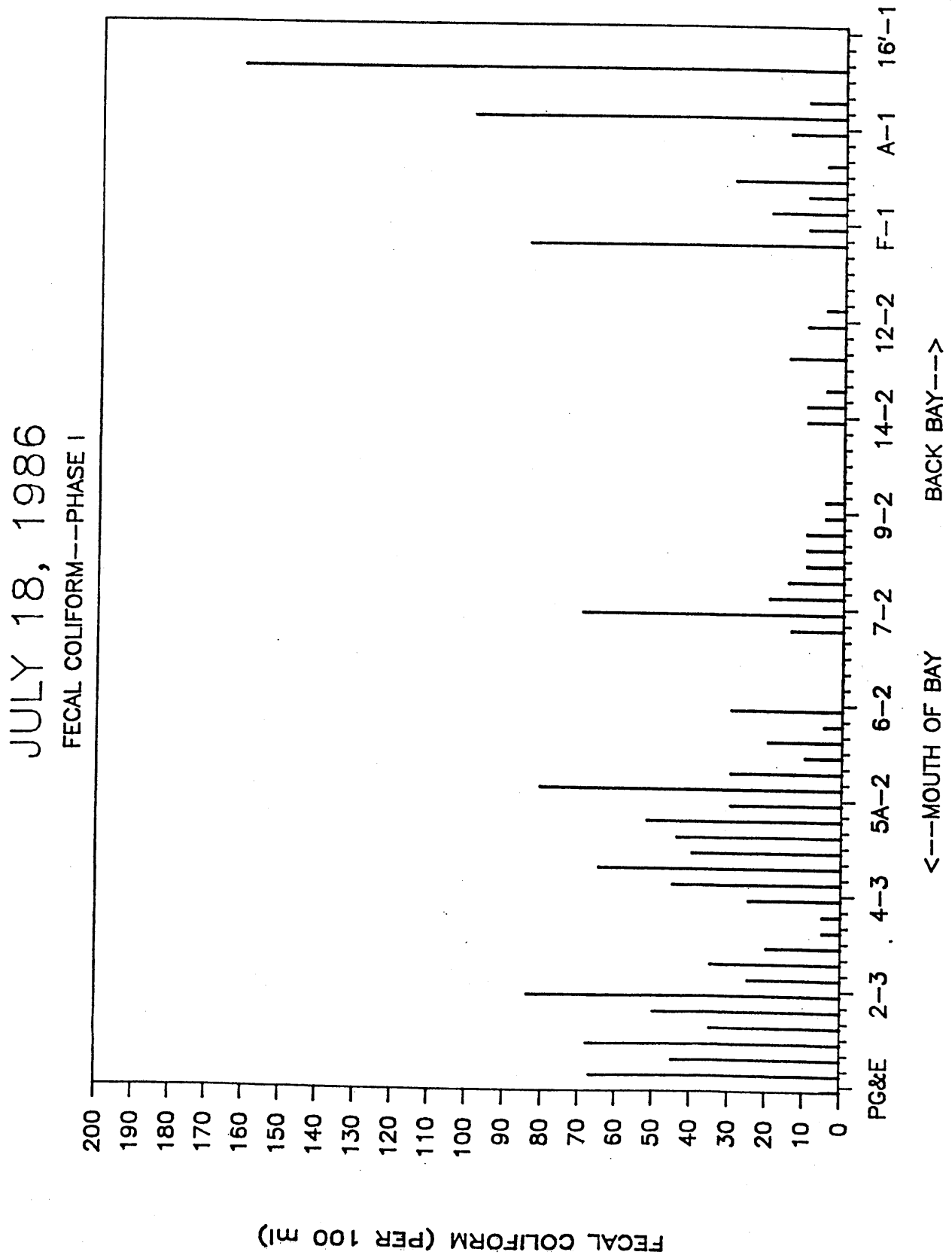

JULY 18, 1986
FECAL COLIFORM--PHASE I
FECAL COLIFORM (PER 100 ml)
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
PG&E
2-3
4-3
5A-2
6-2
7-2
9-2
14-2
12-2
F-1
A-1
16'-1
<--MOUTH OF BAY
BACK BAY-->

FIGURE 11

Currents

Drogue measurements did not begin until Tuesday, July 22nd, well into the first phase, due to a delay in installation. Current data are summarized in Table 6. There were a few days recorded in which Phase I currents were, in fact, southerly. In addition, no chlorination was occurring before August 1st, so there are actually three days where the Bay had the proper conditions to receive contamination from the WWTP. Of specific tidal cycles sampled, two were high tide. The samples were taken twenty-eight to forty-three minutes after the predicted high tide. However, considering the tidal lag recorded within the Bay, the water in the mouth of Morro Bay should contain outfall contamination if, indeed, any reaches the Bay. Therefore, on July 24th and July 30th (with tidal changes of 2.6 and 1.9 feet, respectively) the proper conditions existed to detect whether the WWTP outfall contamination reached the entrance of the Bay.

As the coliform tables show, there is no significant contamination in the mouth of the Bay on either occasion. While these samples provide only two cases for southerly currents they are important to point out since they are the only occasion in the study to evaluate southerly currents' effect before the EPA chlorination order. The source of the major contamination on the July 18th (tidal change of only 1.8 feet) is unknown.

Entrance Channel

With the exception of July 18th, all coliform values, both total and fecal, are reasonably low in the mouth of Morro Bay. All channel stations met shellfish growing water limits, except on July 18th.

Entrance channel stations are generally the cleanest in the bay, especially during incoming tides (see total results for 7/8, 7/10, 7/22, 7/24, and 8/3). Seven days were exceptionally clean at nearly all depth and stations. Five of these seven were sampled at high tide. This trend was repeated in Phase II where only incoming tide samples were collected.

On five of the six days sampled at low tide, minor contamination, in the range of 10-80 total coliform organisms/100 ml of water, is found. It appears that water leaving the bay has a moderately adverse effect on water quality at these stations. This trend is repeated in Phase III sample results. It appears that, <u>in general</u>, clean water enters the bay and lower quality water flows back out at ebb tide. July 18th is the sole exception to this generalization found during the 28 sampling days of this study.

TABLE 6

CURRENT READINGS

DATE	TIME	DIRECTION	WEATHER/OCEAN CONDITION	TIME OF SAMPLE	CURRENT DIRECTION AT SAMPLI
22-Jul-86	08:00	NORTH (10)	VERY CLEAR	12:31	N
	11:00	NORTH-EAST (80)			
24-Jul-86	08:00	SOUTH (190)	CLEAR	13:42	S
	10:00	SOUTH (170)			
26-Jul-86	-	-	-	08:33	?
28-Jul-86	10:00	SOUTH (180)	HEAVY FOG	09:50	S
	15:00	SOUTH (170)			
30-Jul-86	10:00	SOUTH (140)	HEAVY FOG	08:22	S
31-Jul-86	13:10	SOUTH (160)	CALM		
	14:30	NORTH-WEST (280)	-		
01-Aug-86	14:20	SOUTH (140)	CALM	13:53	S
02-Aug-86	14:00	SOUTH-EAST (130)	CALM		
03-Aug-86	11:15	NORTH-EAST (40)	EARLY A.M. FOG, CALM SEA	10:57	N
----------phase break----------					
04-Aug-86	10:00	SOUTH-EAST (120)	EARLY A.M. FOG, CALM SEA		
05-Aug-86	10:00	NORTH (0)	EARLY A.M. FOG, CALM SEA		
	13:00	NORTH (30)			
06-Aug-86	11:00	NORTH (20)	EARLY A.M. FOG, CALM SEA		
07-Aug-86	15:00	SOUTH (170)	EARLY A.M. FOG, CALM SEA		
08-Aug-86	10:00	NORTH (10)	EARLY A.M. FOG, CALM SEA		
09-Aug-86	09:00	SOUTH (180)	EARLY A.M. FOG, CALM SEA		
10-Aug-86	09:00	SOUTH (180)	FOG IN A.M.; CHOPPY IN P.M.		
11-Aug-86	09:00	SOUTH (180)	FOG IN A.M.; CHOPPY IN P.M.		
12-Aug-86	09:00	NORTH (10)	FOG IN A.M.; CHOPPY IN P.M.		
13-Aug-86	11:00	NORTH (10)	FOG IN A.M.; CHOPPY IN P.M.		
14-Aug-86	09:30	NORTH (40)	FOG IN A.M.; CHOPPY IN P.M.		
	15:00	SOUTH (170)			
15-Aug-86	11:15	SOUTH (180)	CALM		
16-Aug-86	08:55	NORTH (10)	CALM		
	11:12	NORTH (10)			
18-Aug-86	09:30	SOUTH (190)	CLEAR AND CALM		
19-Aug-86	09:10	NORTH (350)	CLEAR AND CALM		
21-Aug-86	11:40	SOUTH-EAST (135)	CALM AND OVERCAST	11:30	S
22-Aug-86	13:20	SOUTH (180)	ROUGH OCEAN		
23-Aug-86	12:00	SOUTH (180)	CALM	12:26	S
	13:10	SOUTH (180)			
25-Aug-86	14:00	SOUTH-EAST (150)	FOGGY AND CALM	13:38	S
27-Aug-86	16:15	NORTH-EAST (80)	SLIGHTLY ROUGH	15:40	N
29-Aug-86	-	-	-	08:26	?
01-Sep-86	-	NORTH (10)	MODERATELY ROUGH		
02-Sep-86	-	SOUTH (160)	CALM		
03-Sep-86	-	SOUTH (140)	MODERATELY ROUGH		
04-Sep-86	11:15	SOUTH (180)	CALM		
05-Sep-86	13:10	SOUTH (170)	CALM		
06-Sep-86	11:50	SOUTH (170)	CALM		
07-Sep-86	15:10	SOUTH (170)	-		
08-Sep-86	11:45	SOUTH (170)	MED-ROUGH		
09-Sep-86	12:35	NORTH (30)	1-2 FT. OCEAN SWELL		
10-Sep-86	15:30	SOUTH (160)	CALM	13:58	S
11-Sep-86	14:15	SOUTH (160)	CALM		
12-Sep-86	-	-		16:30	?

Central Coast Seafood, Station 5

In Phase I, this station showed moderately high coliform counts. On the days of high coliform counts, water discharges under the dock were recorded by samplers (July 14, 18, 28, 30, and August 1). Due to these high values, a follow-up investigation of Central Coast Seafood's discharge was conducted.

Morro Bay Aquarium

Station 5B had consistently high coliform counts, both total and fecal, throughout Phase I. Discharges from the aquarium were recorded for every day except for July 20th (on that date Station 5B was "clean"). The results found at this station also prompted a follow-up investigation of the aquarium discharge.

Park Marina

During Phase I of the study, bacterial samples were collected in the State Park Marina on fourteen separate occasions in July and August, 1986. On seven occasions, excessive total bacteria counts were recorded. The counts on Saturday, July 12, and Sunday, August 3, were 460 coliform organisms per/100 ml of water and 1740 per/100 ml, respectively. The standard for shellfish harvesting areas, such as Morro Bay's 70 coliform organisms per/100 ml of water. Also, both of these violations occurred on weekend days. On five other occasions of the fourteen sampling days, the water in the marina equalled or exceeded the shellfish growing standard by lesser amounts.

Sampling at this station was designed to detect a difference between weekend and weekday bacterial levels. More people might be staying on their boats during weekends and possibly more pumping of holding tanks would occur. On Saturday, July 12th and Sunday, August 3rd, the counts were indeed higher, but on Sunday, July 20th, and Saturday, July 26th, the weekend counts were low. Phase I confirms a problem exists but its impact is sporadic.

Oyster Areas

The oyster beds are located near Stations 11 through 14. The results of our water samples indicate almost no bacteriological contamination in these areas (Table 23). Included in Tables 3 and 4 are results from the San Luis Obispo County Health Department's oyster meat samples taken independently during this study at Station 11 or nearby ("misc."). The meat samples are significantly higher than the water, indicating that something other than the growing water is affecting the harvested oysters, that contamination is residual from a previous tidal exchange,

TABLE 23

OYSTER BED WATER RESULTS

SEPTEMBER 1984

WATER:	TC:	MEDIAN <70 MPN/100 ml	:met
		<10% EXCEEDENCE OF 230 MPN/100 ml	:20% of station 11 exceeded 230
	FC:	MEDIAN <14 MPN/100 ml	:met
		<10% EXCEEDENCE OF 43 MPN/100 ml	:20% of station 11 exceeded 230
MEAT:	FC:	MAXIMUM 230 MPN/100 g	:exceeded 7 of 10 samples

JANUARY/FEBRUARY 1985

WATER:	TC:	MEDIAN <70 MPN/100 ml	:met
		<10% EXCEEDENCE OF 230 MPN/100 ml	:met
	FC:	MEDIAN <14 MPN/100 ml	:median is 28--exceeds limit
		<10% EXCEEDENCE OF 43 MPN/100 ml	:met
MEAT:	FC:	MAXIMUM 230 MPN/100 g	:exceeded 10 of 10 samples

that oysters are concentrating bacteria as they filter water through their systems, or a combination of these factors contributes to higher meat coliform. However, since the study was conducted throughout the summer, water and meat samples should be expected to correlate to some degree over time. This issue is discussed in detail in the Qualman Meat Samples portion of "Results from Other Agencies" later in this report.

Creeks

In Phase I, the Los Osos Creek Station, Number 17, had negligible coliform contamination. Chorro Creek at South Bay Boulevard had relatively high coliform counts, with a maximum total coliform of 390 colonies/100 ml, and a maximum fecal coliform of 435 colonies/100 ml. In reviewing previous studies, it was common for Chorro Creek to be dry during these months. However, during this entire Phase, the Creek was definitely flowing to the Bay during both high and low tide sampling. An additional station labeled 16' was added where Chorro Creek joins the Bay. These particular sample results always showed 10 or less than 10 colonies/100 ml.

Staff decided that a better profile of the Creek was necessary to determine the affect of Chorro Creek upon Morro Bay. Station 16 u/s was located upstream of Station 16, on Chorro Creek off of Highway 1 and Canet Road. Station 16 d/s was located between Stations 16 and 16' with access from Country Club Drive, where the Bay water meets with creek water creating slack flow at the Bay/stream interfall (location depends on tide height). Electrical conductivity (EC) tests were taken along the lower part of this Creek (between 16 and 16') to determine where to set this station. Photographs 3 through 6 show portions of this special investigation and three of the stations used on Chorro Creek throughout the two phases of this study. Recognizing that higher conductivities are associated with sea water and lower conductivities with fresh water, Figure 12 shows Station 16 was definitely fresh water, Station 16' was definitely sea water, and various mixes of the two existed in between Station 16 d/s was located between conductivity readings of 1200 and 2200, (as shown in Photograph 5). Photographs of Chorro Creek were taken not only to document the locations of these EC readings but to document algal growth and the visible changes from fresh water vegetation to salt water vegetations.

Not enough samples were taken by the termination of Phase I to completely define Chorro Creek. Consequently, coliform and additional conductivity samples were taken at these creek stations.

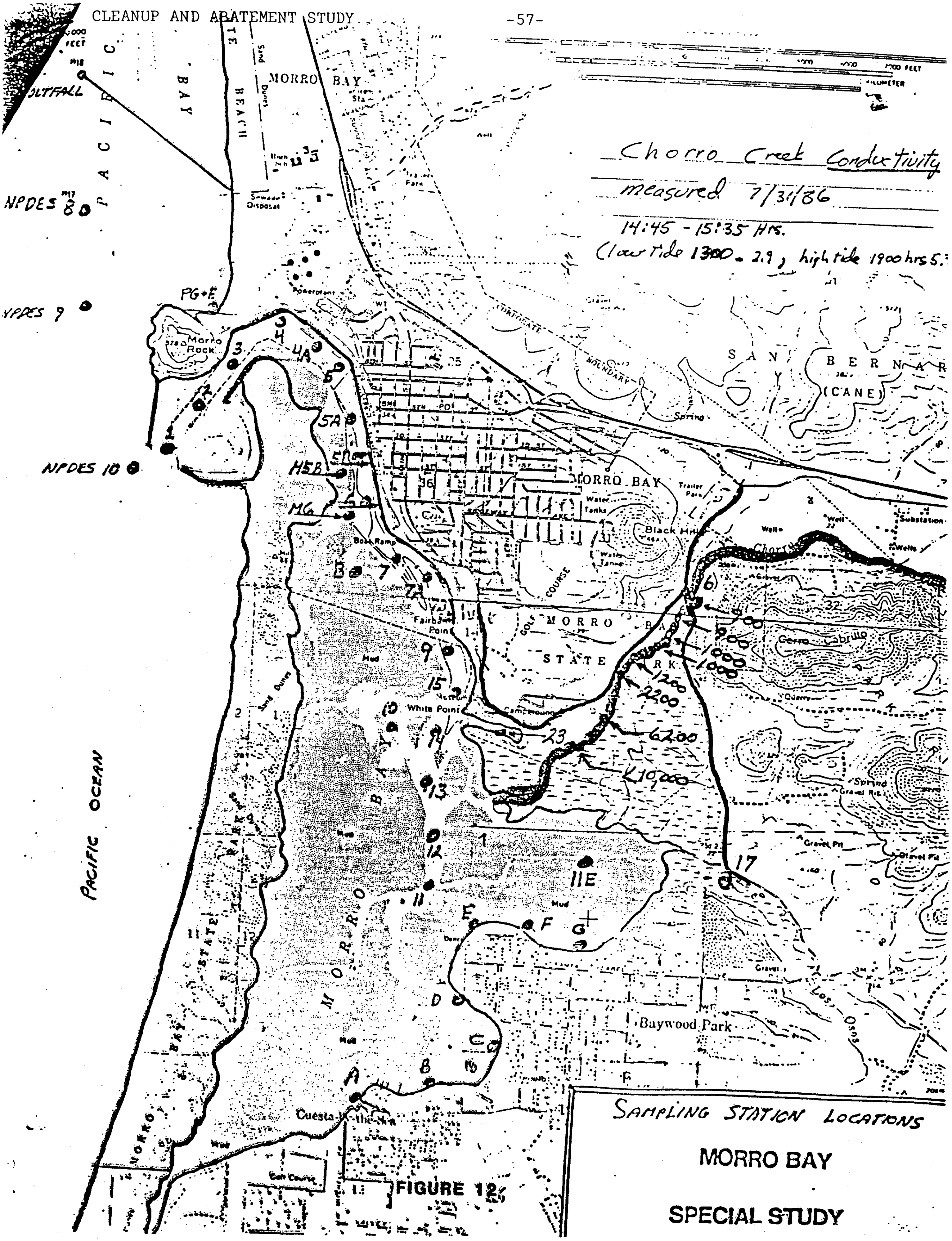

Chorro Creek Conductivity
measured 7/31/86
14:45 - 15:35 Hrs.
(low tide 1300 - 2.9, high tide 1900 hrs 5.
OUTFALL
NPDES 8
NPDES 9
NPDES 10
PG+E
Morro Rock
PACIFIC OCEAN
MORRO BAY
Black Hill
SAN BERNARDO (CANE)
MORRO BAY STATE PARK
Cerro Cabrillo
White Point
Fairbank Point
Boat Ramp
Mud
Sand Dunes
Baywood Park
Cuesta-by-the-Sea
Los Osos
1000
1200
2200
6200
10,000
SAMPLING STATION LOCATIONS
MORRO BAY
SPECIAL STUDY

