Rec'd 5/28/04

DRAFT REPORT FOR BODEGA BAY-CAMPBELL COVE FECAL BACTERIA CONTAMINATION SOURCE IDENTIFICATION AND TIDAL CIRCULATION STUDY AND SOURCE ABATEMENT PROJECT

May 24, 2004

LEAD AGENCY

County of Sonoma Department of Health Services
Division of Environmental Health
3273 Airway Drive, Suite D
Santa Rosa, CA 95403

COOPERATING AGENCIES

Bodega Marine Laboratory
2099 Westside Road
Bodega Bay, CA 94923

North Coast Regional Water Quality Control Board
5550 Skylane Blvd., Suite A
Santa Rosa, CA 95403

State of California Department of Parks and Recreation
The Russian River-Mendocino District Headquarters
25381 Steelhead Blvd.
Duncans Mills, CA 95430

INTRODUCTION

PROBLEM STATEMENT

Campbell Cove State Beach, Bodega Harbor has a frequent problem with microbiological water quality. Preliminary water sampling and assessment during several tidal cycles have shown no clear trends that would identify the origins of the intermittently persisent high bacterial readings. There was insufficient information to adequately assess the sources of this fecal bacteria contamination.

STATEMENT OF PURPOSE

The mission is to produce environmental information to assess sources of fecal bacteria contamination and to implement source abatement measures as deemed appropriate.

SCOPE OF PROJECT

The general goals are:

- Tidal circulation studies for identifying physical watershed characteristics influencing pollutant inputs, transport and fate utilizing Acoustic Doppler Current Profilers, dye studies with aerial photography, temperature and conductivity measurements
- Fecal bacteria source identification by screening for water quality problems utilizing fecal bacteria indicator organism and ribotyping fingerprinting analyses
- Establishing source abatement measures for improving trends in water quality

APPROACH AND TECHNIQUES

PROJECT MANAGEMENT AND ADMINISTRATION

A list of Contract Task deliverables is included in the Appendix. A one page contract summary form was completed and submitted to the State Water Resources Control Board (SWRCB). Contracts and contract modifications were awarded with the Regents of University of California, Bodega Marine Lab (BML) for tidal circulation studies, with the Institute for Environmental Health for ribotyping and with the State Parks and Recreation for assessment report of animal species at Campbell Cove.

A project survey form has been completed and a copy is in the Appendix. Quarterly progress reports were submitted with the exception of the period of February 1, 2004

through April 30, 2004 where approval received from Connie Perkins to waive this quarterly report and prepare the draft final report instead.

PERMITS

The County of Sonoma Department of Health Services (SCDHS) and the North Coast Regional Water Quality Control Board (NCRWQCB) applied for a Notice of Categorical Exemption for the dye utilized in the tidal circulation studies (Copies in Appendix).

QUALITY ASSURANCE PROJECT PLAN

SCDHS and NCRWQCB prepared and obtained approval from the SWRCB for a Quality Assurance Project Plan (QAPP).

TIDAL CIRCULATION, OCEAN WATER SAMPLING AND SOURCE IDENTIFICATION STUDY

Tidal circulation study

SCDHS, NCRWQCB and BML staff conducted an investigation into tidal circulation patterns at Bodega Harbor/Bay, California and a copy of this report is in the Appendix.

Two Acoustic Doppler Current Profilers (ADCP) were purchased and used by BML to study circulation and exchange patterns within Bodega Harbor/Bay. Temperature and conductivity (salinity) measurements were collected during the current studies that enabled research personnel to understand the exchange of water between the ocean and the harbor and how this exchange varies on an hourly and weekly basis (Copy in Appendix).

BML coordinated with the NCRWQCB to deploy patches of dye at microbiological "hot spots" within the harbor to examine advection and dispersion rates from these points. These dye patches were followed over the course of a tidal cycle with dye concentrations monitored with aerial photography and fluorometry. In addition, BML coordinated with the NCRWQCB to deploy dye during a flood tide to examine the near surface transport and dispersion of water coming into the harbor from the coastal ocean.

Several major features of circulation within Bodega Harbor were found that can influence contaminant transport and retention:

- Current data from ADCPs in both the front and rear of the harbor show velocities that are constant throughout the water column, enabling a large amount of exchange between the bay and the harbor water. The flow velocities are about two times greater near Campbell Cove than at the rear of the harbor.

- Temperature surveys of the harbor by CTD casts during different tidal phases showed a large intrusion of cold bay water during flood tides that affected water

properties all the way to the rear of the harbor. Likewise, during ebb tides, surface-warmed rear harbor water was able to flow out to the mouth of the channel within one ebb tide. This suggests that there is a very large degree of flushing of the harbor by bay water during each tidal circulation.

- Tidal flushing is particularly important in the vicinity of Campbell Cove where consistent, vertically uniform tidal flows have the effect of near total replacement of water in that basin each tidal cycle.

- Drifters released in the harbor corroborated the CTD and ADCP data, and showed currents transporting surface water in the channel the entire length of the harbor within one tidal cycle.

- Drifters released more than a couple hundred meters outside the harbor were not entrained into the flood tide current entering the harbor.

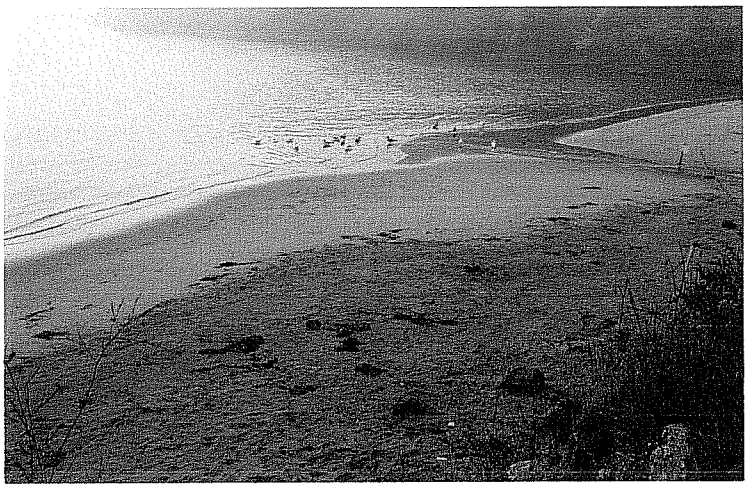
- Dye release experiments also showed that advective transport within the harbor is quite rapid, particularly within the main channel. Water in the rear marinas and over the tidal flats did not have such high velocity, but drainage did occur over the tidal flats, primarily into the main channel, and dispersion in regions of low current velocity was still significant enough to dilute dye patches to non-visible levels over a tidal cycle. No dye tracers were ever detected more than a single tidal period from their release time.

Source Identification Study

Water quality sampling for indicator bacteria occurred during the dye releases to indicate patterns in the fecal pollution signal that will help identify potential sources. On October 2, 7, 9, 14, and 16, 2003 SCDHS staff collected five-ocean water and one-sediment samples at six sampling locations on the NCRWQCB's boat where NCRWQCB staff also performed conductivity, salinity and temperature readings of ocean water at Campbell Cove, Bodega Harbor and Bodega Bay (Seal Rock). The ocean and sediment samples were submitted to the County of Sonoma Public Health Laboratory who performed indicator bacteria and membrane filtration on the samples that were later submitted to the Institute for Environmental Health for ribotyping.