FIGURE 12

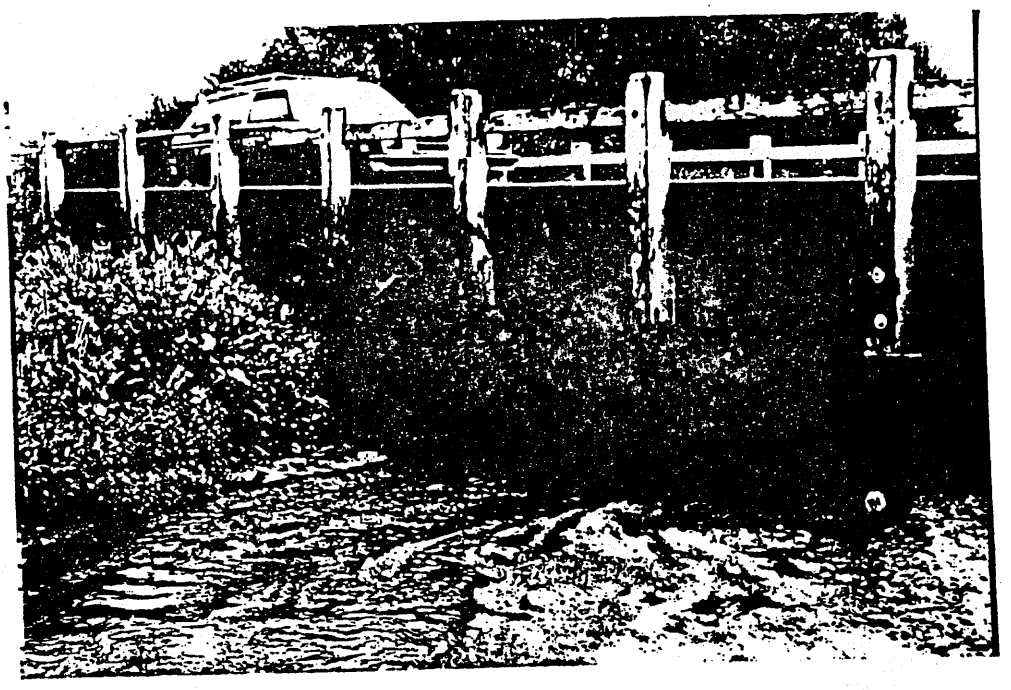


PHOTO 3

PHOTO 4

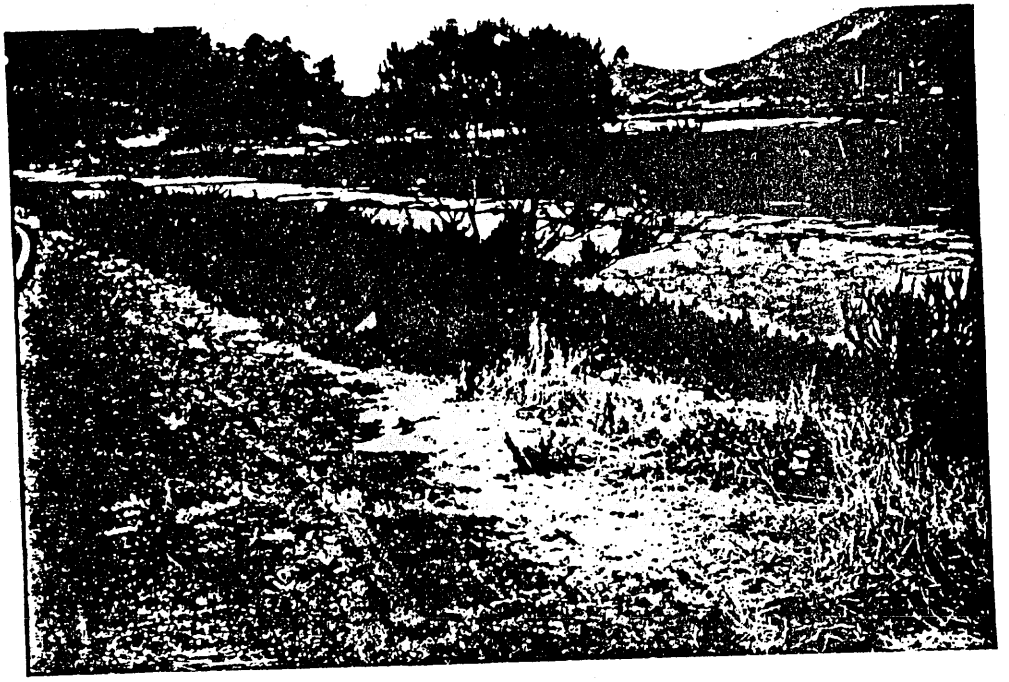


PHOTO 5

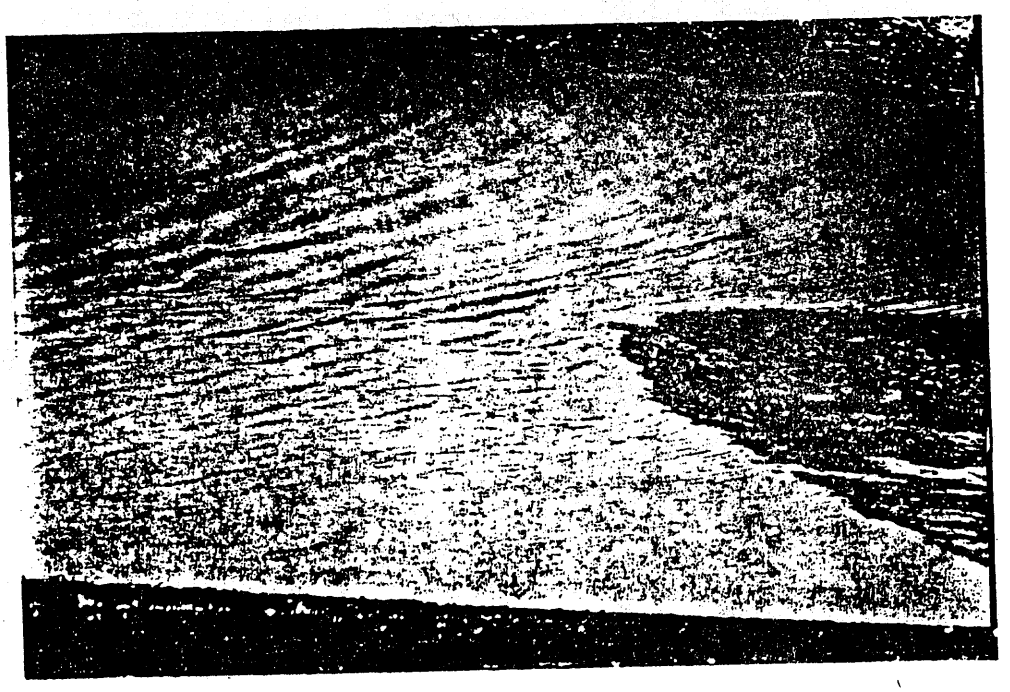


PHOTO 6

Back Bay

Results of the back Bay stations are more complex. No direct discharges were seen. Septic disposal systems and waste from birds and mammals were possible sources of contamination. Stations B, E, and F were clean. Stations A, C, D, and G were routinely contaminated, showing both high total and fecal coliform counts. Stations A and C are both located at drainageways entering the Bay. Stations A' and C' are upstream on these respective drainageways. Station D is located at the Baywood Park Pier and had intermittent contamination problems. Station G also had moderately high coliform counts. (Note: At this site, during low tides, a small stream emanated from the side of the hill).

RESULTS AND DISCUSSION

PHASE II

Sampling results obtained from the second phase are presented in Tables 7, 8 and 9 for total coliform, fecal coliform and fecal streptococcus, respectively. Data presented for each day of sampling include: time sampling began, high tide associated with sampling (occurring approximately one hour after commencement of sampling), current direction, and day and date of sampling. Included for each station is the arithmetic mean, log mean, maximum coliform count, and, for total and fecal coliform, number and percentage of times the shellfish growing limits are exceeded. Graphs of log means of total and fecal coliform results are shown in Figures 13 and 14.

Before discussing individual results, the conditions of this phase should be re-stated: incoming tide, current flow southerly, and WWTP is chlorinating. Thus: (1) water is moving into the Bay quickly, making "pinpointing" of contamination sources difficult; and (2) clean ocean water should be brought into the mouth of the Bay as all samples are at high tide and the WWTP, the only significant source of contamination outside of the Bay, is chlorinating. This sampling was originally to serve as a control to compare to the same southerly currents carrying non-chlorinated water from the WWTP near the entrance to the Bay. Phase II was designed to quantify the quality of water entering the Bay which could be affected by outside sources. Thus, during sampling, the Bay is rapidly filling with ocean water and this is not the best situation for evaluating point sources inside the Bay. Back bay stations are quickly influenced by the inflow of ocean water. The water entering from the ocean proved to be very clean, and diluted point source inputs at Back Bay stations. Since we continued to sample all stations during Phase II, results could be misleading without the this perspective.

Note that sampling had to be cancelled on three days when the Fish and Game boat, used to collect the DOHS samples shown in Table 1, broke down.

Currents

Currents were again variable in Phase II. August 27th had a northerly current; no measurements were received for August 29th nor September 12th (refer again to Table 6). The information is less relevant than intended since the WWTP was chlorinating its effluent throughout this phase.

TABLE 7

Central Coast Region
Water Quality Control Board

TOTAL COLIFORM

<---------- C1 2 ---------->

STATION	THURS 21-Aug 11:30 HIGH(5.0) TOTAL	SAT 23-Aug 12:26 HIGH(5.0) TOTAL	MON 25-Aug 13:38 HIGH(4.8) TOTAL	WED 27-Aug 15:40 HIGH(4.6) TOTAL	FRI 29-Aug 08:26 HIGH(3.6) TOTAL	SUN 31-Aug - HIGH(3.9) TOTAL	TUE 02-Sep - HIGH(4.3) TOTAL	MON 08-Sep - HIGH(5.5) TOTAL	WED 10-Sep 13:58 HIGH(5.3) TOTAL	FRI 12-Sep 16:30 HIGH(5.5) TOTAL	Log Mean	Maximum Count	Number of Samples Exceeding 230	Percent of samples Exceeding 230	Number of Samples Exceeding 70	Percent of samples Exceeding 70
PG&E TOP: PG&E-1	<10	<10	<10	<10	<10				<10	<10	5.0	<10	0	0.0 %	0	0.0 %
CHANNEL ENT. TOP: 1-1	<10	<10	<10	<10	<10	S	S	S	<10	<10	5.0	<10	0	0.0 %	0	0.0 %
CHANNEL ENT. MID: 1-2	10	<10	<10	<10	<10	A	A	A	<10	<10	5.5	10	0	0.0 %	0	0.0 %
CHANNEL ENT. BOT: 1-3	<10	<10	<10	<10	<10	M	M	M	<10	<10	5.0	<10	0	0.0 %	0	0.0 %
CHANNEL TOP: 2-1	<10	<10	<10	<10	<10	P	P	P	<10	<10	5.0	<10	0	0.0 %	0	0.0 %
CHANNEL MID: 2-2	<10	<10	<10	<10	<10	L	L	L	<10	<10	5.5	10	0	0.0 %	0	0.0 %
CHANNEL BOT: 2-3	<10	<10	<10	10	<10	I	I	I	<10	20	7.9	30	0	0.0 %	0	0.0 %
CHANNEL TOP: 3-1	<10	<10	<10	<10	30	N	N	N	<10	<10	5.0	<10	0	0.0 %	0	0.0 %
CHANNEL MID: 3-2	<10	<10	<10	<10	<10	G	G	G	<10	<10	5.0	<10	0	0.0 %	0	0.0 %
CHANNEL BOT: 3-3	<10	<10	<10	<10	<10				<10	<10	5.0	<10	0	0.0 %	0	0.0 %
CHANNEL PG&E TOP: 4-1	<10	<10	<10	<10	<10	C	C	C	<10	<10	5.5	10	0	0.0 %	0	0.0 %
CHANNEL PG&E MID: 4-2	<10	<10	<10	<10	10	A	A	A	<10	10	6.1	10	0	0.0 %	0	0.0 %
CHANNEL PG&E BOT: 4-3	10	<10	<10	<10	<10	N	N	N								
						C	C	C								
STARKIST TOP: 4A-1	10	10	10	<10	<10	E	E	E	<10	<10	6.7	10	0	0.0 %	0	0.0 %
STARKIST MID: 4A-2	30	<10	10	<10	<10	L	L	L	<10	<10	7.1	30	0	0.0 %	0	0.0 %
C.COAST SEAFOOD TOP: 5-1	70	40	340	40	40	L	L	L	30	790	86.5	790	2	28.6 %	2	28.6 %
C.COAST SEAFOOD MID: 5-2	40	60	1110	20	120	E	E	E	10	30	56.8	1110	1	14.3 %	2	28.6 %
QUALMAN'S TOP: 5A-1	130	20	20	<10	70	D	D	D	20	240	36.6	240	1	14.3 %	2	28.6 %
QUALMAN'S MID: 5A-2	60	<10	30	10	50				20	60	24.6	60	0	0.0 %	0	0.0 %
AQUARIUM TOP: 5B-1	1030	<10	10	70	1310				450	230	125.4	1310	3	42.9 %	4	57.1 %
AQUARIUM MID: 5B-2	120	20	40	90	90				590	140	93.9	590	1	14.3 %	5	71.4 %
BOATS OFF 5B TOP: M5B-1	10	<10	10	<10	40				<10	<10	8.2	40	0	0.0 %	0	0.0 %
BOATS OFF 5B MID: M5B-2	<10	<10	<10	10	20				<10	<10	6.7	20	0	0.0 %	0	0.0 %
OLIVE & SOUTH TOP: 6-1	130	30	10	60	60				10	50	35.4	130	0	0.0 %	1	14.3 %
OLIVE & SOUTH MID: 6-2	120	20	10	30	<10				20	100	25.6	120	0	0.0 %	2	28.6 %
BOATS OFF 6 TOP: M6-1	10	<10	<10	<10	<10				10	<10	6.1	10	0	0.0 %	0	0.0 %
BOATS OFF 6 MID: M6-2	10	30	10	<10	20				30	<10	12.4	30	0	0.0 %	0	0.0 %
OYSTER SIGN TOP: 8-1	<10	300	10	10	30				<10	10	15.6	300	1	14.3 %	1	14.3 %
OYSTER SIGN MID: 8-2	10	140	10	<10	40				<10	10	14.6	140	0	0.0 %	1	14.3 %
LAUNCH RAMP TOP: 7-1	80	340	40	20	40				10	40	44.5	340	1	14.3 %	2	28.6 %
LAUNCH RAMP MID: 7-2	60	140	40	20	30				60	<10	34.7	140	0	0.0 %	1	14.3 %
M.B. FUEL DOCK TOP: 7A-1	100	40	30	10	10				50	20	27.5	100	0	0.0 %	1	14.3 %
M.B. FUEL DOCK MID: 7A-2	40	10	20	30	10				20	30	20.3	40	0	0.0 %	0	0.0 %
GOLDEN TEE TOP: 7B-1	40	20	10	40	20				<10	30	19.2	40	0	0.0 %	0	0.0 %
GOLDEN TEE MID: 7B-2	30	30	10	10	<10				10	20	13.7	30	0	0.0 %	0	0.0 %
TRIANGLE 20 TOP: 9-1	<10	<10	<10	<10	20				<10	<10	6.1	20	0	0.0 %	0	0.0 %
TRIANGLE 20 MID: 9-2	<10	<10	10	10	10				<10	<10	6.7	10	0	0.0 %	0	0.0 %
MUSEUM TOP: 15-1	60	<10	10	20	30				<10	<10	12.4	60	0	0.0 %	0	0.0 %
MUSEUM MID: 15-2	30	<10	<10	<10	<10				<10	20	7.9	30	0	0.0 %	0	0.0 %
NEAR 3 PILES TOP: 10-1	<10	<10	10	<10	no samp				<10	10	6.3	10	0	0.0 %	0	0.0 %
NEAR 3 PILES MID: 10-2	10	<10	<10	<10	no samp				<10	<10	1.9	10	0	0.0 %		
CHANNEL/MUSEUM TOP: 14-1	10	<10	<10	10	80				<10	<10	9.1	80	0	0.0 %	1	14.3 %
CHANNEL/MUSEUM MID: 14-2	20	10	10	<10	40				<10	<10	10.0	40	0	0.0 %	0	0.0 %
PARK MARINA TOP: 23-1	90	50	10	10	260				<10	80	33.4	260	1	14.3 %	3	42.9 %
PARK MARINA MID: 23-2	70	190	80	<10	210				10	60	48.9	210	0	0.0 %	3	42.9 %
OYSTER BEDS TOP: 13-1	10	<10	<10	<10	30				<10	20	8.7	30	0	0.0 %	0	0.0 %
OYSTER BEDS MID: 13-2	10	<10	<10	10	50				<10	<10	8.5	50	0	0.0 %	0	0.0 %

TABLE 7 (continued)

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ater Quality Control Board

TOTAL COLIFORM

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STATION	THURS 21-Aug 11:30 HIGH(5.0) TOTAL	SAT 23-Aug 12:26 HIGH(5.0) TOTAL	MON 25-Aug 13:38 HIGH(4.8) TOTAL	WED 27-Aug 15:40 HIGH(4.6) TOTAL	FRI 29-Aug 08:26 HIGH(3.6) TOTAL	SUN 31-Aug - HIGH(3.9) TOTAL	TUE 02-Sep - HIGH(4.3) TOTAL	MON 08-Sep - HIGH(5.5) TOTAL	WED 10-Sep 13:58 HIGH(5.3) TOTAL	FRI 12-Sep 16:30 HIGH(5.5) TOTAL	Log Mean	Maximum Count	Number of Samples Exceeding 230	Percent of samples Exceeding 230	Number of Samples Exceeding 70	Percent of samples Exceeding 70
B.W. PARK PIER TOP: D-1	60	20	10	est 3450	100				190	500	121.6	500	2	28.6 %	4	57.1 %
. OF BRODERSON TOP: C-1	200	80	20	310	110				<10	870	89.9	870	2	28.6 %	5	71.4 %
P CHANNEL OF C TOP:C'-1	300	260	90	780	220				2180	2680	492.6	2680	5	71.4 %	7	100.0 %
VESTA-BY-THE-SEA TOP:B-1	10	10	<10	<10	<10				10	<10	6.7	10	0	0.0 %	0	0.0 %
N. OF PECHO TOP: A-1	10	<10	<10	<10	10				<10	<10	6.1	10	0	0.0 %	0	0.0 %
P CHANNEL OF A TOP:A'-1	<10	10	<10	<10	120				<10	<10	8.7	120	0	0.0 %	1	14.3 %
LOS OSOS CK. TOP: 17-1	<10	20	<10	<10	20				<10	<10	7.4	20	0	0.0 %	0	0.0 %
CANET RD. TOP:16W/S-1	240	370	90	400	250				350	192	245.5	400	5	71.4 %	7	100.0 %
CHORRO CK. TOP: 16-1	310	220	est 190	280	100				130	180	188.6	310	2	28.6 %	7	100.0 %
OWNSTREAM 16 TOP:16D/S-1	10	<10	<10	<10	<10				30	20	8.7	30	0	0.0 %	0	0.0 %
MOUTH OF 16 TOP:16'-1	10	<10	<10	<10	20				<10	<10	6.7	20	0	0.0 %	0	0.0 %

*NOTES: FOR ARITHMETIC MEANS, (a)"<10" ARE FIGURED AT "5"
(b)"tntc" ARE FIGURED AT "3000"
"est" MEANS ESTIMATED
***NOTE: OYSTER MEAT SAMPLES PERFORMED INDEPENDENTLY BY THE COUNTY HEALTH DEPARTMENT

TABLE 8

Central Coast Region
Water Quality Control Board

<------------------------------C1 2-->

STATION	THURS 21-Aug 11:30 HIGH(5.0) FECAL	SAT 23-Aug 12:26 HIGH(5.0) FECAL	MON 25-Aug 13:38 HIGH(4.8) FECAL	WED 27-Aug 15:40 HIGH(4.6) FECAL	FRI 29-Aug 08:26 HIGH(3.6) FECAL	SUN 31-Aug - HIGH(3.9) FECAL	TUE 02-Sep - HIGH(4.3) FECAL	MON 08-Sep - HIGH(5.5) FECAL	WED 10-Sep 13:58 HIGH(5.3) FECAL	FRI 12-Sep 16:30 HIGH(5.5) FECAL	Arithmetic Mean	Log Mean	Maximum Count	Number of Samples Exceeding 43	Percent of samples Exceeding 43	Number of Samples Exceeding 14	Percent of samples Exceeding 14
PG&E TOP: PG&E-1	<5	<5	<5	<5	<5				<5	5	2.9	2.8	5	0	0.0 %	0	0.0 %
CHANNEL ENT. TOP: 1-1	<5	<5	<5	<5	<5	S	S	S	<5	<5	2.5	2.5	<5	0	0.0 %	0	0.0 %
CHANNEL ENT. MID: 1-2	<5	<5	5	<5	10	A	A	A	<5	<5	3.9	3.4	10	0	0.0 %	0	0.0 %
CHANNEL ENT. BOT: 1-3	<5	<5	<5	<5	<5	M	M	M	<5	<5	2.5	2.5	<5	0	0.0 %	0	0.0 %
CHANNEL TOP: 2-1	<5	<5	<5	<5	<5	P	P	P	<5	<5	2.5	2.5	<5	0	0.0 %	0	0.0 %
CHANNEL MID: 2-2	<5	<5	<5	5	5	L	L	L	<5	<5	3.6	3.0	5	0	0.0 %	0	0.0 %
CHANNEL BOT: 2-3	<5	<5	<5	<5	<5	I	I	I	<5	<5	2.5	2.5	<5	0	0.0 %	0	0.0 %
CHANNEL TOP: 3-1	<5	<5	<5	<5	<5	N	N	N	<5	5	2.9	2.8	5	0	0.0 %	0	0.0 %
CHANNEL MID: 3-2	<5	<5	<5	<5	<5	G	G	G	<5	<5	2.5	2.5	<5	0	0.0 %	0	0.0 %
CHANNEL BOT: 3-3	<5	<5	<5	<5	5				<5	<5	2.9	2.8	5	0	0.0 %	0	0.0 %
CHANNEL PG&E TOP: 4-1	<5	<5	<5	<5	<5	C	C	C	<5	<5	2.5	2.5	<5	0	0.0 %	0	0.0 %
CHANNEL PG&E MID: 4-2	<5	<5	<5	<5	<5	A	A	A	<5	5	2.9	2.8	5	0	0.0 %	0	0.0 %
CHANNEL PG&E BOT: 4-3	<5	<5	<5	<5	<5	N	N	N	<5	<5	2.5	2.5	<5	0	0.0 %	0	0.0 %
						C	C	C									
STARKIST TOP: 4A-1	<5	<5	<5	<5	<5	E	E	E	<5	<5	2.5	2.5	<5	0	0.0 %	0	0.0 %
STARKIST MID: 4A-2	5	<5	<5	<5	<5	L	L	L	<5	<5	2.9	2.8	5	0	0.0 %	0	0.0 %
C.COAST SEAFOOD TOP: 5-1	<5	5	10	<5	<5	L	L	L	<5	30	7.9	4.8	30	0	0.0 %	1	14.3 %
C.COAST SEAFOOD MID: 5-2	10	5	<5	<5	5	E	E	E	<5	<5	4.3	3.7	10	0	0.0 %	0	0.0 %
QUALMAN'S TOP: 5A-1	10	5	10	5	5	D	D	D	<5	20	8.2	6.7	20	0	0.0 %	1	14.3 %
QUALMAN'S MID: 5A-2	<5	<5	5	5	10				<5	<5	4.3	3.7	10	0	0.0 %	0	0.0 %
AQUARIUM TOP: 5B-1	400	5	<5	5	612				15	72	158.8	28.8	612	3	42.9 %	4	57.1 %
AQUARIUM MID: 5B-2	15	<5	<5	<5	10				<5	30	9.3	5.6	30	0	0.0 %	2	28.6 %
BOATS OFF 5B TOP: M5B-1	<5	<5	<5	<5	25				<5	<5	5.7	3.5	25	0	0.0 %	1	14.3 %
BOATS OFF 5B MID: M5B-2	<5	<5	<5	5	<5				<5	<5	2.9	2.8	5	0	0.0 %	0	0.0 %
OLIVE & SOUTH TOP: 6-1	15	<5	<5	5	10				15	5	7.9	4.8	15	0	0.0 %	2	28.6 %
OLIVE & SOUTH MID: 6-2	15	5	5	<5	10				5	10	7.5	6.5	15	0	0.0 %	1	14.3 %
BOATS OFF 6 TOP: M6-1	5	<5	<5	<5	<5				<5	5	3.2	3.0	5	0	0.0 %	0	0.0 %
BOATS OFF 6 MID: M6-2	<5	15	<5	<5	<5				<5	<5	4.3	3.7	15	0	0.0 %	1	14.3 %
OYSTER SIGN TOP: 8-1	<5	67	<5	<5	<5				<5	<5	11.7	4.0	67	1	14.3 %	1	14.3 %
OYSTER SIGN MID: 8-2	<5	117	<5	<5	15				<5	<5	20.6	5.6	117	1	14.3 %	2	28.6 %
LAUNCH RAMP TOP: 7-1	50	10	5	5	<5				<5	15	12.9	7.4	50	1	14.3 %	2	28.6 %
LAUNCH RAMP MID: 7-2	80	15	25	10	10				5	<5	21.1	12.1	80	1	14.3 %	3	42.9 %
M.B. FUEL DOCK TOP: 7A-1	10	<5	<5	5	5				<5	10	5.4	4.5	10	0	0.0 %	0	0.0 %
M.B. FUEL DOCK MID: 7A-2	5	5	5	5	<5				<5	5	4.3	3.7	5	0	0.0 %	0	0.0 %
GOLDEN TEE TOP: 7B-1	20	<5	5	5	<5				<5	<5	5.7	3.5	20	0	0.0 %	1	14.3 %
GOLDEN TEE MID: 7B-2	<5	5	10	<5	<5				<5	5	4.3	3.7	10	0	0.0 %	0	0.0 %
TRIANGLE 20 TOP: 9-1	<5	<5	<5	<5	<5				<5	<5	2.5	2.5	<5	0	0.0 %	0	0.0 %
TRIANGLE 20 MID: 9-2	5	<5	<5	<5	10				<5	<5	3.9	3.4	10	0	0.0 %	0	0.0 %
MUSEUM TOP: 15-1	60	5	<5	<5	<5				5	<5	11.4	4.8	60	1	14.3 %	1	14.3 %
MUSEUM MID: 15-2	30	<5	<5	<5	<5				<5	<5	6.4	3.6	30	0	0.0 %	1	14.3 %
NEAR 3 PILES TOP: 10-1	5	<5	<5	<5	no samp				<5	<5	2.9	2.8	5	0	0.0 %	0	0.0 %
NEAR 3 PILES MID: 10-2	5	<5	<5	<5	no samp				<5	<5	2.9	2.8	5	0	0.0 %	0	0.0 %
CHANNEL/MUSEUM TOP:14-1	5	<5	<5	<5	10				<5	<5	3.9	3.4	10	0	0.0 %	0	0.0 %
CHANNEL/MUSEUM MID:14-2	<5	5	<5	<5	5				<5	<5	2.9	2.8	5	0	0.0 %	0	0.0 %
PARK MARINA TOP: 23-1	5	<5	<5	<5	10				<5	5	4.3	3.7	10	0	0.0 %	0	0.0 %
PARK MARINA MID: 23-2	5	5	<5	<5	<5				<5	<5	3.2	3.0	5	0	0.0 %	0	0.0 %
OYSTER BEDS TOP: 13-1	<5	<5	<5	<5	10				<5	<5	3.6	3.0	10	0	0.0 %	0	0.0 %
OYSTER BEDS MID: 13-2	<5	<5	<5	<5	<5				<5	<5	2.5	2.5	<5	0	0.0 %	0	0.0 %

TABLE 8 (continued)

Central Coast Region
Water Quality Control Board

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STATION	THURS 21-Aug 11:30 HIGH(5.0) FECAL	SAT 23-Aug 12:26 HIGH(5.0) FECAL	MON 25-Aug 13:38 HIGH(4.8) FECAL	WED 27-Aug 15:40 HIGH(4.6) FECAL	FRI 29-Aug 08:26 HIGH(3.6) FECAL	SUN 31-Aug - HIGH(3.9) FECAL	TUE 02-Sep - HIGH(4.3) FECAL	MON 08-Sep - HIGH(5.5) FECAL	WED 10-Sep 13:58 HIGH(5.3) FECAL	FRI 12-Sep 16:30 HIGH(5.5) FECAL	Arithmeti Mean	Log Mean	Maximum Count	Number of Samples Exceeding 43	Percent of samples Exceeding 43	Number of Samples Exceeding 14	Percent of samples Exceeding 14
B.W. PARK PIER TOP: D-1	<5	<5	10	est 2250	10				100	252	375.3	32.1	252	3	42.9 %	3	42.9
E. OF BRODERSON TOP: C-1	60	25	<5	108	25				<5	est 160	54.7	23.6	108	3	42.9 %	5	71.4
UP CHANNEL OF C TOP:C'-1	76	103	10	120	5				824	427	223.6	77.3	824	5	71.4 %	5	71.4
CURSTA-BY-THE-SEA TOP:B-1	<5	<5	<5	<5	5				<5	<5	2.5	2.5	5	0	0.0 %	0	0.0
W. OF REGHQ TOP: A-1	5	<5	<5	<5	<5				<5	<5	2.9	2.8	5	0	0.0 %	0	0.0
UP CHANNEL OF A TOP:A'-1	<5	<5	<5	<5	<5				<5	<5	2.5	2.5	<5	0	0.0 %	0	0.0
LOS OSOS CK. TOP: 17-1	5	10	<5	<5	5				5	<5	4.6	4.1	10	0	0.0 %	0	0.0
GANET RD. TOP:16U/S-1	100	68	20	35	36				69	10	48.3	38.2	100	3	42.9 %	6	85.7
CHORRO CK. TOP: 16-1	150	80	155	185	85				103	140	122.6	118.0	185	7	100.0 %	7	100.0
DOWNSTREAM 16 TOP:16Q/S-1	5	10	5	5	5				5	15	7.1	6.5	15	0	0.0 %	1	14.3
MOUTH OF 16 TOP:16'-1	5	5	<5	<5	<5				<5	5	3.6	3.4	5	0	0.0 %	0	0.0

*NOTES: FOR ARITHMETIC MEANS, (a)"<5" ARE FIGURED AT "2.5"
(b)"tntc" ARE FIGURED AT "3000"
"est" MEANS ESTIMATED
***NOTE: OYSTER MEAT SAMPLES PERFORMED INDEPENDENTLY BY THE COUNTY HEALTH DEPARTMENT

Central Coast Region
Water Quality Control Board TABLE 9

STATION	MON 25-Aug 13:38 HIGH(4.8) STREP	MON 25-Aug 13:38 ** f.c./s.c
PG&E TOP: PG&E-1	<2	2.5
CHANNEL ENT. TOP: 1-1	<2	2.5
CHANNEL ENT. MID: 1-2	<2	ERR
CHANNEL ENT. BOT: 1-3	<2	2.5
CHANNEL TOP: 2-1	<2	2.5
CHANNEL MID: 2-2	<2	2.5
CHANNEL BOT: 2-3	<2	2.5
CHANNEL TOP: 3-1	<2	2.5
CHANNEL MID: 3-2	<2	2.5
CHANNEL BOT: 3-3	<2	2.5
CHANNEL PG&E TOP: 4-1	<2	2.5
CHANNEL PG&E MID: 4-2	<2	2.5
CHANNEL PG&E BOT: 4-3	<2	2.5
STARKIST TOP: 4A-1	<2	2.5
STARKIST MID: 4A-2	<2	2.5
C.COAST SEAFOOD TOP: 5-1	6	ERR
C.COAST SEAFOOD MID: 5-2	2	1.3
QUALMAN'S TOP: 5A-1	8	ERR
QUALMAN'S MID: 5A-2	2	ERR
AQUARIUM TOP: 5B-1	6	0.4
AQUARIUM MID: 5B-2	4	0.6
BOATS OFF 5B TOP: M5B-1	<2	2.5
BOATS OFF 5B MID: M5B-2	<2	2.5
OLIVE & SOUTH TOP: 6-1	4	0.6
OLIVE & SOUTH MID: 6-2	<2	ERR
BOATS OFF 6 TOP: M6-1	<2	2.5
BOATS OFF 6 MID: M6-2	<2	2.5
OYSTER SIGN TOP: 8-1	<2	2.5
OYSTER SIGN MID: 8-2	<2	2.5
LAUNCH RAMP TOP: 7-1	2	ERR
LAUNCH RAMP MID: 7-2	<2	ERR
M.B. FUEL DOCK TOP: 7A-1	<2	2.5
M.B. FUEL DOCK MID: 7A-2	<2	ERR
GOLDEN TEE TOP: 7B-1	2	ERR
GOLDEN TEE MID: 7B-2	<2	ERR
TRIANGLE 20 TOP: 9-1	<2	2.5
TRIANGLE 20 MID: 9-2	<2	2.5
MUSEUM TOP: 15-1	<2	2.5
MUSEUM MID: 15-2	<2	2.5
NEAR 3 PILES TOP: 10-1	<2	2.5
NEAR 3 PILES MID: 10-2	<2	2.5

Central Coast Region
Water Quality Control Board

TABLE 9 (continued)

STATION	MON 25-Aug 13:38 HIGH(4.8) STREP	MON 25-Aug 13:38 ** f.c./s.c
CHANNEL/MUSEUM TOP:14-1	2	1.3
CHANNEL/MUSEUM MID:14-2	<2	2.5
PARR MARINA TOP: 23-1	<2	2.5
PARR MARINA MID: 23-2	8	0.3
OYSTER BEDS TOP: 13-1	<2	2.5
OYSTER BEDS MID: 13-2	<2	2.5
LOS OSOS CK. TOP: 17-1	<2	2.5
CANET RD. TOP:16U/S-1	60	ERR
CHORRO CK. TOP: 16-1	20	ERR
DOWNSTREAM 16 TOP:16D/S-1	2	ERR
MOUTH OF 16 TOP:16'-1	<2	2.5

**NOTE: OYSTER MEAT SAMPLES PERFORMED INDEPENDENTLY BY THE COUNTY HEALTH DEPARTMENT

NOTE: FOR CALCULATIONS: (a) "<2" ARE FIGURED AT "1.0" FOR STREP
(b) "<5" ARE FIGURED AT "2.5" FOR FECAL

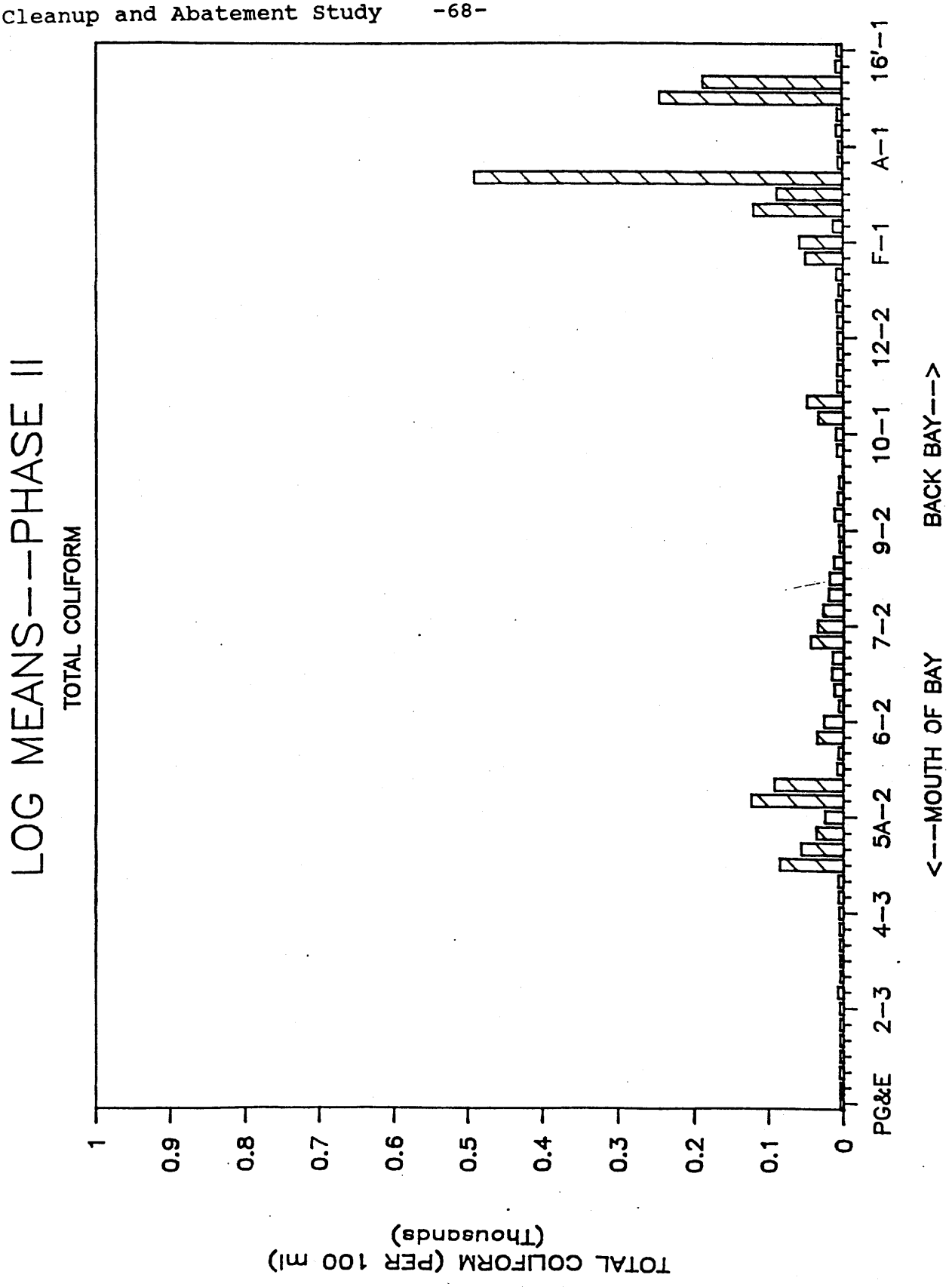

LOG MEANS---PHASE II
TOTAL COLIFORM
TOTAL COLIFORM (PER 100 ml)
(Thousands)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
PG&E
2-3
4-3
5A-2
6-2
7-2
9-2
10-1
12-2
F-1
A-1
16'-1
<--MOUTH OF BAY
BACK BAY-->

FIGURE 13

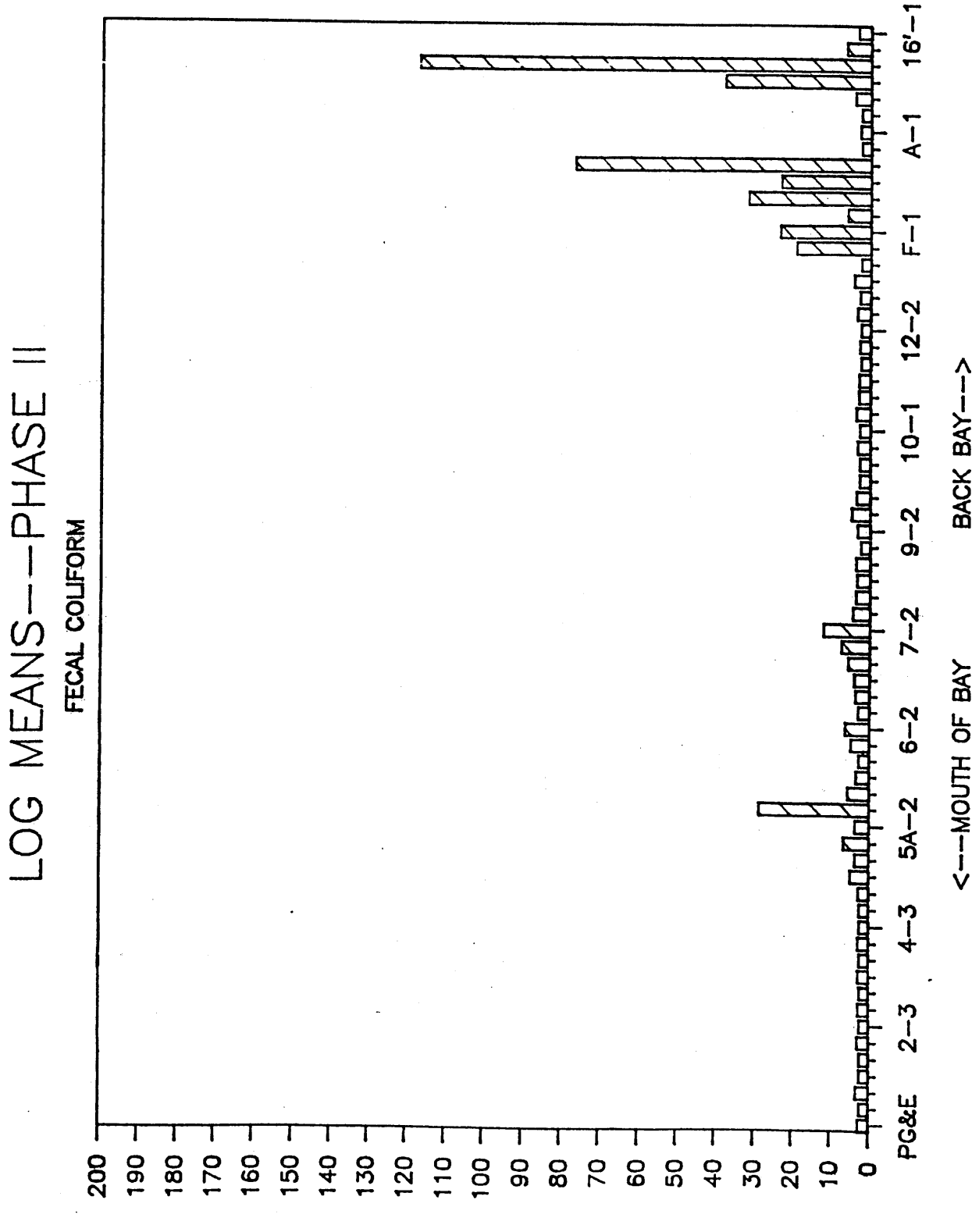

LOG MEANS--PHASE II
FECAL COLIFORM
FECAL COLIFORM (PER 100 ml)
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
PG&E
2-3
4-3
5A-2
6-2
7-2
9-2
10-1
12-2
F-1
A-1
16'-1
<--MOUTH OF BAY
BACK BAY-->

FIGURE 14

Entrance Channel

As expected and as found in Phase I, the values of all of the samples in the mouth of the Bay were generally less than 10: no contamination was found. (Note: All are incoming tides, so ocean water quality rather than bay quality is reflected in the <10 total, <5 fecal results).

Central Coast Sea Food, Station 5

It was unexpected that all of the contaminated stations noted in Phase I were also found contaminated in the rapid moving waters of Phase II. Central Coast Seafood showed a few instances of high counts, especially on August 25th with 1100 colonies/100 ml for middle-depth. Discharges were noted on all days in this phase except August 23rd.

Morro Bay Aquarium

Again, this location proved to be one of the most contaminated stations. Discharge observations were not as well correlated with high values as in Phase I, suggesting that swift flows can move clean water in and out of the sampling area.

Park Marina

During Phase II of this study, conducted under different tidal and current conditions, the Marina exceeded shellfish harvesting standards on five of seven occasions.

Oyster Areas

Stations 11 through 14 remained clean in Phase II. County Health Department oyster meat samples, however, continued to be contaminated. Since only clean water is entering the Bay, it seems reasonable that sources causing the contamination of oysters are located within the Bay. However, the exact source and/or method of contamination is unknown as the oyster bed station water was always clean during this phase. This phenomena is discussed further in "Results from Other Agencies" later in this report.

Creeks

Los Osos Creek, Station 17, was clean throughout this phase. This station can be eliminated from the list of suspected dry weather bacteriological contributors.

Chorro Creek, however, has moderately high coliform counts. Following the Creek to the Bay, note that the highest counts occur inland and disappear by the time the water mixes with the Bay. This is especially evident in the Department of Health Services' monthly studies reviewed later in this report. Looking at Stations 16 u/s and 16, it appears that contamination of the Creek occurs above Canet Road. Table 10 shows results of EC sampling to help differentiate between fresh and bay water throughout the study. Station 16 is freshwater throughout the study with strong downstream flow regardless of tide height. Station 16' is saltwater throughout the study while Station 16D/S is the true mixing zone. Conductivities at 16D/S vary from just above freshwater to nearly seawater depending on tide height and creek flow (see also Figure 13 for more detailed one day survey results).

Back Bay

Even though more birds were found in the back Bay during this phase, there is no direct correlation between birds and bacteria (where birds were recorded, the coliform values were often low). However, as we learn later in the study, high tide sampling, designed to evaluate outside bay sources, is not reliable for looking at subtle in - bay sources due to the huge inflow of clean ocean water into the study area. Stations A and A' look cleaner than in Phase I, with arithmetic averages being less than ten and twenty-two, respectively. Stations B and E had negligible contamination again. Stations C and C' were contaminated consistently in Phase II as in Phase I. The remaining stations, D, F, and G, had some low counts and a few extremely high counts with some correlation to bird and dog presence.

TABLE 10

CHORRO CREEK CONDUCTIVITIES

DATE	16 U/S	16	16 D/S	16'
*********	********	******	********	*******
01-AUG-86	-	800	-	>10000
03-AUG-86	1000	800	4300	>10000
21-AUG-86	1100	900	>10000	>10000
23-AUG-86	4000	1000	4000	>10000
25-AUG-86	1600	1000	7600	>10000
27-AUG-86	1100	1000	2700	>10000
29-AUG-86	1000	1000	2500	>10000
10-SEP-86	2300	900	9000	>10000
12-SEP-86	1200	900	-	-
19-MAR-87	-	1000	1300	-
21-MAR-87	-	1000	1400	-
23-MAR-87	-	1000	2050	-
25-MAR-87	-	950	2150	-
01-APR-87	-	950	3600	-
03-APR-87	-	950	1800	-
06-APR-87	-	950	1250	-

RESULTS AND DISCUSSION

Phase III

Phase III was designed to evaluate the impact of wet weather on bacterial levels in Morro Bay. This portion of the study was originally unfunded as the Cleanup and Abatement Funds allotted funds to Phases I and II only. After Phase IIB was canceled (due to reasons described in detail earlier in this report), the money for seven sampling days was transferred to a short Phase III program. Note that the other phases were fourteen day duration so cancellation of one-half of Phase II only freed funds for seven days of winter work in Phase III.

Sampling procedures for Phase III were identical to Phase I (see Table 2 for number of stations, days and total samples). Samples were collected at the same stations, and depths. By three teams as before, in the two-hour period during slack tide. Three high tides and four low tides were sampled over the period March 19-April 6, 1987. Sampling would have been conducted earlier but the weather did not cooperate. Sampling was finally scheduled for the last period during which wet weather could be expected (note: such delays required two extensions to our sampling and laboratory services agreement to cover the later sampling). Ultimately, some wet weather did occur during the Phase III study (see Phase III Rain table in Appendix D), but no sampling was cancelled or rescheduled (A March 30th sampling run originally scheduled was cancelled by Department of Fish and Game due to lack of personnel. The April 6th sampling was added to compensate for the loss).

Sampling crews encountered strong winds on March 19th, which kept the sampling boat away from shore sources along the Embarcadero. Thus, sampling on this date for these stations may not be representative. The boat crew reported that south of the launch ramp (Station 7) they were able to access the regular station locations.

Rain was encountered by the sampling crews on March 21st, 23rd, and April 3rd which provided ideal conditions for Phase III. These are probably the most representative sampling days of the Phase III work as the rest of the sampling days were clear (3/25, 4/1, and 4/6), and/or windy (3/19). The official rain record for the study period provided by the City of Morro Bay Fire Department is provided in Appendix D.

The results of Phase III sampling are presented in Tables 26 and 27 which are total coliform and fecal coliform results respectively. Results are discussed below in the same format as Phase I and II.

Currents

The tethered drogue used during Phases I and II remained on station until December 12, 1986, at which time it was lost in rough seas. Consequently, no current data is available for Phase III. Current data is less important during Phase III because: (1) the City's wastewater plant has been continuously disinfecting wastewater effluent since August, 1986, and (2) entrance channel stations sampled on incoming tides were clean on all sampling days (refer to Tables 26 and 27). Current data might have been useful to discern any influence from down coast dredge spoil disposal. Note that dredging was occurring during most of Phase III, but results show no apparent influence from the harbor dredging either within the bay of from downcoast disposal.

Entrance Channel

As discussed above, entrance channel stations were generally clean throughout Phase III. Low tide sample result means were slightly higher than high tide means, reflecting the contrast between high quality ocean water entering the bay (see Phase II results) and lower quality water leaving the Bay.

This pattern is most clearly seen in Table 27, fecal coliform results for Phase III. Note that very small amounts of rain (.05 inches and trace) fell on the two low tide days with the largest results.

Central Coast Seafood, Station 5

High total coliform values exceeding shellfish growing criteria were recorded at Station 5, Central Coast Seafood, on March 21, 23, and April 6, 1987 (i.e. three of seven sampling days). See Table 26. Note that small (.05 inches) and trace amounts of rain fell on March 21st and 23rd (reference rain table Appendix D). Interestingly, results at this station and its neighbors are all elevated on these three low tide days, yet completely clean on the three high tide days (this pattern is best demonstrated on Table 27, fecal coliform results). The pattern is the same as noted in the entrance channel stations, only more acutely as the low tide results are larger here than along the Embarcadero.

TABLE 26

MORRO BAY COLIFORM SAMPLING--PHASE THREE 1987 TOTAL COLIFORM

Water Quality Control Board

STATION	THURS HIGH(3.2) 12:35 19-Mar	SAT LOW(0.3) 9:12 21-Mar	MON LOW(-0.4) 12:10 23-Mar	WED LOW(-0.9) 13:42 25-Mar	WED HIGH(3.5) 11:58 03-Apr	FRI HIGH(2.6) 14:42 03-Apr	MON LOW(0.4) 12:54 06-Apr
PG&E TOP:PG&E-1	no samp	16	no samp	18	2	<2	6
CHANNEL ENT. TOP: 1-1	<10	26	8	2	<2	4	4
CHANNEL ENT. MID: 1-1	20	56	22	8	<2	2	<2
CHANNEL ENT. BOT: 1-3	40	54	6	<2	<2	<2	2
CHANNEL TOP: 2-1	120	24	4	4	<2	<2	8
CHANNEL MID: 2-2	10	28	10	2	<2	<2	<2
CHANNEL BOT: 2-3	<10	52	10	12	<2	<2	2
CHANNEL TOP: 3-1	<10	44	36	108	2	2	10
CHANNEL MID: 3-2	<10	38	22	4	<2	4	8
CHANNEL BOT: 3-3	<10	42	16	12	2	<2	18
CHANNEL PG&E TOP: 4-1	10	56	56	16	2	<2	8
CHANNEL PG&E TOP: 4-2	20	40	16	16	<2	6	16
CHANNEL PG&E TOP: 4-3	<10	68	18	8	<2	<2	22
STARKIST TOP: 4A-1	<10	58	536	<10	<2	80	238
STARKIST MID: 4A-2	<10	62	226	<10	<2	16	30
C.COAST SEAFOOD TOP: 5-1	<10	100	40	10	<10	<10	940
C.COAST SEAFOOD MID:5-2	<10	1130	80	10	<10	<10	80
QUALMAN'S TOP: 5A-1	<10	200	70	140	<10	50	50
QUALMAN'S MID: 5A-2	<10	100	150	10	<10	20	60
AQUARIUM TOP: 5B-1	<10	220	2060	100	<10	430	250
AQUARIUM MID: 5B-2	<10	70	570	140	<10	<10	220
BOATS OFF 5B TOP: M5B-1	<10	80	20	<10	<10	<10	10
BOATS OFF 5B MID: M5B-2	<10	90	50	<10	<10	<10	<10
OLIVE & SOUTH TOP: 6-1	<10	90	30	10	<10	<10	<10
OLIVE & SOUTH MID: 6-2	<10	50	<10	<10	<10	30	<10
BOATS OFF 6 TOP: M6-1	<10	54	26	2	<2	<2	2
BOATS OFF 6 MID: M6-2	<10	60	38	<2	<2	<2	2
OYSTER SIGH TOP: 8-1	<10	16	28	60	<2	6	2
OYSTER SIGH MID: 8-2	<10	48	40	4	<2	<2	10
LAUNCH RAMP TOP: 7-1	10	70	32	8	36	28	<2
LAUNCH RAMP MID: 7-2	<10	66	26	100	96	34	208
M.B. FUEL DOCK TOP: 7A-1	<10	58	12	14	44	2	<2
M.B. FUEL DOCK MID: 7A-2	10	50	44	8	26	8	2
GOLDEN TEE TOP: 7B-1	<10	32	18	2	6	24	<2
GOLDEN TEE MID: 7B-2	<10	34	18	14	4	16	4
TRIANGLE 20 TOP: 9-1	<10	72	30	6	<2	6	4
TRIANGLE 20 MID: 9-2	<10	76	46	2	<2	2	6
MUSEUM TOP: 15-1	<10	84	<2	<2	<2	2	2
MUSEUM MID: 15-2	<10	40	12	<2	<2	4	2
NEAR 3 PILES TOP: 10-1	10	78	2	<2	<2	<2	<2
NEAR 3 PILES MID: 10-2	<10	102	10	2	<2	6	<2

TABLE 26 (continued)

MORRO BAY COLIFORM SAMPLING--PHASE THREE 1987 TOTAL COLIFORM

STATION	THURS HIGH(3.2) 12:35 19-Mar #######	SAT LOW(0.3) 9:12 21-Mar #######	MON LOW(-0.4) 12:10 23-Mar #######	WED LOW(-0.9) 13:42 25-Mar #######	WED HIGH(3.5) 11:58 03-Apr #######	FRI HIGH(2.6) 14:42 03-Apr #######	MON LOW(0.4) 12:54 06-Apr #######
CHANNEL/MUSEUM TOP: 14-1	<10	50	4	2	2	6	4
CHANNEL/MUSEUM MID: 14-2	<10	78	10	6	<2	4	<2
PARK MARINA TOP: 23-1	<10	250	10	<10	<2	10	<2
PARK MARINA MID: 23-2	10	24	<10	10	80	10	<20
UP CHANNEL OF C TOP:C'-1	120	1080	70	90	60	190	10
CUESTA-BY-THE-SEA TOP: B-1	30	760	no samp	no samp	10	40	10
W. OF PECHO TOP: A-1	<20	3360	720	60	<10	2880	<100
UP CHANNEL OF A TOP:A'-1	1100	2580	3200	540	80	>4000	1660
LOS OSOS CK. TOP: 17-1	40	490	70	40	10	60	<10
CANET RD. TOP:16U/S-1	490	1320	430	240	310	570	700
CHORRO CK. TOP: 16-1	125	480	250	190	310	360	420
DOWNSTREAM 16 TOP:16D/S-1	80	450	30	50	40	220	30

TABLE 27

MORRO BAY COLIFORM SAMPLING--PHASE THREE 1987 FECAL COLIFORM

Water Quality Control Board

STATION	THURS HIGH(3.2) 12:35 19-Mar	SAT LOW(0.3) 9:12 21-Mar	MON LOW(-0.4) 12:10 23-Mar	WED LOW(-0.9) 13:42 25-Mar	WED HIGH(3.5) 11:58 03-Apr	FRI HIGH(2.6) 14:42 03-Apr	MON LOW(0.4) 12:54 06-Apr
PG&E TOP:PG&E-1	no samp	2	no samp	<2	<2	2	<2
CHANNEL ENT. TOP: 1-1	<5	8	4	<2	<2	<2	<2
CHANNEL ENT. MID: 1-1	<5	25	6	<2	<2	<2	<2
CHANNEL ENT. BOT: 1-3	<5	30	2	<2	<2	<2	<2
CHANNEL TOP: 2-1	<5	4	2	2	<2	<2	<2
CHANNEL MID: 2-2	<5	6	8	<2	<2	<2	<2
CHANNEL BOT: 2-3	<5	8	2	2	<2	<2	<2
CHANNEL TOP: 3-1	<5	32	14	16	<2	<2	<2
CHANNEL MID: 3-2	<5	14	12	4	<2	<2	<2
CHANNEL BOT: 3-3	<5	22	12	<2	<2	<2	4
CHANNEL PG&E TOP: 4-1	<5	32	31	<2	<2	<2	2
CHANNEL PG&E TOP: 4-2	<5	28	20	4	<2	<2	8
CHANNEL PG&E TOP: 4-3	<5	18	20	<2	<2	<2	4
STARKIST TOP: 4A-1	<5	22	38	<2	<2	2	5
STARKIST MID: 4A-2	<5	18	34	<5	<2	2	<5
C.COAST SEAFOOD TOP: 5-1	<5	36	15	<5	<5	5	241
C.COAST SEAFOOD MID:5-2	<5	14	25	<5	<5	<5	49
QUALMAN'S TOP: 5A-1	5	25	25	<5	<5	<5	10
QUALMAN'S MID: 5A-2	5	16	52	<5	<5	<5	20
AQUARIUM TOP: 5B-1	<5	58	990	60	5	310	160
AQUARIUM MID: 5B-2	<5	36	459	45	<5	5	180
BOATS OFF 5B TOP: M5B-1	<5	18	30	5	<5	<5	5
BOATS OFF 5B MID: M5B-2	<5	58	10	5	<5	<5	<5
OLIVE & SOUTH TOP: 6-1	<5	40	23	<5	5	<5	<5
OLIVE & SOUTH MID: 6-2	<5	49	9	<5	<5	<5	5
BOATS OFF 6 TOP: M6-1	<5	38	31	<2	<2	<2	4
BOATS OFF 6 MID: M6-2	<5	29	23	<2	<2	2	<2
OYSTER SIGH TOP: 8-1	<5	9	29	46	<2	<2	<2
OYSTER SIGH MID: 8-2	<5	20	20	2	<2	<2	<2
LAUNCH RAMP TOP: 7-1	<5	36	23	2	16	<2	<2
LAUNCH RAMP MID: 7-2	5	23	20	2	80	2	4
M.B. FUEL DOCK TOP: 7A-1	<5	38	22	<2	38	<2	<5
M.B. FUEL DOCK MID: 7A-2	<5	50	29	2	46	<2	<2
GOLDEN TEE TOP: 7B-1	<5	23	5	6	4	2	<2
GOLDEN TEE MID: 7B-2	<5	25	5	2	<2	2	<2
TRIANGLE 20 TOP: 9-1	<5	72	20	8	<2	2	<2
TRIANGLE 20 MID: 9-2	<5	65	25	<2	<2	<2	<2
MUSEUM TOP: 15-1	<5	84	<2	<2	<2	4	<2
MUSEUM MID: 15-2	<5	27	2	<2	<2	<2	<2
NEAR 3 PILES TOP: 10-1	<5	76	2	<2	<2	<2	<2
NEAR 3 PILES MID: 10-2	<5	76	<2	6	<2	<2	2

TABLE 27 (continued)

MORRO BAY COLIFORM SAMPLING--PHASE THREE 1987 FECAL COLIFORM

STATION	THURS HIGH(3.2) 12:35 19-Mar	SAT LOW(0.3) 9:12 21-Mar	MON LOW(-0.4) 12:10 23-Mar	WED LOW(-0.9) 13:42 25-Mar	WED HIGH(3.5) 11:58 03-Apr	FRI HIGH(2.6) 14:42 03-Apr	MON LOW(0.4) 12:54 06-Apr
EAST BAY TOP: 11E-1	<5	68	5	10	<2	2	<2
EAST BAY MID: 11E-2	5	41	4	2	<2	4	<2
END OF 7TH TOP: G-1	<5	<10	no samp	140	<5	<5	<100
END OF 2ND TOP: F-1	<5	10	99	<10	5	5	<10
COASTAL ACCESS TOP: E-1	<5	no samp	no samp	no samp	<5	<5	10
B.W. PARK PIER TOP: D-1	25	810	126	1090	5	900	100
E. OF BROADBERSON TOP: C-1	240	297	45	20	<5	25	200
UP CHANNEL OF C TOP:C'-1	120	387	13	20	<5	5	<5
CURSTA-BY-THE-SEA TOP: B-1	30	432	no samp	20	15	45	5
W. OF PECHO TOP: A-1	<20	1143	54	no samp	<5	680	<100
UP CHANNEL OF A TOP:A'-1	1100	1156	747	40	<10	1232	160
LOS OSOS CK. TOP: 17-1	40	229	22	5	5	40	15
CANET RD. TOP:16U/S-1	490	148	13	30	20	30	49
CHORRO CK. TOP: 16-1	126	121	13	5	<5	<5	<5
DOWNSTREAM 16 TOP:16D/S-1	80	54	9	10	<5	5	5

While the small amounts of rain may have affected the two March results, April 6th was dry and clear. It appears that results correlate best with the tide cycle. Rain runoff likely contributes to bacterial levels, but is only one of several sources within the Bay.

Morro Bay Aquarium

Station 5B, Morro Bay Aquarium, recorded the highest results along the Embarcadero on all low tide days and even on one of the high tide samples. This station consistently violates shellfish growing standards on both rainy and clear days, high and low tides. Phase I results at this station were even more conclusive and prompted the follow-up sampling and actions described in the subsequent section "Follow-up Sampling" beginning on page 84.

Park Marina

Marina Station 23 samples exceeded shellfish growing criteria on two of seven days sampled. The two high results were on different days, different tides and at different depths (one surface, one mid-depth). Also, one was after a minor rain (.05 inches), the other on a clear day and one on a weekend, one mid-week. Apparently, water quality in the enclosed marina basin varies independently of the variables discussed above, and may be related to holding tank dumping from the resident live aboard community.

There are ten full-time residence-boats in the Marina. The Marina lacks both shower facilities and a pump-out station. Thus, residents report that their tanks fill rapidly from on board showers and there is little practical alternative to a discharge. (Note that since the residents are generally employed and gone during the day, evening or night sampling would probably have better evaluated this source). Since Phase III sampling was completed, the State Park has authorized boaters to use a shower in an adjacent campground. This should lessen the load on holding tanks; however, a permanent solution will require sewer hookups for each boat-residence, or at least a pump-out station in the Marina. The Regional Board is corresponding with the State Park on this issue.

Oyster Areas

Oyster growing areas, Stations 11-14, like the entrance channel and Embarcadero areas, are clean on high tides. On the two rainy day low tides, oyster area results are approaching or exceeding shellfish harvesting standards. Values on these days are very similar throughout the oyster stations, the mid-channel and mid-bay areas. Note that samples from March 21st recorded the

highest values following a one-half inch rain on March 20th. It is clear that on rainy day low tides, the mid-bay and oyster areas are impacted. For this reason, State Health Services prohibits oyster harvesting for five days. Oyster areas and mid-bay are clean on the other two low tides and on the three high tides.

Qualman oysters were sampled by Department of Health Services' monthly during spring, 1987, but only one sample, taken March 24, 1987, was collected during the Phase III sampling (March 24th results: 330 total MPN/100 gr, 230 fecal MPN/100 gr, 130 SOC/gr). The fecal coliform result for March 24th of 230/100 ml is at the State limit for harvesting oysters for human consumption. Our water samples for the previous days (March 21st and 23rd) were approaching or barely exceeding the shellfish growing water limit as described in the paragraph above. It appears that in this case, water quality results were effective in predicting marginal oyster meat results. It is obvious from the data that high tide samples would not have been indicative of the oysters exposure to poor water quality, and would not have been useful in predicting the marginal March 24th meat coliform results.

Creeks

As in Phases I and II, Los Osos Creek (Station 17) was generally clean in Phase III with the exception of rainy days. During light rains (March 23, April 3) total coliform values rose to 70 and 60 MPN/100 ml respectively. After the 0.5 inch rain on March 20th (Appendix D), Los Osos Creek total coliform results the following day rose to 490/100 ml. Otherwise, Los Osos Creek is consistently clean throughout all three study phases, a remarkable finding considering that water fowl were often noted at Station 17 and the water was often murky and/or discolored.

By contrast, Chorro Creek was consistent polluted during all phases of the study. Water flow at Station 16 was very uniform at five to ten cubic feet per second (cfs) on every sampling day. Total coliform averaged 200-300 MPN/100 ml throughout the study, with fecal results about 100 MPN. Rains during Phase III had little impact on the uniform Chorro Creek pattern of results (an increase to 400 total/100 ml was noted on the day after the 0.5 inches rain; however, even this is barely double the 200-300/100 ml average). Samples upstream at Canet Road are consistently higher than Station 16 throughout Phase III.

It appears that Chorro Creek is subject to a very constant input of bacteria in both wet and dry weather, probably year-round. Note again, this is in direct contrast to Los Osos Creek where the only problems are directly related to rain runoff. Since the creek flow and bacterial content of Chorro Creek were constant over the study period, it is easy to calculate the potential for impact. Assuming a flow of five cfs, the input to the bay is just under one million gallons (MG) of water (at 200-300 MPN total/100 ml) per six hour tide. Considering this discharge is into the back/east bay area, the impact on nearby oyster beds might be very significant at low tides, with less dilution available.

The source of bacterial pollution must be determined. The most obvious upstream discharge to the Creek is the one MGD California Men's Colony (CMC) effluent. However, a review of their 1986 annual report reveals an average effluent bacterial quality of <2 MPN/100 ml throughout 1986. In contrast, Department of Health Services monthly surveys in 1985, and 1987, occasionally found much higher values in plant effluent. (DOHS did not record CMC effluent results during 1986). As part of a more detailed survey, (1) the possibility for coliform regrowth from this discharge must be addressed, and (2) changes in plant operations and/or discharge quality must be related to any unusual variations in downstream bacterial levels over an extended study period. For example, <u>fecal</u> coliform levels which had remained constant at about 100 MPN/100 ml throughout the study, began decreasing on March 23rd and rapidly leveled off at <5 for the remainder of Phase III. (Note the constant <u>total</u> coliform levels remained unchanged throughout this period). If the reason was known for this sudden change in fecal levels, pollution sources and their interrelationships in this watershed would be better understood.

Many other potential sources exist along the creek and its tributaries, including dairies (already under RWQCB surveillance), direct cattle access to the creek (a land use problem), residual septic systems, agricultural runoff, and overflows/ illegal discharges. An example of the latter is the two illegal discharges currently under enforcement action found on CMC property by RWQCB surveillance staff on April 11, 1987. A detailed bacterial survey of the drainage is needed to locate additional sources.

Back Bay

Without question, the back bay samples yielded the highest results in Phase III. Twelve of the fifteen Phase III samples exceeding 1000 MPN/100 ml total coliform were back bay shoreline stations (Note that 1000 MPN/100 ml is the State's body contact

standard for total coliform bacteria). Thus, 80% of the body contact violations occurred along the Baywood/Cuesta By the Sea shoreline. Back Bay shoreline water samples collected in Phase III violated the shellfish harvesting of >0 MPN/100 ml total coliform 31 of 57 times (54%).

The Back Bay stations fall loosely into two groups as in Phase I: (1) a cleaner group (Stations B, E, F, and G), which are clean during high tides and moderately polluted during low tides; and (2) a polluted group, which exceeds standards by wide margins on high or low tides (Stations A, A', C, C', and D). Stations A' and D are the worst, exceeding 1000 total coliform/100 ml on five of seven and four of seven sampling runs respectively. Rain runoff on March 21st, 23rd, and April 3rd may have contributed to high results at Stations A, A', C, C' but it is difficult to discern any rain related pattern at other backbay stations. Both Stations A' and C' are minor tributaries to the bay, so rain runoff may be most localized at these tributaries (Stations A' and C') and their adjacent bay Stations A and C. The source of such polluted land runoff/seepage at Stations A' and C' should be investigated.

One major problem with the back Bay results is the number of missing samples. Seven samples, during low tides on March 21st, 23rd, 25th, were not collected because the sampling person could not reach the water. At low tide, the bay recedes hundreds of yards from shore and the intervening mud resembles quicksand and is impossible to cross on foot. The lack of these samples at Stations B, E and G makes comparison of these stations impossible on low tide days. To remedy this loss, isolated puddles which remain on the mudflats at these stations were sampled on the final sampling day, April 6, 1987. These data are dubious, as hundreds of birds inhabit the low tide mudflats and frequent the puddles. Most likely these data overstate the impact of birds on bay waters due to the concentrations (i.e. high bird: water ratio). Also, this technique could artificially exaggerate the trend towards polluted low tides vs clean high tides already evident in the data. Future studies should develop a way to collect representative shoreline samples at low tide.

During shoreline surveys, observations of bird presence/activity were recorded at each station. Stations C and D are generally occupied by hundreds of birds: gulls, ducks (also shorebirds at low tide). At low tide the birds congregate near the puddles as described above. Bird droppings, feathers, and bird tracks cover the area near mudflat puddles at low tide. Station B, the Cuesta by the Sea inlet, is home to about fifty ducks at low tide, probably because plenty of water remains in the inlet even during low tides. The remaining stations (A, E, F, and G) are frequented by shorebirds and gulls/ducks, but in lesser numbers

than Stations C and D (of course this observation applies only to the short period studies). It seems logical to assume that distributions may change due to seasons, weather and tides. Also, since Morro Bay is a bird sanctuary with attractive mudflats, large numbers of birds will probably always be present.

RESULTS AND DISCUSSION

FOLLOW-UP SAMPLING

Because of elevated bacterial results and observed discharges noted in Phases I and II of the study, supplemental sampling was performed in general locations: (1) Abalone Farm, (2) Central Coast Seafood, (3) Morro Bay Aquarium, (4) Station C, and (5) Qualman's processing. The results are presented as each station is discussed below:

Abalone Farm

Located between Morro Bay Aquarium and Central Coast Sea Food is an abalone hatchery owned by Abalone Unlimited. The temporary facility grows young abalone to be reared at the large Abalone Unlimited plant near Guadalupe. The hatchery was noted discharging into the Bay by field crews. Samples taken of the three hatchery discharges were found to be low in coliform contamination (see Table 11). Since all piping on the site was new, and visible above ground, and sampling results were low as would be expected, no further investigation of this site was conducted.

Central Coast Sea Food

On first inspection, field crews noted discharges under the dock at this location. Two wall pipes and one overhead pipe were found discharging into the Bay. A third wall pipe was also found and could be a part-time contributor. Photograph 7 is a photograph of these drains. "Wall #1" is the pipe closest to the south access under the dock. Emanating from the wall on the right of the frame, it never discharged on any of the days sampled. Further back is "Wall #2" and "Wall #3". A very distinct odor of fish processing sludge and a swarm of flies accompanied Walls #2 and #3 pipes. On several occasions, the water dripping from wall #3 was a deep red.

Photograph 2 shows the obviously dirty water sampled on September 17, 1986. In the center of the frame is the pipe named "overhead." It is simply a drain (hole) from the floor above where water drains from the fish processing area of Central Coast Sea Food Company. At times, the flow rate was high, at other times, just a trickle, but water was always leaving the drain and entering the Bay. On September 17th, a sample was taken when the flow rate was low. Then as the other wall stations were being sampled, the flow rate increased, so another sample was taken. The results shown in Table 12 were essentially the same. Early

TABLE 11

ABALONE FARM DISCHARGE

8-26-86
?

		TOTAL	FECAL	STREP
ABALONE FARM:	1:	70	<5	N.A.
	2:	20	<5	N.A.
	3:	50	5	N.A.

(membrane filter technique)

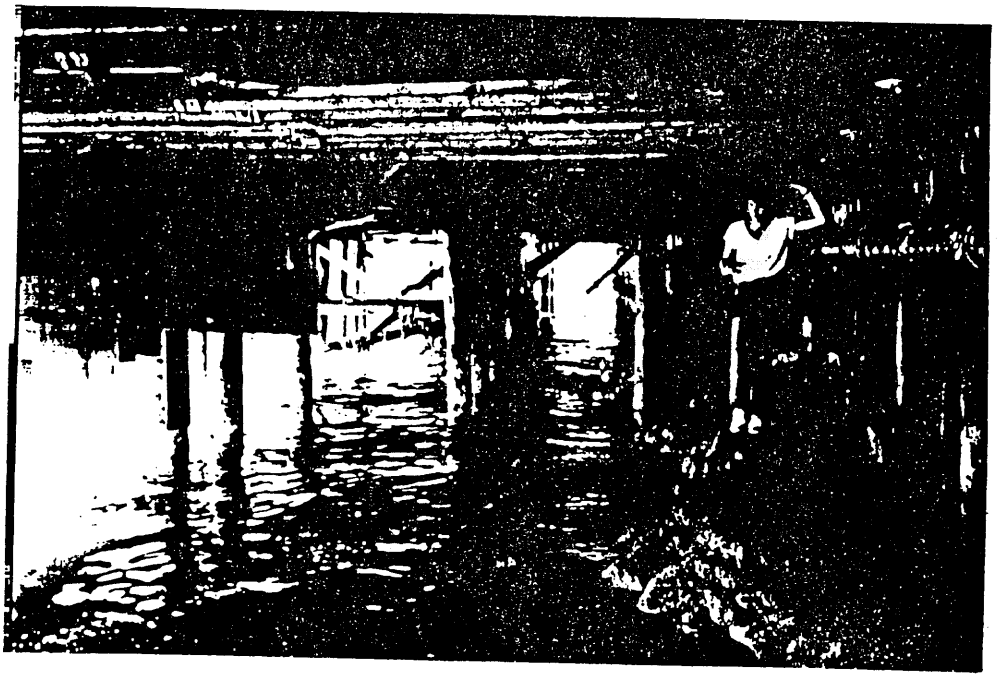


PHOTO 7

TABLE 12

CENTRAL COAST SEA FOOD DISCHARGES

	8-26-86 ?			9-4-86: 13:00		9-11-86 13:30	
	TOTAL	FECAL	STREP	TOTAL	FECAL	TOTAL	FECAL
wall #1:	dry	dry	dry	dry	dry	dry	dry
wall #2:	1800	<5	N.A	3100	610	64800	730
wall #3:	dry	dry	dry	9800	220	36400	200
overhead:	est 100,000	165	N.A.	47200	85	50000	160

	9-11-86 13::00		9-23-86 10:00		10-7-86 1:00	
	TOTAL	FECAL	TOTAL	FECAL	TOTAL	FECAL
wall #1:	dry	dry	dry	dry	dry	dry
wall #2:	>40000	1000	1800	30	3000	3000
wall #3:	33000	1000	>40000	180	MPN:>2400	MPN: 540
overhead:	est 35200	<100	>40000	700	MPN:>2400	MPN:>2400
	(fast:) 30000	<100				

in the investigation, the fecal results were overshadowed by the total, but subsequent days proved fecal contamination serious as well. The results presented in Table 12 are recorded as colonies/100 ml (membrane filter technique), unless marked by MPN.

An NPDES permit application has been requested from Central Coast Sea Food for the discharges from its business. A complete profile of discharges must be provided. The sources of the wall discharges are to be investigated to pinpoint exactly what is entering the Bay. Early results from detailed sampling by the Company have indicated that the quality of discharged water improves with improved general housekeeping practices in the processing area. However, most recent results from Phase III sampling reveal high counts again and indicate the problem is not yet solved, as shown on Table 12.

Morro Bay Aquarium

Due to the high bacterial counts in Bay water samples in the vicinity of the Aquarium, water discharging during Phases I and II was sampled. Photograph 8 shows the magnitude of water discharged on September 4, 1986. As shown by Table 13, the discharge exceeds not only shellfish growing standards, but also water contact limits. On August 26th, fecal streptococcus was also measured. The FC/FS ratio is about 1.2. This is between the ranges used to identify human (<0.7) vs. animal (>4.0) contamination. The Aquarium samples fall in between which may imply a mixture of both. (Note, in order to consider ratios valid, fecal strep results must exceed 100. That criterion is used throughout this report). Dye testing, discussed later, failed to reveal any human contribution.

Lab technicians commented on the quality of the samples from Central Coast Seafood and the Aquarium which were submitted for testing. The Central Coast Seafood discharges were very turbid: a lot of excess "garbage," particles, etc., were discharged in the water (most likely fish parts). The Aquarium samples looked clear, with no particles.

Board staff requested an NPDES permit application from Morro Bay Aquarium. A draft permit has been prepared and has been adopted. The discharger is installing an ultraviolet (UV) treatment system to comply with terms of the proposed permit. On-site dye testing has been performed to determine that no cross connections to sanitary sewers exist. A monitoring program is included with the proposed permit to verify that permit limits (i.e. shellfishing standards) are being consistently met.

PHOTO 8

TABLE 13

MORRO BAY AQUARIUM DISCHARGES

	8-26-86 ?			9-4-86: 13:00		9-11-86 13:30	
	TOTAL	FECAL	STREP	TOTAL	FECAL	TOTAL	FECAL
tank:	110	40	10	no samp	no samp	no samp	no samp
discharge:	39600	25400	33100	34400	31400	no samp	no samp

	9-11-86 13:00		9-23-86 10:00		10-7-86 1:00	
	TOTAL	FECAL	TOTAL	FECAL	TOTAL	FECAL
tank:	no samp	no samp	550	325	42899	18600
discharge:	27100	16300	1740	1420	10600	6600

Station C

Due to consistently high coliform counts at this back bay station, a supplemental investigation was conducted on two days in September, 1986. The drainageway which enters the Bay at Station C was walked from the Bay to the stream source, a seep from the ground by Ramona Street. Table 14 provides: station locations and descriptions, conductivity readings used to differentiate between Bay water and fresh water, and results of coliform analyses.

Generally, coliform counts increase near Station C at the Bay. However, there remains significant coliform emanating from the source. Field staff looked for a rumored rench drain which may have been installed in the adjacent residential area to combat septic system overflows during heavy rains. No evidence of the drain or discharge was found. Further investigation of the high coliform levels at Station C is necessary.

Qualman's Dock

In response to a complaint by the City of Morro Bay, the discharge from oyster processing at Qualman's Oyster Store was sampled on November 17, 1986. The oyster processing is completed in a relatively clean environment. Oysters in shells are cleaned of mud outside, on the dock, and brought inside to a table. Shells are shucked, thrown into a large plastic waste- can. Water is used to hose down the oysters and most of the water is caught in the same waste can. Some water is hosed down a floor drain and discharged to the Bay via a spillway. This discharge was sampled. A slight odor and few flies were noted. In addition, a sample from the waste can was taken (at the time, only a few shells were in the can). Waste shells from the can are either sun dried and returned to the oyster beds, or taken back directly. Results from this sampling follow:

TABLE 15
11-17-86

	Total	Fecal
Discharge:	>2400	17
Waste-Can:	>2400	49

TABLE 14

STATION C SAMPLING

STATION *******	DESCRIPTION **********	CONDUCTIVITY **********	TOTAL *****	FECAL *****	TOTAL *****	FECAL *****
C-1	Bay Station C	-	3290	1633	420	205
C'-1	Tributary U/S of Station C	-	549	300	2140	670
C-2	At Tributary Fork	>10000	630	400	1220	335
C-3	At Fallen Tree	1700	250	15	350	75
C-4	At first pond	1400	279	10	430	85
C-5	At second pond	600	230	25	740	210
C-6	d/s of Road	270	240	40	460	305

COLIFORM VALUES ARE REPORTED IN COLONIES/ 100 ml
NO CONDUCTIVITY DATA FOR 9-23-86

The high total coliform values with low fecal values imply that the oysters and mud may be contaminated with large quantities of bacteria from land runoff or other non-fecal source. The discharge water and waste-can water violate both shellfish harvesting and body contact standards for total coliform bacteria. More work is needed to determine:

1. Source of the large amount of total coliform.

2. Is it the mud, oysters, or both which are contaminated?

3. Are large levels of bacteria surviving in the Saline Bay environment (for example in the mud) or is there a continuous and frequent input?

4. Could oysters be contaminated during processing?

CHAPTER V

RESULTS FROM OTHER AGENCIES

This chapter summarizes the data and reports of other agencies' recent studies of Morro Bay. Included is a discussion of Qualman oyster meat samples, a summary of FDA's dye study of 1985, a summary of DOHS' '84-85 sanitary investigation, and a compilation of DOHS' monthly reports.

RESULTS FROM OTHER AGENCIES

QUALMAN'S MEAT SAMPLES

As explained in Compendium of Methods for the Microbiological Contamination of Foods (p. 603), the maximum fecal coliform count allowed for human consumption is 230 MPN/100 grams of sample. If counts exceed this limit, the shellfish is unfit for consumption and DOHS will temporarily close the oyster beds to harvesting.

Oyster meat data are presented in Tables 16 and 17. A quick comparison of successive years can be made by reviewing the log means of one period to the next (computed in Table 18). There is essentially no change in either total or fecal coliform counts. A significant increase of about 240% is found in the standard plate count from 1985 to 1986. It is obvious from Table 17 that effluent chlorination had no beneficial effect on oyster bacterial levels after August 1, 1986. In fact, August, 1986, is the only month after chlorination began, for which data are available in both years.

A correlation between water samples and meat samples is provided in Tables 3 and 4 for Phase I and in Tables 7 and 8 for Phase II. During our sampling, the water around the oyster growing beds was generally clean, even on days when the oyster meat samples were contaminated. It appears that meat contamination cannot be linked directly to water contamination. This finding is very significant and supports findings in other coastal areas (such as Santa Barbara channel where offshore oysters were contaminated throughout 1986 while total water coliform values were consistently <2). Even sampling as frequently as every other day (as in the RWQCB Morro Bay study), water samples still prove unreliable in predicting meat values.

Several factors must be noted: There is a retention time for coliform within the oysters, thus, each tidal exchange has the potential to affect the oysters. Even if contamination of oyster bed waters occurred several tidal exchanges before clean water was sampled, oysters would not necessarily have time to purge themselves of all the contamination. The water may have been clean but the meat was still contaminated. However, this theory is clouded, because throughout this entire study, contaminated water in growing areas was rarely found. New findings by bacterial researchers suggest that coliform bacteria may lie dormant in Marine water and sediments and later revive in suitable media. Recent findings of the EPA Buzzards Bay study published in Commercial Fisheries News, June, 1987, address this issue. "The study found coliforms could live in water much

TABLE 18

LOG MEANS OF OYSTER
MEAT SAMPLES

	TOTAL COLIFORM MPN/100 g	FECAL COLIFORM MPN/100 g	STD. PLATE COUNT per g at 35 C
LOG MEANS--1985	806	314	349
ARITHMETIC MEANS--1985	12870	7934	8537
LOG MEANS--1986	806	320	824
ARITHMETIC MEANS--1986	2444	1136	5068

longer than previously thought possible. Bacteria in Canadian geese feces can get in the wrack or strand line (seaweed along the shore) and stay viable for months. Since is it covered by seaweed, the bacteria is sheltered from sunlight and ultraviolet radiation, which ordinarily causes it to break down quickly.

The same is true in murky water, which tends to protect the coliforms from breakdown caused by sunlight. In addition, once coliforms get into sediments, they stay viable for long periods of time, and could become re-suspended into the water by storms or wave action. These represent "significant diffuse sources of coliforms whose prolonged effect can be cumulative over time"

Also, a congressional report just released, prepared by the Office of Technology Assessment, an investigative arm of Congress, concludes that present bacterial testing methods are inadequate and that bacteria live longer in seawater than previously believed. Conclusions are based on data by Dr. Jay Grimes of the University of Maryland. (See also Dr. Grimes paper entitled "Fate of Enteric Pathogenic Bacteria in Estuarine and Marine Environments," tentatively scheduled for publication in Microbiological Services). Should these findings prove correct, locating bacterial sources of pollution will be more difficult and even less exact than previously assumed.

RESULTS FROM OTHER AGENCIES

FDA DYE STUDY

In August of 1986, the Ocean Outfall Study, Morro Bay, California report was released by the U. S. Food and Drug Administration. This single purpose FDA study was performed to determine if undisinfected effluent from the Morro Bay-Cayucos WWTP can enter and contaminate Morro Bay. Their study consisted of microbiological analysis of water samples, drogue studies, and Rhodamine WT dye tracings from the WWTP effluent for the period October 7 through October 16, 1985. The outfall study was designed to determine dispersion, dilution, and time of travel of the effluent. Seventeen stations were located outside of Morro Bay to monitor the path of the City's effluent. Eight stations were established within the Bay to detect effluent entering the Bay. The in-Bay stations corresponded with the RWQCB Stations 1, 2, 3, 5, 5A (DOHS' 31), 7, 8, and 11. Current conditions were southerly.

Results of the FDA study include:

* Effluent was found to travel from the outfall to the Bay in about twelve hours by Rhodamine WT dye tracings (p. 44).

* The highest dye concentrations were found sub-surface along with higher total and fecal coliform densities (p. 48).

* The stations sampled at high tide were generally more polluted than those at low tides (p. 17).

An excerpt from an FDA table is reproduced as Table 19 and shows the path which was followed by the Rhodamine WT dye on October 15th. Dye entered the Bay, and coliform was detected at Bay stations as well.

Interestingly, to note that FDA found evidence of coliform bacteria entering the Bay, yet in the RWQCB study, the entrance channel was the cleanest part of the Bay during all but one of the 28 sampling days. In the Ambient Water Quality Criteria for Bacteria-1986, EPA states that low coliform counts in marine environments are "most likely due to the injurious effects of seawater on coliform bacteria causing high die-off rates." Die-off appears to be significant in the RWQCB study results. In Phase II, with water moving quickly, coliform from high count stations (e.g. aquarium station) seldom transported significant

TABLE 19

FDA DYE STUDY

LOCATION	TIME	DISTANCE FROM OUTFALL	RHODAMINE DYE ppb	T.C. MPN/100 ml	F.C. MPN/100 ml
OUTFALL	17:30	-	30	90*10^3	70*10^3
STATION 113	18:18	2000 FT.	0.15	300	130
T-PIER *	22:32	4700 FT.	0.1	170	79

*NOTE: Fecal and total coliform levels found by FDA at the T pier did not necessarily come from outside the Bay. RWQCB results presented throughout this report reveal the waterfront stations along the Embarcadero to be consistently among the most polluted Bay stations, while the entrance channel is simultaneously clean at all three depths.

bacteria to even the closest neighboring station. Given dilution, die-off, and a distance of three miles, the outfall is an unlikely bacterial source for the oyster beds. An analysis of the FDA's results is included in Appendix F.

RESULTS FROM OTHER AGENCIES

DOHS' SANITARY INVESTIGATION OF MORRO BAY

A study was conducted by DOHS on five consecutive days in September, 1984, and five more days in January/February, 1985, to examine bacteriological contamination of Morro Bay. Its purposes were, among other things:

* To evaluate water quality in both dry summer and wet winter seasons.
* To identify sources affecting the Bay.
* To determine the necessity for shellfish harvesting reclassification of the Bay.

The first part of this study was to look at dry weather conditions (only 0.16 inch of rain fell on September 28), and the second part was to examine sources during wet weather (however, the only rain was 0.50 inch which fell after sampling was completed on February 1). Note that both periods were essentially dry weather sampling periods.

Tables 21 and 22 show the results of this study. (A list of station descriptions is given in Table 20.) The following trends are noted:

1. Contamination from Chorro Creek Station 16 and the upstream station, DOHS 20 (RWQCB 16 u/s) at Canet Road is apparent.
2. As in the RWQCB study, the worst stations are on Chorro Creek and along the Embarcadero Waterfront (Stations 5 and 6).
3. Los Osos Creek again ranks "clean" compared to Chorro Creek.
4. Entrance channel stations record clean levels during the September work and are slightly contaminated during the January-February sampling. (In the RWQCB study, it was found that slight contamination levels in the channel are generally associated with the outflow of contaminated bay waters. This observation is supported by much higher levels along the Embarcadero in both studies). At the entrance of the Bay, coliform values were higher than those reported in

our RWQCB study. The five days of September sampling, however, provided only one entrance station at one depth. Finally, there is no information given to determine the general direction of the Ocean's current flow.

5. Water at oyster Stations 11, 12, 13, and 14 is clean enough to meet shellfish standards during the summer, except for Station 11 on September 21st.

In comparing meat samples with water samples at the oyster stations, the same problems are noted as presented in the Qualman meat samples section: poor correlation between meat values and water quality. High meat counts may be residuals from previous contamination of Bay water in the oyster stations or from other factors previously discussed.

RESULTS FROM OTHER AGENCIES

DOHS MONTHLY SURVEYS

DOHS conducts monthly sampling on Morro Bay and the two creeks entering the Bay. They also collect the oyster meat samples reviewed previously in Tables 16 and 17. The monthly results of water samples are presented in Tables 24 and 25 (Station locations were described in Table 20).

A striking feature of the DOHS monthly reports is the regular contamination along the Embarcadero (Stations 5, 6, and 31) and the shoreline between the boat launch range and the Marina (Stations 7, 9, 32, and 33), and the contrastingly clean water at Bay entrance stations (Stations 1, 2, and 3). A review of these reports prompted RWQCB staff to add stations along the Embarcadero to pinpoint sources during this study. The DOHS monthly reports clearly show a bacteria source within the Bay during the months surveyed.

Chorro Creek stations regularly show high coliform counts. Junctions of creeks and the Bay were not sampled so the impact of creek water upon Bay water quality was not measured. Also, on several occasions in summer, 1985, the creek water does not reach Station 16 (the Chorro Creek station at South Bay Boulevard) or the Bay. This is probably fortunate as the Creek was highly polluted upstream on these occasions (See Station 20 results). Interestingly, during all three phases of the RWQCB study, there was always a strong flow at Station 16. Clearly, additional work on sources on contamination in Chorro Creek is still needed. The creek appears to be the largest single bacterial input to the bay.

TABLE 24
DOHS MONTHLY SAMPLING
TOTAL COLIFORM-- in MPN/100 ml

STATION	26-Mar-85	23-Apr-85	06-May-85	24-Jun-85	15-Jul-85	19-Aug-85	16-Sep-85	15-Apr-86	27-May-86	30-Jun-86	22-Jul-86	25-Aug-86
1:	<2	4	-	<2	<2	7	no samp	<10	10	<10	<10	<10
2:	2	2	-	5	<2	<2	no samp	-	-	-	-	-
3:	33	7	2	5	2	11	2	-	-	-	-	-
4:	<2	7	<2	2	<2	<2	4	<10	40	30	<10	10
5:	49	2	9	8	5	21	245	-	-	-	-	-
6:	49	17	23	<2	13	22	540	-	-	-	-	-
7:	33	2	110	11	14	27	49	10	20	20	10	<10
8:	8	2	49	<2	2	7	33	-	-	-	-	-
9:	8	2	7	13	<2	7	8	-	-	-	-	-
10:	4	2	46	8	17	13	11	10	<10	no samp	20	<10
11:	2	4	<2	5	8	13	110	<10	110	70	160	<10
12:	17	2	22	33	8	13	33	-	-	-	-	-
13:	9	2	49	4	8	17	33	10	20	40	40	<10
14:	11	2	13	11	8	8	7	-	-	-	-	-
15:	22	2	8	2	2	33	11	-	-	-	-	-
16:	240	94	540	no flow	dry	no flow	no flow	120	-	-	-	-
17:	79	<2	110	230	10	2	4	-	-	-	-	-
18:	>2400	1600	1100	no flow	dry	no flow	no flow	-	-	-	-	-
19:	1600	>2400	2800	1700	9200	no flow	no flow	-	-	-	-	-
20:	>1400	>2400	920	5400	16000	>24000	>2400	-	-	-	-	-
21:	49	920	130	330	1700	5400	>2400	-	-	-	-	-
22:	<2	<2	46	1100	1100	<2	<2	-	-	-	-	-
23:	<2	8	8	23	13	17	70	10	250	15	<10	<10
30:	-	49	9	8	5	2	8	-	-	-	-	-
31:	9	13	33	49	49	17	170	90	40	40	90	20
32:	-	5	46	8	14	7	79	<10	30	70	<10	<10
(CANNERY)33:	-	-	-	5	33	17	33	80	-	10	10	-
35:	-	-	-	>240,000k	no samp	no samp	>2400	-	-	-	-	-
M.B. EFFLUENT 1:	-	-	-	-	-	-	-	-	-	-	-	50
M.B. EFFLUENT 2:	-	-	-	-	-	-	-	-	-	-	-	270

TABLE 25
DOHS MONTHLY SAMPLING
FECAL COLIFORM-- in MPN/100 ml

STATION	26-Mar-85	23-Apr-85	06-May-85	24-Jun-85	15-Jul-85	19-Aug-85	16-Sep-85	15-Apr-86	27-May-86	30-Jun-86	22-Jul-86	25-Aug-86
1:	<2	2	-	<2	<2	5	no samp	<10	<10	<10	<10	<5
2:	2	<2	-	<2	<2	<2	no samp	-	-	-	-	-
3:	17	2	2	<2	<2	2	<2	-	-	-	-	-
4:	<2	2	<2	<2	<2	<2	4	<10	<10	40	5	<5
5:	23	<2	23	5	<2	11	27	-	-	-	-	-
6:	45	7	110	<2	8	4	110	-	-	-	-	-
7:	33	2	49	4	2	2	22	<10	<10	<10	5	<5
8:	8	<2	2	3	<2	2	8	-	-	-	-	-
9:	8	2	<2	8	<2	5	<2	-	-	-	-	-
10:	4	2	22	5	11	<2	2	<10	<10	-	<10	<5
11:	2	4	2	5	5	8	4	<10	40	30	58	5
12:	11	2	13	5	5	<2	<2	-	-	-	70	-
13:	7	<2	8	4	8	<2	11	<10	20	40	<5	<5
14:	11	<2	33	2	<2	2	7	-	-	-	-	-
15:	11	<2	79	<2	2	17	4	-	-	-	-	-
16:	49	23	49	no flow	dry	no flow	no flow	50	-	-	-	-
17:	23	2	33	130	20	2	2	-	-	-	-	-
18:	920	350	490	no flow	dry	no flow	no flow	-	-	-	-	-
19:	16000	>240	330	790	1300	no flow	no flow	-	-	-	-	-
20:	350	280	27	170	1100	3500	>2400	-	-	-	-	-
21:	17	26	130	50	170	5400	>2400	-	-	-	-	-
22:	<2	<2	2	60	<20	<2	<2	-	-	-	-	-
23:	<2	5	8	<2	2	<2	11	<10	270	<10	5	<5
30:	-	8	<2	2	2	<2	2	-	-	-	-	-
31:	4	8	17	8	8	7	70	<10	<10	10	10	5
32:	-	<2	23	2	5	5	33	<10	<10	10	<10	<5
(CANNERY)33:	-	-	-	<2	13	2	33	30	<10	10	10	-
35:	-	-	-	>240,000k	-	-	>2400	-	-	-	-	-
M.B. EFFLUENT 1:	-	-	-	-	-	-	-	-	-	-	-	4
M.B. EFFLUENT 2:	-	-	-	-	-	-	-	-	-	-	-	20

CHAPTER VI

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

The purpose of this study was to locate and characterize sources of contamination within Morro Bay. The sampling of numerous locations allowed evaluation of specific sources as well as unforeseen sources of contamination. While the Morro Bay WWTP impact could not be examined as extensively as intended due to untimely mandatory chlorination, various other sources were distinctly noted as described below:

1. The entrance of the Bay was always clean on both incoming and slack tides, with the exception of July 18th. This includes two days of southerly currents and nonchlorination. Entrance channel water at all three depths was routinely the cleanest water in the bay.

2. Second only to the entrance stations, oyster stations were clean, regardless of meat sample contamination. This finding leads to the conclusion that current bacterial water quality objectives or standards are inadequate. Oyster meat is apparently being contaminated even though the bivalves are filtering water through their systems that meets water quality standards.

3. Contamination was consistently found along the Embarcadero in the RWQCB study as in DOHS studies. Morro Bay Aquarium and Central Coast Seafood discharged unacceptable water into the Bay, significantly impacting surrounding water quality.

4. Chorro Creek routinely recorded high coliform levels, originating upstream of the Canet Road Station. DOHS and RWQCB studies revealed this creek to be the largest (gallons) single point source of bacteria to the Bay.

5. The Back Bay was subject to periodically high coliform contamination; irregularity of these peaks made pinpointing specific sources difficult. However, both drainageways at A and C had consistently high coliform counts, even at Bay and drainageway junctions where some dilution is provided by bay waters.

6. The Marina Station showed several days of contamination. Direct sewage dumping from boat holding tanks at random intervals is difficult to detect and/or quantify.

7. Finally, this study highlights problems of conflicting uses of Morro Bay as a water resource. Morro Bay oysters may never enjoy a clean bill of health as long as the Bay is a bird refuge, and a recipient of storm water runoff from agricultural lands and City streets, discharges from water front commerce, live-aboard boats, and the South Bay urban area.

Recommendations

Following is a list of recommended actions to reduce known contamination sources and to evaluate sources which present themselves during the wet winter months.

1. The lift stations which were analyzed in 1985, should be reinspected to assure the necessary repairs have been implemented and to monitor operations in order to prevent unnecessary discharges into the Bay. The City of Morro Bay should conduct these inspections quarterly (see map Appendix C).

2. Additional work is still needed on Chorro Creek and its tributaries. A special study of the drainage is recommended. Presently, both DOHS and RWQCB studies reveal Chorro Creek to be the largest single contributor of bacteria to Morro Bay. As part of this study, the CMC discharge should be carefully checked. CMC records show the discharge bacterial count was always <2 but DOHS monthly sampling revealed several instances of noncompliance in 1985 and 1987.

3. Further site specific work is needed at Central Coast Seafood. During Phase I and II of the RWQCB study, we recorded significant pollution being discharged by CCSF. However, later reports from the company and their consultant showed little pollution. A spot check during Phase III revealed the problem had returned. Further work may show a generic dockside and/or fish processing problem is involved. If so, results may be useful elsewhere on the Embarcadero.

4. Morro Bay State Park Marina sanitary facility improvements are needed. The State park and RWQCB should work together to implement a solution.

5. A detailed special study of bacterial inputs from Baywood Park is needed. The study should investigate runoff in Stations A' and C' drainageways. Detailed work begun on Station C' in September, 1986, should be expanded. This study may not be necessary if a wastewater collection and treatment system is constructed as planned. Some follow up sampling, after construction, should be conducted to verify correction of problems noted at Stations A' and C'.

6. As part of No. 5 above, a method must be developed to collect representative low tide samples in the Bay. As discussed in Phase III, there was no good method for shore crews to collect such samples. The question of sea bird impacts on low tide samples must be addressed as well as whether to collect standing water from puddles at shore stations.

7. In any future work on the Bay, it would be important to quantify the impact of birds on back bay samples. Since the Bay will likely remain a bird sanctuary, thousands of birds will continue to frequent back bay mudflats. This impact may represent the baseline pollution level which will exist regardless of point sources. An attempt to quantify the water quality baseline impact would be helpful.

8. Waste discharge from live aboard boats in the City and County portions of Morro Bay must be controlled. A permit system would allow live aboards, but would require pumping holding tanks at regular intervals. Boats would be required to have adequate tanks and be capable of moving to shoreside pump-out stations. Records of regular pump-outs would be reviewed as a condition of permit renewal.

9. As part of the program in No. 8 above, the City must make pump-out facilities more readily available. Boaters complained that pump-out stations are unused partially because City personnel are unavailable to operate them and/or the equipment is broken. As part of the permit process in No. 8, all permittees would have a key to operate the pump-out station at any time. The City would maintain the stations in working order using funds generated from the permit fees.

10. Visiting and resident ocean fishing boats tied up to piers along the Embarcadero should be required to pump-out regularly while in port. These boats likely empty holding tanks at sea; however, problems may develop while in port for extended periods. City staff could make pumping mandatory as a condition of dock use at City piers. Similar requirements are needed at private landings.

11. More work is needed to understand the oyster pollution problem. The questions on Page 93 of this report concerning bacterial inputs, bacterial survival in mud and oysters, and sampling, testing and processing procedures should be investigated. Such information is needed to reach a better understanding of the dynamics of water quality in Morro Bay.

APPENDICES

Appendix A

Central Coast Tides

This section includes the tide charts for the California Central Coast, from May, 1986, through December, 1986, and March and April, 1987. These charts contain information for all of the days sampled in Phases I, II, and III.

MAY 1986

		LOW TIDE AM	Ht.	PM	Ht.	HIGH TIDE AM	Ht.	PM	Ht.
		Sunrise 6:08 -PDT-				Sunset 7:47			
1	Th	—	—	12:15	−0.4	4:44	4.5	7:26	4.0
2	F	12:43	2.3	1:10	−0.2	6:10	4.4	8:01	4.4
3	Sa	1:42	1.6	1:52	0.0	7:21	4.3	8:30	4.8
4	Su	2:31	1.1	2:26	0.2	8:18	4.3	8:54	5.0
5	M	3:12	0.6	2:57	0.6	9:05	4.2	9:17	5.3
		Sunrise 6:03 -PDT-				Sunset 7:51			
6	Tu	3:49	0.1	3:23	0.9	9:50	4.0	9:39	5.4
7	W	4:21	−0.2	3:45	1.2	10:29	3.8	9:59	5.5
8	Th	4:52	−0.4	4:07	1.5	11:08	3.6	10:21	5.6
9	F	5:26	−0.4	4:29	1.8	11:48	3.4	10:46	5.5
10	Sa	6:00	−0.4	4:50	2.1	(12:30	3.2)	11:11	5.4
		Sunrise 5:58 -PDT-				Sunset 7:55			
11	Su	6:40	−0.3	5:09	2.3	(1:19	3.0)	11:40	5.2
12	M	7:24	−0.1	5:28	2.6	—	—	2:31	2.8
13	Tu	8:15	0.1	—	—	12:12	5.0	—	—
14	W	9:18	0.2	—	—	12:51	4.7	—	—
15	Th	10:21	0.3	9:36	3.2	1:48	4.3	6:49	3.3
		Sunrise 5:54 -PDT-				Sunset 7:59			
16	F	11:18	0.3	11:40	2.8	3:11	4.0	7:00	3.6
17	Sa	—	—	12:07	0.4	4:49	3.8	7:16	4.0
18	Su	12:50	2.2	12:46	0.4	6:10	3.8	7:34	4.5
19	M	1:39	1.4	1:23	0.6	7:19	3.9	7:59	5.1
20	Tu	2:24	0.6	2:02	0.8	8:21	4.0	8:28	5.6
		Sunrise 5:50 -PDT-				Sunset 8:03			
21	W	3:09	−0.3	2:37	1.0	9:18	4.0	9:00	6.1
22	Th	3:55	−1.0	3:17	1.2	10:11	4.0	9:36	6.5
23	F	4:43	−1.4	3:55	1.5	11:07	3.9	10:16	6.7
24	Sa	5:33	−1.6	4:37	1.8	(12:04	3.7)	10:58	6.7
25	Su	6:24	−1.7	5:22	2.1	(1:07	3.6)	11:45	6.5
		Sunrise 5:47 -PDT-				Sunset 8:07			
26	M	7:20	−1.4	6:18	2.4	—	—	2:18	3.5
27	Tu	8:20	−1.2	7:27	2.7	12:38	6.1	3:30	3.5
28	W	9:24	−0.8	9:03	2.8	1:40	5.5	4:43	3.7
29	Th	10:26	−0.4	10:48	2.6	2:49	4.8	5:46	4.0
30	F	11:24	0.0	—	—	4:15	4.3	6:30	4.4
		Sunrise 5:45 -PDT-				Sunset 8:11			
31	Sa	12:18	2.0	12:15	0.4	5:41	3.9	7:08	4.8

● 8 ☽ 16 ○ 23 ☾ 30

JUNE 1986

		LOW TIDE AM	Ht.	PM	Ht.	HIGH TIDE AM	Ht.	PM	Ht.
		Sunrise 5:45 -PDT-				Sunset 8:11			
1	Su	1:23	1.4	12:59	0.8	6:57	3.6	7:41	5.1
2	M	2:19	0.9	1:37	1.2	8:02	3.5	8:09	5.3
3	Tu	3:01	0.4	2:09	1.4	9:02	3.4	8:34	5.5
4	W	3:37	0.0	2:37	1.7	9:50	3.4	9:00	5.6
5	Th	4:12	−0.3	3:06	2.0	10:35	3.4	9:25	5.7
		Sunrise 5:43 -PDT-				Sunset 8:14			
6	F	4:47	−0.5	3:31	2.2	11:16	3.3	9:53	5.8
7	Sa	5:19	−0.6	4:00	2.3	11:56	3.3	10:22	5.7
8	Su	5:54	−0.6	4:28	2.5	(12:38	3.2)	10:53	5.7
9	M	6:32	−0.5	5:00	2.6	(1:26	3.2)	11:27	5.5
10	Tu	7:11	−0.4	5:31	2.8	—	—	2:19	3.2
		Sunrise 5:43 -PDT-				Sunset 8:16			
11	W	7:54	−0.2	6:24	2.9	12:02	3.3	3:14	3.2
12	Th	8:36	0.0	7:03	3.0	12:41	5.0	4:09	3.4
13	F	9:19	0.2	9:11	3.0	1:31	4.6	4:51	3.6
14	Sa	10:08	0.4	10:55	2.6	2:35	4.2	5:28	4.0
15	Su	10:53	0.7	—	—	3:58	3.7	5:59	4.4
		Sunrise 5:43 -PDT-				Sunset 8:18			
16	M	12:14	1.9	(11:39	1.0)	5:31	3.4	6:31	5.0
17	Tu	1:20	1.2	12:25	1.2	7:00	3.3	7:08	5.5
18	W	2:11	0.3	1:13	1.5	8:15	3.4	7:48	6.1
19	Th	3:01	−0.6	1:58	1.8	9:21	3.5	8:30	6.6
20	F	3:50	−1.2	2:50	1.9	10:21	3.7	9:13	6.9
		Sunrise 5:43 -PDT-				Sunset 8:20			
21	Sa	4:38	−1.6	3:36	2.1	11:16	3.7	9:59	7.1
22	Su	5:27	−1.8	4:28	2.1	(12:07	3.8)	10:48	7.0
23	M	6:16	−1.7	5:20	2.2	(1:00	3.8)	11:40	6.7
24	Tu	7:06	−1.4	6:19	2.3	—	—	1:54	3.9
25	W	7:56	−1.1	7:25	2.4	12:29	8.2	2:48	4.0
		Sunrise 5:44 -PDT-				Sunset 8:21			
26	Th	8:42	−0.6	8:42	2.5	1:28	5.6	3:43	4.2
27	F	9:32	0.0	10:13	2.3	2:24	4.8	4:35	4.4
28	Sa	10:21	0.6	11:45	1.9	3:36	4.1	5:23	4.6
29	Su	11:07	1.2	—	—	4:59	3.5	6:10	4.9
30	M	12:58	1.4	(11:56	1.6)	6:36	3.1	7:48	5.1

● 7 ☽ 15 ○ 21 ☾ 28

JULY 1986

		LOW TIDE AM	Ht.	PM	Ht.	HIGH TIDE AM	Ht.	PM	Ht.
		Sunrise 5:46 -PDT-				Sunset 8:21			
1	Tu	2:00	0.9	12:41	2.0	8:01	3.1	7:24	5.3
2	W	2:48	0.5	1:23	2.3	9:10	3.1	8:00	5.5
3	Th	3:28	0.1	2:05	2.4	10:01	3.3	8:32	5.7
4	F	4:03	−0.2	2:40	2.5	10:43	3.3	9:07	5.8
5	Sa	4:35	−0.4	3:16	2.6	11:19	3.4	9:39	5.9
		Sunrise 5:49 -PDT-				Sunset 8:20			
6	Su	5:09	−0.5	3:51	2.5	11:53	3.5	10:11	6.0
7	M	5:42	−0.6	4:27	2.5	(12:23	3.5)	10:46	6.0
8	Tu	6:13	−0.6	5:05	2.6	(12:59	3.6)	11:21	5.9
9	W	6:47	−0.5	5:45	2.6	(1:33	3.6)	11:21	5.6
10	Th	7:19	−0.3	6:32	2.6	(2:08	3.8)	—	—
		Sunrise 5:51 -PDT-				Sunset 8:19			
11	F	7:51	0.0	7:32	2.8	12:32	5.3	2:43	3.9
12	Sa	8:26	0.3	8:42	2.5	1:18	4.8	3:22	4.2
13	Su	9:01	0.8	10:12	2.1	2:11	4.2	4:01	4.5
14	M	9:44	1.2	11:45	1.6	3:29	3.5	4:49	4.9
15	Tu	10:32	1.7	—	—	5:16	3.1	5:38	5.3
		Sunrise 5:54 -PDT-				Sunset 8:17			
16	W	1:06	0.9	(11:32	2.1)	7:08	3.0	6:31	5.8
17	Th	2:03	0.1	12:38	2.3	8:38	3.2	7:21	6.2
18	F	2:56	−0.7	1:44	2.4	9:36	3.5	8:16	6.7
19	Sa	3:47	−1.2	2:40	2.3	10:25	3.7	9:05	7.0
20	Su	4:32	−1.4	3:35	2.2	11:10	4.0	9:55	7.1
		Sunrise 5:58 -PDT-				Sunset 8:14			
21	M	5:17	−1.5	4:28	2.0	11:52	4.1	10:43	7.0
22	Tu	5:59	−1.4	5:19	1.9	(12:31	4.3)	11:29	6.7
23	W	6:38	−1.1	6:12	1.9	—	—	1:13	4.4
24	Th	7:17	−0.8	7:08	1.9	12:17	6.2	1:52	4.5
25	F	7:56	0.0	8:10	2.0	1:06	5.4	2:34	4.6
		Sunrise 6:02 -PDT-				Sunset 8:11			
26	Sa	8:33	0.7	9:27	2.0	1:55	4.8	3:19	4.7
27	Su	9:09	1.2	11:00	1.8	2:57	3.8	4:04	4.7
28	M	9:50	1.9	—	—	4:25	3.2	4:57	4.8
29	Tu	12:25	1.4	10:39	2.4	6:31	2.9	5:50	4.9
30	W	1:42	1.1	(11:48	2.7)	8:22	3.0	6:43	5.1
		Sunrise 6 05 -PDT-				Sunset 8 07			
31	Th	2:30	0.8	12:57	2.9	9:31	3.3	7:32	5.3

● 6 ☽ 14 ○ 21 ☾ 28

AUGUST 1986

		LOW TIDE AM	Ht.	PM	Ht.	HIGH TIDE AM	Ht.	PM	Ht.
		Sunrise 6:05 -PDT-				Sunset 8:07			
1	F	3:12	0.2	1:53	2.9	10:09	3.5	8:14	5.5
2	Sa	3:50	−0.1	2:38	2.7	10:35	3.8	8:52	5.8
3	Su	4:19	−0.3	3:16	2.6	10:57	3.7	9:30	6.0
4	M	4:47	−0.4	3:49	2.4	11:22	3.9	10:02	6.1
5	Tu	5:14	−0.5	4:25	2.2	11:47	4.0	10:35	6.1
		Sunrise 6:09 -PDT-				Sunset 8:02			
6	W	5:44	−0.5	5:03	2.1	(12:12	4.1)	11:09	6.0
7	Th	6:09	−0.3	5:41	2.0	(12:37	4.3)	11:45	5.7
8	F	6:36	0.0	6:25	1.9	—	—	1:05	4.5
9	Sa	7:04	0.4	7:17	1.8	12:23	5.2	1:34	4.6
10	Su	7:33	0.9	8:23	1.7	1:07	4.8	2:11	4.8
		Sunrise 6:13 -PDT-				Sunset 7:57			
11	M	8:05	1.3	9:47	1.5	2:04	3.9	2:53	5.0
12	Tu	8:41	1.9	11:13	1.2	3:28	3.2	3:46	5.2
13	W	9:33	2.4	—	—	5:44	2.9	4:53	5.4
14	Th	12:52	0.6	(11:06	2.8)	7:53	3.1	6:07	5.7
15	F	1:58	−0.1	12:43	2.8	8:59	3.5	7:12	6.1
		Sunrise 6:17 -PDT-				Sunset 7:52			
16	Sa	2:50	−0.7	1:52	2.6	9:39	3.8	8:14	6.5
17	Su	3:35	−1.0	2:50	2.2	10:13	4.1	9:05	6.8
18	M	4:17	−1.2	3:39	1.9	10:44	4.4	9:52	6.9
19	Tu	4:54	−1.1	4:26	1.6	11:19	4.6	10:34	6.7
20	W	5:29	−0.9	5:12	1.4	11:48	4.8	11:16	6.3
		Sunrise 6:21 -PDT-				Sunset 7:45			
21	Th	6:01	−0.5	5:57	1.3	(12:30	5.0)	11:58	5.7
22	F	6:32	0.1	6:43	1.2	—	—	12:54	5.0
23	Sa	6:58	0.7	7:35	1.4	12:41	5.0	1:26	5.0
24	Su	7:27	1.3	8:34	1.5	1:30	4.3	1:58	4.9
25	M	7:53	1.9	9:57	1.6	2:26	3.5	2:38	4.8
		Sunrise 6.25 -PDT-				Sunset 7:39			
26	Tu	8:10	2.5	11:40	1.4	4:04	3.0	3:27	4.7
27	W	—	—	—	—	—	—	4:40	4.6
28	Th	1:13	1.2	—	—	—	—	6:03	4.7
29	F	2:05	0.7	1:02	3.2	9:29	3.6	7:05	5.0
30	Sa	2:46	0.4	1:55	2.9	8:44	3.8	7:54	5.3
		Sunrise 6:29 -PDT-				Sunset 7:32			
31	Su	3:19	0.1	2:35	2.6	10:02	3.9	7:36	5.7

● 5 ☽ 13 ○ 19 ☾ 27

CENTRAL COAST TIDES

APPENDIX A

SEPTEMBER 1986

		LOW TIDE AM	Ht.	PM	Ht.	HIGH TIDE AM	Ht.	PM	Ht.
		Sunrise 6:33 -PDT-				Sunset 7:25			
1	M	3:45	−0.1	3:06	2.3	10:17	4.1	9:11	5.9
2	Tu	4:13	−0.3	3:42	1.9	10:36	4.3	9:45	6.0
3	W	4:35	−0.3	4:15	1.6	10:58	4.6	10:20	6.0
4	Th	5:01	−0.2	4:53	1.3	11:19	4.8	10:57	5.8
5	F	5:25	0.1	5:31	1.1	11:43	5.1	11:34	5.4
		Sunrise 6:39 -PDT-				Sunset 7:25			
6	Sa	5:51	0.5	6:14	1.0	—	—	12:08	5.3
7	Su	6:19	1.0	7:06	0.9	12:18	4.9	12:38	5.4
8	M	6:45	1.4	8:09	0.9	1:05	4.3	1:15	5.5
9	Tu	7:14	2.0	9:31	0.9	2:11	3.5	1:58	5.4
10	W	7:49	2.6	11:14	0.7	4:06	3.0	2:58	5.3
		Sunrise 6:42 -PDT-				Sunset 7:18			
11	Th	—	—	—	—	—	—	4:26	5.3
12	F	12:44	0.3	(11:34	3.3)	8:18	3.6	5:58	5.5
13	Sa	1:45	−0.2	1:07	2.9	8:47	4.0	7:11	5.8
14	Su	2:35	−0.6	2:08	2.3	9:18	4.3	8:10	6.1
15	M	3:14	−0.7	3:57	1.8	9:44	4.7	9:01	6.3
		Sunrise 6:44 -PDT-				Sunset 7:11			
16	Tu	3:50	−0.7	3:42	1.3	10:12	5.0	9:44	6.2
17	W	4:19	−0.4	4:21	1.0	10:37	5.2	10:25	6.0
18	Th	4:50	−0.1	5:00	0.8	11:05	5.4	11:04	5.6
19	F	5:15	0.1	5:39	0.7	11:30	5.5	11:44	5.0
20	Sa	5:41	0.9	6:21	0.7	11:56	5.5	—	—
		Sunrise 6:47 -PDT-				Sunset 7:03			
21	Su	6:03	1.4	7:03	0.8	12:25	4.5	12:20	5.4
22	M	6:24	2.0	7:52	1.0	1:10	3.8	12:46	5.2
23	Tu	6:36	2.5	9:01	1.2	2:10	3.3	1:15	5.0
24	W	6:18	2.8	10:44	1.2	4:15	2.9	1:57	4.7
25	Th	—	—	—	—	—	—	3:10	4.4
		Sunrise 6:50 -PDT-				Sunset 6:56			
26	F	12:23	1.1	—	—	—	—	5:10	4.4
27	Sa	1:23	0.8	1:02	3.3	8:56	3.8	6:33	4.6
28	Su	2:03	0.5	1:44	2.8	9:02	4.0	7:27	4.9
29	M	2:32	0.3	2:21	2.3	9:15	4.3	8:09	5.2
30	Tu	2:59	0.1	2:53	1.8	9:28	4.6	8:49	5.5

● 3 ☽ 10 ○ 17 ☾ 25

OCTOBER 1986

		LOW TIDE AM	Ht.	PM	Ht.	HIGH TIDE AM	Ht.	PM	Ht.
		Sunrise 6:54 -PDT-				Sunset 6:49			
1	W	3:24	0.1	3:25	1.3	9:46	4.9	9:26	5.5
2	Th	3:49	0.2	4:03	0.9	10:05	5.3	10:04	5.5
3	F	4:15	0.4	4:38	0.4	10:29	5.6	10:46	5.3
4	Sa	4:40	0.7	5:20	0.1	10:55	5.9	11:29	4.9
5	Su	5:09	1.1	6:05	−0.1	11:23	6.1	—	—
		Sunrise 6:59 -PDT-				Sunset 6:41			
6	M	5:37	1.5	6:58	−0.1	12:28	4.4	(11:55	6.1)
7	Tu	6:05	2.1	8:02	0.1	1:18	3.8	12:34	6.0
8	W	6:37	2.6	9:23	0.2	2:43	3.3	1:23	5.7
9	Th	7:22	3.1	11:59	0.2	5:13	3.2	2:34	5.4
10	F	9:49	3.4	—	—	7:04	3.6	4:13	5.1
		Sunrise 7:02 -PDT-				Sunset 6:34			
11	Sa	12:18	0.0	12:09	3.1	7:45	4.0	5:52	5.1
12	Su	1:18	−0.2	1:20	2.5	8:14	4.4	7:06	5.3
13	M	2:03	−0.3	2:13	1.8	8:42	4.8	8:04	5.4
14	Tu	2:40	−0.2	2:57	1.2	9:08	5.2	8:51	5.4
15	W	3:14	0.1	3:37	0.8	9:33	5.5	9:35	5.3
		Sunrise 7:07 -PDT-				Sunset 6:27			
16	Th	3:40	0.4	4:13	0.4	9:58	5.7	10:17	5.0
17	F	4:08	0.8	4:48	0.1	10:20	5.9	10:55	4.7
18	Sa	4:30	1.2	5:23	0.1	10:42	5.9	11:35	4.3
19	Su	4:51	1.6	5:59	0.1	11:07	5.8	—	—
20	M	5:10	2.0	6:40	0.3	12:17	3.9	(11:29	5.7)
		Sunrise 7:11 -PDT-				Sunset 6:21			
21	Tu	5:28	2.4	7:25	0.5	1:07	3.5	(11:54	5.4)
22	W	5:36	2.9	8:25	0.8	2:13	3.1	12:22	5.1
23	Th	—	—	9:46	1.0	—	—	12:57	4.8
24	F	—	—	11:13	0.9	—	—	1:55	4.4
25	Sa	10:29	3.6	—	—	8:30	3.7	3:47	4.2
		Pacific Standard Time Starts Sunday, Oct.26 - 2:00 a.m.							
26	Su	12:17	0.8	(11:35	3.3)	7:01	3.9	4:37	4.2
27	M	12:01	0.6	12:21	2.7	7:09	4.2	5:44	4.4
28	Tu	12:36	0.5	12:58	2.0	7:21	4.5	6:35	4.6
29	W	1:06	0.5	1:35	1.3	7:39	5.0	7:22	4.7
30	Th	1:32	0.6	2:11	0.7	7:54	5.4	8:08	4.8
		Sunrise 6:20 -PST-				Sunset 5:15			
31	F	2:01	0.7	2:47	0.0	8:19	5.9	8:54	4.7

● 3 ☽ 10 ○ 17 ☾ 25

NOVEMBER 1986

		LOW TIDE AM	Ht.	PM	Ht.	HIGH TIDE AM	Ht.	PM	Ht.
		Sunrise 6:23 -PST-				Sunset 5:04			
1	Sa	2:29	1.0	3:29	−0.5	8:44	6.3	9:41	4.6
2	Su	3:00	1.2	4:11	−0.9	9:16	6.6	10:31	4.3
3	M	3:32	1.6	5:00	−1.0	9:51	6.7	11:30	3.9
4	Tu	4:08	2.0	5:56	−0.9	10:28	6.6	—	—
5	W	4:44	2.5	6:57	−0.7	12:39	3.6	(11:14	6.4)
		Sunrise 6:28 -PST-				Sunset 4:59			
6	Th	5:36	2.9	8:11	−0.4	2:09	3.4	12:10	5.9
7	F	6:54	3.2	9:30	−0.2	3:52	3.5	1:23	5.3
8	Sa	9:17	3.2	10:37	−0.1	5:10	3.9	2:58	4.9
9	Su	11:06	2.7	11:36	0.1	5:56	4.3	4:34	4.7
10	M	—	—	12:16	2.0	6:32	4.8	5:50	4.6
		Sunrise 6:33 -PST-				Sunset 4:55			
11	Tu	12:21	0.3	1:08	1.3	7:04	5.2	6:53	4.5
12	W	1:00	0.6	1:53	0.8	7:29	5.5	7:47	4.4
13	Th	1:32	0.9	2:32	0.3	7:54	5.8	8:34	4.3
14	F	2:01	1.3	3:07	−0.1	8:19	6.0	9:17	4.1
15	Sa	2:25	1.5	3:39	−0.3	8:42	6.1	9:58	3.9
		Sunrise 6:38 -PST-				Sunset 4:51			
16	Su	2:50	1.9	4:15	−0.4	9:07	6.1	10:38	3.7
17	M	3:15	2.1	4:47	−0.3	9:32	6.0	11:23	3.5
18	Tu	3:36	2.4	5:27	−0.2	9:58	5.8	—	—
19	W	3:57	2.6	6:11	0.0	12:13	3.3	10:26	5.6
20	Th	4:15	2.9	6:59	0.3	1:16	3.1	(10:58	5.3)
		Sunrise 6:43 -PST-				Sunset 4:49			
21	F	—	—	7:57	0.5	11:38	3.0	—	—
22	Sa	—	—	8:57	0.8	—	—	12:25	4.8
23	Su	8:13	3.5	9:54	0.7	5:33	3.8	1:35	4.2
24	M	10:33	3.2	10:43	0.8	5:54	3.9	3:17	3.9
25	Tu	11:43	2.5	11:22	0.9	5:59	4.3	4:51	3.8
		Sunrise 6:48 -PST-				Sunset 4:47			
26	W	—	—	12:36	1.7	6:19	4.7	6:00	3.8
27	Th	12:00	1.0	1:14	1.0	6:43	5.2	7:01	3.9
28	F	12:36	1.1	1:56	0.2	7:06	5.8	7:59	4.0
29	Sa	1:14	1.3	2:38	−0.6	7:38	6.3	8:52	4.0
30	Su	1:50	1.6	3:21	−1.2	8:13	6.7	9:44	4.0

● 1 ☽ 8 ○ 16 ☾ 24

DECEMBER 1986

		LOW TIDE AM	Ht.	PM	Ht.	HIGH TIDE AM	Ht.	PM	Ht.
		Sunrise 6:53 -PST-				Sunset 4:46			
1	M	2:28	1.8	4:09	−1.5	8:52	7.0	10:43	3.9
2	Tu	3:10	2.0	4:57	−1.5	9:34	7.1	11:38	3.8
3	W	3:56	2.2	5:50	−1.4	10:19	6.9	—	—
4	Th	4:46	2.5	6:46	−1.2	12:40	3.7	11:08	6.6
5	F	5:50	2.7	7:46	−0.8	1:47	3.7	12:05	6.0
		Sunrise 6:57 -PST-				Sunset 4:46			
6	Sa	7:15	2.9	8:48	−0.3	2:59	3.8	1:11	5.3
7	Su	9:00	2.8	9:49	0.1	4:05	4.2	2:32	4.6
8	M	10:45	2.3	10:41	0.5	4:57	4.5	4:01	4.0
9	Tu	11:59	1.8	11:28	1.0	5:39	4.9	5:31	3.7
10	W	—	—	12:59	1.0	6:17	5.3	6:45	3.6
		Sunrise 6:57 -PST-				Sunset 4:46			
11	Th	12:14	1.3	1:45	0.5	6:51	5.6	7:51	3.5
12	F	12:52	1.6	2:27	0.0	7:20	5.8	8:43	3.5
13	Sa	1:24	1.9	3:02	−0.3	7:50	5.9	9:26	3.5
14	Su	1:56	2.2	3:37	−0.5	8:15	6.0	10:10	3.5
15	M	2:25	2.3	4:09	−0.6	8:45	6.0	11:48	3.5
		Sunrise 7:01 -PST-				Sunset 4:47			
16	Tu	2:53	2.4	4:41	−0.6	9:15	6.0	11:28	3.4
17	W	3:25	2.5	5:16	−0.5	9:45	5.9	—	—
18	Th	3:57	2.6	5:54	−0.4	12:06	3.4	(10:17	5.7)
19	F	4:29	2.7	6:30	−0.2	12:49	3.3	(10:49	5.5)
20	Sa	5:11	2.9	7:10	0.1	1:38	3.4	(11:24	5.2)
		Sunrise 7:04 -PST-				Sunset 4:48			
21	Su	6:08	3.0	7:49	0.3	2:27	3.5	12:06	4.7
22	M	7:31	3.0	8:31	0.6	3:16	3.7	12:57	4.2
23	Tu	9:17	2.8	9:16	1.0	3:58	3.9	2:14	3.7
24	W	10:54	2.2	10:05	1.2	4:33	4.3	3:57	3.2
25	Th	(12:02	1.4)	10:54	1.5	5:10	4.8	5:37	3.1
		Sunrise 7:07 -PST-				Sunset 4:49			
26	F	(12:55	0.8)	11:43	1.8	5:47	5.3	7:01	3.2
27	Sa	—	—	1:46	−0.3	6:27	5.9	8:08	3.4
28	Su	12:36	2.0	2:30	−1.0	7:09	6.4	9:03	3.6
29	M	1:24	2.0	3:18	−1.5	7:53	6.8	9:54	3.7
30	Tu	2:14	2.1	4:04	−1.9	8:39	7.1	10:41	3.8
		Sunrise 7:09 -PST-				Sunset 4:53			
31	W	3:05	3.0	4:49	−1.8	9:25	7.2	11:29	3.9

● 1 ☽ 8 ○ 15 ☾ 24 ● 30

Occasionally three tides will occur in a 12 hour a.m. or p.m. time period. This tide will be printed with ( ) parenthesis around the time and tide to indicate that it is the opposite of the column in which it appears. If the "( )" time and tide are in the a.m. column they are p.m. time and tide, and vice versa.

APPENDIX A

MARCH

Date	Day	HIGH TIDE AM	Ht.	PM	Ht.	LOW TIDE AM	Ht.	PM	Ht.
		Sunrise 6:29						Sunset 5:56	
1	S	10:37	5.5	11:15	5.1	4:36	0.5	5:00	-0.3
2	M	11:19	4.8	11:47	5.1	5:23	0.4	5:31	0.3
3	T	12:06 P	4.0			6:11	0.5	5:56	1.0
4	W	12:19	5.0	1:01	3.3	7:04	0.7	6:18	1.6
5	T	12:51	4.8	2:28	2.6	8:16	0.9	6:30	2.2
		Sunrise 6:23						Sunset 6:00	
6	F	1:36	4.5			10:03	1.0		
7	S	2:44	4.2			11:48	0.7		
8	S	4:25	4.2	8:25	3.3	12:52 P	0.4	11:59	3.0
9	M	5:48	4.4	8:37	3.5	1:35 P	0.0		
10	T	6:44	4.7	8:45	3.7	12:55	2.6	2:06	-0.2
		Sunrise 6:16						Sunset 6:05	
11	W	7:22	5.0	9:00	3.8	1:34	2.3	2:33	-0.4
12	T	8:01	5.2	9:15	4.1	2:03	1.9	2:57	-0.4
13	F	8:33	5.3	9:33	4.3	2:35	1.5	3:19	-0.4
14	S	9:05	5.3	9:51	4.6	3:07	1.1	3:41	-0.3
15	S	9:41	5.1	10:13	4.8	3:39	0.8	4:03	-0.1
		Sunrise 6:09						Sunset 6:09	
16	M	10:13	4.8	10:35	5.0	4:14	0.5	4:25	0.3
17	T	10:54	4.4	11:01	5.2	4:54	0.3	4:46	0.7
18	W	11:39	3.8	11:31	5.2	5:36	0.2	5:11	1.2
19	T	12:35 P	3.2			6:30	0.2	5:32	1.7
20	F	12:08	5.2	2:06	2.7	7:39	0.3	5:57	2.2
		Sunrise 6:02						Sunset 6:13	
21	S	12:56	5.0			9:12	0.3		
22	S	2:13	4.8			10:53	0.0		
23	M	3:57	4.8	7:26	3.5	12:10 P	-0.4	11:30	2.7
24	T	5:29	5.0	7:48	3.9	1:00 P	-0.7		
25	W	6:33	5.4	8:13	4.3	12:41	2.1	1:42	-0.9
		Sunrise 5:54						Sunset 6:17	
26	T	7:30	5.6	8:38	4.7	1:34	1.5	2:19	-0.9
27	F	8:16	5.6	9:06	5.0	2:19	0.8	2:51	-0.8
28	S	9:01	5.4	9:33	5.3	3:01	0.3	3:23	-0.4
29	S	9:45	5.1	10:00	5.5	3:43	-0.1	3:50	0.0
30	M	10:27	4.6	10:26	5.5	4:22	-0.3	4:17	0.5
31	T	11:11	4.1	10:54	5.4	5:04	-0.3	4:42	1.1

APRIL

Date	Day	HIGH TIDE AM	Ht.	PM	Ht.	LOW TIDE AM	Ht.	PM	Ht.
		Sunrise 5:47						Sunset 6:22	
1	W	11:58	3.5	11:21	5.2	5:48	-0.1	5:04	1.6
2	T	12:57 P	3.0	11:52	4.9	6:38	0.1	5:15	2.1
3	F	2:42 P	2.6			7:36	0.4	5:13	2.5
4	S	12:27	4.5			9:03	0.7		
5	S	1:27	4.1			11:46	0.6		
		Daylight Savings Begins 2:00 a.m., Sunday, April 5							
		Sunrise 6:40						Sunset 7:26	
6	M	4:19	3.9	8:39	3.4	12:54 P	0.4	12:44 A	3.0
7	T	6:03	4.0	8:48	3.6	1:41 P	0.2		
8	W	7:04	4.2	8:56	3.9	1:34	2.5	2:13	0.1
9	T	7:53	4.5	9:07	4.1	2:10	2.0	2:42	0.0
10	F	8:32	4.6	9:22	4.5	2:45	1.5	3:06	0.0
		Sunrise 6:33						Sunset 7:30	
11	S	9:11	4.7	9:41	4.8	3:18	0.9	3:29	0.1
12	S	9:49	4.6	10:02	5.2	3:49	0.4	3:54	0.3
13	M	10:28	4.5	10:25	5.5	4:24	-0.1	4:16	0.6
14	T	11:11	4.2	10:51	5.7	5:03	-0.4	4:42	1.0
15	W	11:57	3.9	11:23	5.8	5:44	-0.6	5:10	1.4
		Sunrise 6:26						Sunset 7:34	
16	T	12:53 P	3.4	11:59	5.7	6:34	-0.7	5:38	1.8
17	F	2:06 P	3.0	12:41 A	5.5	7:30	-0.6	6:10	2.2
18	S	3:55 P	2.9			8:39	-0.4	6:45	2.6
19	S	1:40	5.1	6:06	3.1	10:01	-0.3	8:18	2.9
20	M	3:05	4.8	7:01	3.5	11:24	-0.3	11:02	2.9
		Sunrise 6:20						Sunset 7:39	
21	T	4:45	4.6	7:33	3.9	12:32 P	-0.4	12:40 A	2.3
22	W	6:14	4.6	8:05	4.4	1:23 P	-0.4		
23	T	7:23	4.7	8:33	4.8	1:40	1.6	2:05	-0.3
24	F	8:18	4.7	8:59	5.2	2:32	0.9	2:40	-0.1
25	S	9:11	4.6	9:26	5.5	3:14	0.3	3:12	0.2
		Sunrise 6:13						Sunset 7:43	
26	S	9:57	4.4	9:52	5.7	3:56	-0.2	3:41	0.6
27	M	10:43	4.1	10:20	5.8	4:34	-0.5	4:09	1.0
28	T	11:26	3.8	10:45	5.7	5:13	-0.7	4:34	1.4
29	W	12:12 P	3.5	11:10	5.6	5:52	-0.7	4:56	1.8
30	T	1:03 P	3.2	11:41	5.3	6:31	-0.5	5:21	2.2

APPENDIX A

Appendix B

Coliform Limits

Appendix B includes water quality criteria taken from the Water Quality Control Plan, Ocean Waters of California (Ocean Plan). The Plan contains total and fecal coliform bacteria limits for body contact; however, only total coliform objectives are included for shellfish harvesting areas.

A. Bacteriological Characteristics

1. Body-Contact Standards

Within a zone bounded by the shoreline and a distance of 1,000 feet from the shoreline or the 30-foot depth contour, whichever is further from the shoreline, and in areas outside this zone used for body-contact sports, as determined by the Regional Board, but including all kelp* beds, the following bacteriological objectives shall be maintained throughout the water column:

a. Samples of water from each sampling station shall have a concentration of total coliform organisms less than 1,000 per 100 ml (10 per ml); provided that not more than 20 percent of the samples at any sampling station, in any 30-day period, may exceed 1,000 per 100 ml (10 per ml), and provided further that no single sample when verified by a repeat sample taken within 48 hours shall exceed 10,000 per 100 ml (100 per ml).

b. The fecal coliform concentration based on a minimum of not less than five samples for any 30-day period, shall not exceed a log mean of 200 per 100 ml nor shall more than 10 percent of the total samples during any 60-day period exceed 400 per 100 ml.

The "Initial* Dilution Zone" of wastewater outfalls shall be excluded from designation as "kelp* beds" for purposes of bacteriological standards, and Regional Boards should extend the area of such exclusion zone where warranted. Adventitious assemblages of kelp plants on waste discharge structures (e.g. outfall pipes and diffusers) do not constitute kelp* beds for purposes of bacteriological standards.

2. Shellfish* Harvesting Standards

At all areas where shellfish* may be harvested for human consumption, as determined by the Regional Board, the following bacteriological objectives shall be maintained throughout the water column:

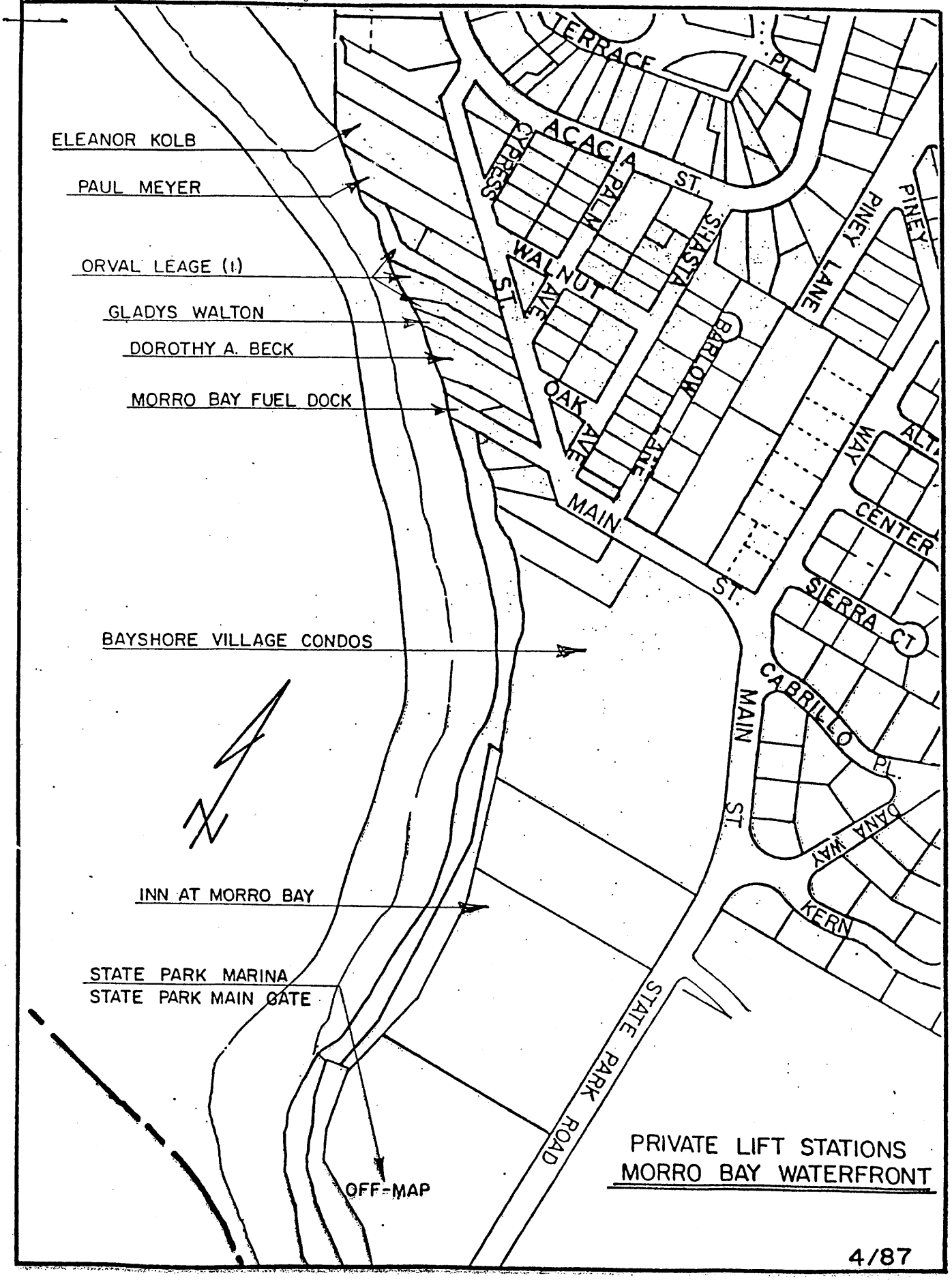
The median total coliform concentration shall not exceed 70 per 100 ml, and not more than 10 percent of the samples shall exceed 230 per 100 ml.

APPENDIX B

Appendix C

Lift Stations

As referenced in the text, the RWQCB inspected several lift stations adjacent to Morro Bay. The following map shows all known lift stations and should be used with recommendation No. 1.


ELEANOR KOLB
PAUL MEYER
ORVAL LEAGE (1)
GLADYS WALTON
DOROTHY A. BECK
MORRO BAY FUEL DOCK
BAYSHORE VILLAGE CONDOS
INN AT MORRO BAY
STATE PARK MARINA
STATE PARK MAIN GATE
OFF-MAP
TERRACE
PL.
ACACIA
ST.
CYPRESS
PALM
WALNUT
AVE.
SHASTA
PINEY
LANE
PINEY WAY
ALT
OAK
PARK
PARLOW
MAIN
ST.
CENTER
SIERRA CT.
CABRILLO
PL.
DANA WAY
KERN
STATE PARK ROAD
PRIVATE LIFT STATIONS
MORRO BAY WATERFRONT
4/87

APPENDIX C

Appendix D

Rain Table

Phases I and II of this study were to document Morro Bay contamination in dry weather. All rain was recorded by the Morro Bay Fire Department. As the table shows, rainfall was negligible throughout both phases. Phase III was to be conducted during wet weather. The Phase III table shows rain recorded during the March and April periods of Phase III.

Phase III

Rain Records during the Phase III Study
City of Morro Bay Fire Department

Date	Rain Amount in Inches
March 15	-
March 16	-
March 17	-
March 18	-
March 19	- Sample day
March 20	.46
March 21	.05
March 21	-
March 23	trace
March 24	-
March 25	- Sample day
March 26-31	-
April 1	- Sample day
April 2	-
April 3	.09 Sample day
April 4	-
April 5	-
April 6	- Sample day
April 7-28	-
April 29	.27

Appendix D

Appendix E

Morro Bay Study Chronology

3/19/87 - 4/6/87	Phase III sampling conducted
11/10/86	Fish & Game removes sport harvest prohibition
11/01/86	Department of Health Services removes commercial harvest prohibition.
9/12/86	EPA again refuses to suspend chlorination at Morro Bay outfall for our Phase II B. study. (Remaining Phase II cancelled).
9/09/86	RWQCB letter to EPA again requesting chlorine suspension and explaining Regional Boards 9/5 resolution.
9/05/86	RWQCB members unanimously adopt resolution asking EPA to allow us to complete Phase II Morro Bay study.
9/04/86	EPA refuses RWQCB request for chlorine suspension during last half of Phase II.
8/21/86	Phase II sampling begins. This portion to be conducted with chlorinated effluent.
8/20/86	RWQCB Executive Officer asks EPA by letter for cooperation with Phase II B study. Chlorine at Morro Bay discharge must be off for two weeks during final Phase II sampling.
8/01/86	Chlorination begins at Morro Bay WWTP as per EPA administrative order.
7/08/86	RWQCB Morro Bay Study, Phase I begins.
6/03/86	Interagency meeting to discuss RWQCB Morro Bay Study workplan.
5/30/86	EPA issues administrative order to City of Morro Bay to chlorinate effluent.
4/25/86	SWRCB approves Cleanup & Abatement funding for Morro Bay Study.

Appendix E

Morro Bay Study Chronology (continued)

4/18/86	EPA-RWQCB joint Fact Finding Public Workshop in Morro Bay pollution sources.
4/03/86	Fish & Game closes sport shellfish harvesting - Morro Bay.
4/02/86	RWQCB Executive Officer requests Cleanup & Abatement funding to study Morro Bay bacterial sources.
3/26/86	SWRCB Budget Review Committee suggests Morro Bay Special Study be funded under Cleanup and Abatement Program.
3/12/86	Department of Health Services closes Morro Bay to commercial shellfishing.
3/86	Department of Health Services asks RWQCB to order disinfection of Morro Bay city wastewater effluent.
12/10/85	Regional Board staff, DOHS, FDA, and City of Morro Bay meeting at EPA, Region IX, to discuss preliminary results of FDA study.
12/12/85	Qualman Oyster vs State of California "Claim for Damages." Qualman files suit against RWQCB.
11/08/85	Letter from Douglas Price, DOHS, stating, FDA "study indicates rather conclusively effluent could enter bay."
10/07-10/18/85	FDA Study of Morro Bay effluent.
10/04/85	Revised plan for Morro Bay Study provided by FDA.
8/09/85	RWQCB provides comments on proposed FDA study of Morro Bay.
7/05/85	Preliminary study plan for Morro Bay outfall study by FDA.

Appendix E

Morro Bay Study Chronology (continued)

6/06/85	RWQCB meeting with DFG, FDA, DOHS, and City of Morro Bay concerning Morro Bay contamination and proposed FDA study.
3/29/85	301(H) Permit issued by EPA administrator.
3/08/85	EPA/RWQCB joint public hearing on 301(h) waiver permit for Morro Bay City.
3/05/85	DOHS letter to R submitting data obtaining during their study of Morro Bay and expressing their belief that pollution was from the City's outfall.

State of California
California Regional Water Quality Control Board
Central Coast Region

April 18, 1986

JOINT ENVIRONMENTAL PROTECTION AGENCY AND REGIONAL BOARD

WORKSHOP ON

SOURCE OF CONTAMINATION OF MORRO BAY

PURPOSE:

High coliform counts have been detected in Morro Bay waters and the State Department of Health Services has closed Morro Bay to commercial shellfishing. Subsequently, the State Department of Fish and Game closed the Bay to sports shellfishing. On the presumption that the municipal waste discharge into Estero Bay is the source of contamination, the Department of Health Services requested the Environmental Protection Agency and the Regional Board to modify the waste discharge permit for the City of Morro Bay and Cayucos Sanitary District to include continuous disinfection of the effluent. The Regional Board and Environmental Protection Agency called this workshop to gather information on all the potential causes of poor water quality in the Bay in an effort to determine if a change in the waste discharge permit should be considered.

STAFF ANALYSIS:

Regional Board staff has reviewed the "Morro Bay Ocean Outfall Study--Preliminary Report" (draft) by the Food and Drug Administration, dated December 6, 1985 (FDA Report, Attachment 1). This report is supposed to be finalized by the end of April, 1986. Staff recently received a report by the Department of Health Services, Sanitary Engineering Branch, Santa Barbara District, entitled "Sanitary Investigation of Shellfish and Water Quality, Morro Bay, September 1984 and January 1985" (DOHS Report, Attachment 2).

Staff observations on the draft FDA report and the recently released DOHS report follow:

FDA REPORT:

Dye and coliform sampling were used to determine if the Morro Bay/Cayucos wastewater discharge could enter and contaminate Morro Bay. Sampling was performed when a southerly Estero Bay ocean current carried waste from the vicinity of the outfall terminus past the Morro Bay mouth. On a rising tide, large volumes of ocean water flood Morro Bay. FDA reportedly used DOHS

estimates of 2.2 billion cubic feet of water that enter the bay each tidal cycle (DOHS Report, page 12). Staff believes a more accurate figure is 2.2 billion gallons. A tidal prism of 2.2 billion cubic feet would require a tidal rise of 23 feet over the Bay's 2200 acres. This should be clarified, since FDA is using this estimate in its calculations of volume of effluent influx to Morro Bay.

FDA concluded from dye and coliform analyses at various monitoring stations south of the outfall that effluent rose from the outfall, traveled along the ocean surface southward, and sunk to the ocean bottom around Station 109, then continued along the bottom to Station 110, directly opposite the harbor entrance. No dye was detected in the Morro Bay entrance stations at 1830 hours (dye had been released to the outfall at 0920 hrs. on the morning of October 15, 1985), but the tide had not commenced flooding.

Staff agrees that dye concentrations and coliform counts follow the pattern indicated by the FDA. It's expected that effluent warmer than seawater would rise from the diffuser. This actually increases initial dilution as effluent travels through the entire water column rather than being trapped and confined by a warmer upper layer of ocean water. Initial dilution is one of the three mechanisms that reduce bacteria concentrations in ocean discharges. The other two components of attenuation are dispersion (plume spreading as it travels with the current) and bacterial decay in the hostile ocean environment. Staff believes these mechanisms can be seen at work in the FDA data. Effluent bacterial densities are reported at 23×10^6 total coliform and 11×10^6 fecal coliform (Most Probable Number, MPN, per 100 ml values from the last page of data in the FDA report), while outfall plume Station 101 had counts of 30,000 and 20,000 as median MPN for total and fecal coliform, respectively. Incidentally, the Morro Bay/Cayucos permit assumes an initial dilution of 170:1 for Ocean Plan compliance. The FDA data, if accurate, represent initial dilution of 767 and 550 for total and fecal, respectively. This indicates the outfall diffuser is performing three to four-and-a-half times better than expected.

The phenomenon of the sinking plume at Station 109 could be explained by the PG&E discharge of warm water. Attachment 3 is an infra-red aerial photo from Regional Board files showing the PG&E plume during a northerly current. A clockwise eddy is created by the Morro Rock 'peninsula.' It's reasonable to assume the PG&E plume goes west and then counter-clockwise during a southerly current. On a flood tide, warm water could then continue in this rotation into the Morro Bay entrance, with some recirculating through the PG&E intake structure adjacent to the Fish and Game dock in the harbor. City effluent plume temperatures (somewhat tempered by initial dilution) could cause the City's plume to be driven under the warmer PG&E plume, and could continue south and along the bottom to the entrance channel, held down by the thermal plume, on a flood tide. However, the entrance is much shallower and is subject to wave action and high current velocities, which should result in substantial mixing.

FDA has indicated to staff (telephone 4/9/86) that it assumes complete mixing by the time any effluent reached the Fish and Game dock next to the PG&E intake structure.

As already stated, FDA assumed that no effluent (dye or coliform) was detected in the entrance because, at the time of sampling, 1830 hrs., the tide had not commenced flooding. FDA detected dye at the F&G dock in the harbor later that night (2120 hours) during the next flood tide.

Staff notes that dye was not detected at the dock until a couple of hours into the flood tide. This seems odd, since dye was supposedly just outside the harbor entrance at low, slack tide. FDA used Figure 7 in the FDA report to calculate the quantity of effluent entering the Bay. FDA used 0.09 ppb (telephone 4/9/86) diluted in 2.2 billion cubic feet of incoming tidal prism and reported that over 50,000 gallons of City effluent entered the Bay during the studied tidal cycle (FDA Report, page 5). Regional Board Staff attempted to use FDA's methodology but calculated different results. A weighted average of the dye concentration found during the initial tidal cycle (figure 7, FDA report) yields 0.06 ppb rather than 0.09 ppb used by FDA. This is equivalent to 0.06 pounds of dye per billion pounds of Bay water, which yields:

$$\frac{0.06 \text{ \#dye}}{10^9 \text{ \# } H_2O}\left(2.2 \times 10^9 \text{ gal}\right)\left(\frac{8.34 \text{ \# } H_2O}{\text{Gal.}}\right) = 1.1 \text{ lb. dye in bay}$$

Since twenty pounds of dye were released into 440,000 gallons of effluent:

$$\frac{1.1 \text{ \# dye}}{20 \text{ \# dye in effl}}\left(440{,}000 \text{ gal. effl.}\right) = 24{,}200 \text{ gal effluent}$$

This represents a total physical dilution of:

$$\frac{2.2 \times 10^9 \text{ gal}}{24{,}200 \text{ gal.}} = 91{,}000:1$$

Therefore, without <u>any</u> decay, effluent coliform concentrations should be reduced to the following concentration at the F&G dock:

TOTAL

$$\frac{23 \times 10^6 \text{ MPN/100 ml}}{91{,}000} = 250/100 \text{ ml}$$

FECAL

$$\frac{11 \times 10^6 \text{ MPN/100 ml}}{91{,}000} = 120/100 \text{ ml.}$$

Bacterial decay due to factors including temperature, predation, salinity, and sunlight is commonly expressed in terms of t_{90}, or time for 90% reduction in bacterial concentrations. A t_{90} of two

to six hours is normally used for central coast outfalls. There is evidence that higher values are appropriate for nighttime t_{90}, due to elimination of solar radiation. The effect of decay over the ten hour travel time from the outfall diffuser to the F&G dock can be demonstrated as follows:

$$\text{Coliform} = \frac{\text{Concentration Without Decay}}{\exp\left[\frac{(2.3)(\text{travel time, hours})}{t_{90}}\right]}$$

Travel time, Hrs.	T_{90}	Total Coli., MPN/100 ml	Fecal Coli. MPN/100 ml
10	4	5.4	2.6
10	8	14	6.8
10	10	25	12
11	10	20	9.6
11	4	0.4	0.2

The FDA report has median total and fecal coliform concentrations at Station 004 (F&G dock) of 33 and 11.9, respectively. This would correlate very well with concentrations calculated above for t_{90} = 10 hours (a conservative nighttime value), ignoring any other sources of bacteria. It's unlikely that no other bacterial sources are represented by the Station 004 results. Staff believes this makes the four to six hour assumption for T_{90} very reasonable. The table above also shows the effects of an eleven hour travel time (assumed travel time to oyster beds) for the conservative assumption of T_{90} = 10 hours. The results are 20 and 9.6 median MPN for total and fecal coliform, respectively. The Basin Plan bacteriological objectives are 70 and 230 for median and ten percentile values, respectively, for total coliform in waters with shellfish. FDA refers to more stringent National Shellfish Sanitation Program guidelines for shellfishing waters of 14 median and 43 ten-percentile fecal coliform values. The values indicated above are still significantly less than even these more stringent NSSP guidelines. Calculations indicate a T_{90} of up to 20 hours would still reduce bacteria to Basin Plan objectives.

Staff analysis indicates the FDA report's other data support the assumption of typical bacterial decay rates. FDA reports City plume concentrations of about 0.3 ppb dye at Stations 113, 114, and 110. This indicates a physical dilution of 16,700:1 (5000 ppb dye in effluent/0.3ppb dye in plume). Resultant coliform concentrations, without decay would be:

TOTAL

$$\frac{23 \times 10^6}{16{,}700} = 1400 \text{ MPN}$$

FECAL

$$\frac{11 \times 10^6}{16{,}700} = 650 \text{ MPN}$$

FDA found median values of 155 total/69 fecal, 9 total/9 fecal, and 200 total/85 fecal at Stations 113, 114, and 110, respectively (values were reported as medians for 2, 4, and 3 samples at the respective stations). This would seem to represent percentage reductions due to decay of 0.6% to 14%. Travel time to these stations, according to the FDA dye study, was on the order of seven hours. These values (assuming an average of 7% decay factor) yields a T_{90} of six hours. Again, this correlates extremely well with staff assumptions (based on accepted engineering practice for ocean outfall design).

Staff questions the FDA report's dye concentration findings in the Bay. As stated, a weighted average of 0.06 ppb dye is reported at the F&G dock. The maximum concentration found at Stations 113, 114, and 110 was about 0.3 ppb dye at the bottom. Station 113 is about 0.7 miles away from the harbor mouth. How is it possible that the effluent plume was diluted only about 4:1 as it traveled nearly a mile to the mouth and entered Morro Bay along with 2.2 billion gallons of seawater? This question is even harder to answer and the in-harbor dye results are even more difficult to believe considering FDA's calculations that only 11% of the plume and the dye entered the Bay (staff calculations using FDA's data indicates about 6% entered the Bay). With mixing which occurs at the entrance to the Bay, dilution would be 44,000:1 using FDA's estimate of 50,000 gallons of effluent entering Morro Bay.

SUMMARY

If Bay dye results are accurate, bacterial concentrations coming into the Bay and reaching the oyster beds should be well within objectives for shellfishing. This is confirmed by bacterial results from the plume correlated with dye tracking. Also, dye results in the harbor are suspiciously high compared to open ocean plume concentrations.

DEPARTMENT OF HEALTH SERVICES REPORT

This report contains strictly bacterial monitoring results for two time periods (not coinciding with the FDA report), September 1984, and January-February 1985.

DOHS concludes from the data presented in appendices that Morro Bay is contaminated from the City's outfall as evidenced by total coliform values ranging from 49 to 230 MPN and fecal coliform ranging from 33 to 94 MPN/100 ml at Station 1B beyond the breakwater (DOHS report, page 2). Staff review indicates these values were for samples collected January 24 through February 1, 1985. The sample on the 29th was collected on an ebb-slack tide and the other samples were all during ebb tide (DOHS report, page 35). Obviously, this was when water was rushing out of the Bay, not into the Bay. The only creek analyses just before this sampling period were taken at Station 21 (upstream of CMC) with results of 490 total and 49 fecal coliform. On January 29th, Chorro Creek

(Station 16) had total and fecal coliform of 2400 and 49 MPN per 100 ml, respectively (DOHS report, page 41). DOHS considers all sampling periods in the report 'dry' periods (page 1) even though 0.06 inches of rain fell on January 28th, and 0.44 inches fell on January 7, 1985.

All creek samples, except Los Osos Creek, are extremely high in coliform counts in September 1984, sampling runs. DOHS acknowledges problems from creeks during stormy periods but states that bacterial problems are minimal during low creek flows (page 4). Other pollution hazards, besides the City's outfall in Estero Bay, cited in the DOHS report are California Men's Colony wastewater treatment plant (CMC), birds, boating activity, and urban street runoff.

Staff has investigated creek runoff problems and found Chorro Creek to have very high bacterial counts (e.g., 160,000 and 90,000 total and fecal coliform, respectively, at the Chorro Creek Road crossing on March 10, 1986). CMC's discharge was <2.2 MPN for both total and fecal coliform. The Regional Board has taken enforcement action against the Domenghini Dairy, located on a tributary to Chorro Creek.

Staff has also investigated storm drains and boat wastes as bacterial sources (Attachment 4). Boat holding tank pump-out stations in Morro Bay have been used only twice in five years, according to the harbor master. This means wastes from live-aboards, party boats, visiting boats and tour boats are being discharged without treatment into the waters of Morro Bay or the ocean.

A former Morro Bay boat dweller estimated that less than ten percent of live-aboards empty their waste in the open ocean. Morro Bay's entrance is dangerous much of the time," and live-aboard boats do not go out frequently.

Staff has also investigated City and private sewage pump stations along the Bay and is requiring improvements to stop raw sewage leaks and overflows. (Attachments 5, 6, and 7)

Staff has reviewed Morro Bay's receiving water monitoring program data from both before and after the new, longer outfall was put into operation and chlorination was stopped . There is no trend of increasing bacterial concentrations after stopping chlorination. If anything, there is evidence of water quality improvement.

CONCLUSION

The DOHS report concludes that the Morro Bay outfall is a significant source of pollution which needs to be improved. This is based on ebb tide samples at the harbor mouth when creeks draining to the Bay are high in bacteria counts and there is evidence of raw sewage discharges directly to the bay from boats.

The FDA report concludes City effluent entered the Bay during a southerly current and is a significant source of contamination. Staff agrees that during certain current and tidal conditions, traces of effluent will enter the Bay. Staff's interpretation of the data indicates it is not a significant source of contamination.

The Porter-Cologne Water Quality Control Act forbids Regional Boards from dictating methods of compliance. The Regional Board's charge is to take enforcement action based on violation of requirements. Receiving water monitoring data required by the City's NPDES permit shows consistent compliance with requirements since the City began using the new outfall into Estero Bay and stopped chlorination. Staff review of DOHS/FDA data does not implicate the City's outfall in bacterial problems in Morro Bay. Without additional data, a change in requirements or enforcement against the City would be unjustified.

RECOMMENDATIONS

1. Receive responses to Staff analyses from DOHS and FDA.

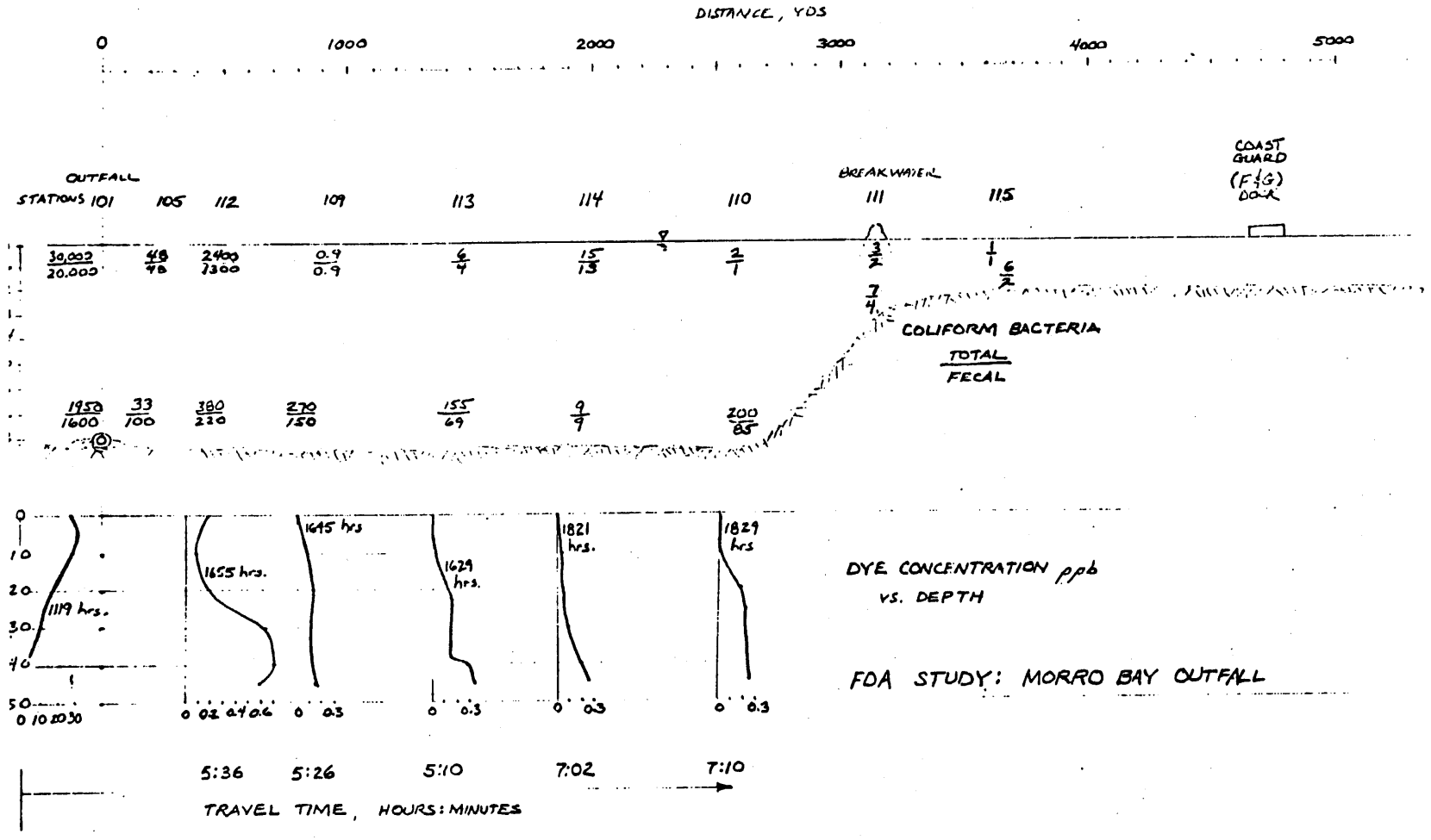
2. Receive other available information concerning the contamination in Morro Bay.

3. Intensify City's receiving water monitoring program in conjunction with EPA 301h permit, including monitoring of the entrance to Morro Bay for coliform bacteria.

4. Request County and City to investigate live-aboard boat discharges.

5. Conduct comprehensive bacterial study of Morro Bay as requested by Regional Board, using Cleanup & Abatement Account funds. Pursue appropriate regulatory and/or enforcement action to abate contamination of shellfishing areas.

6. Consider designation of shellfishing areas, as appropriate, as referenced in Finding No. 12 of the 301h permit for the Morro Bay/Cayucos waste discharge.



DYE CONCENTRATION ppb
VS. DEPTH

FDA STUDY: MORRO BAY OUTFALL

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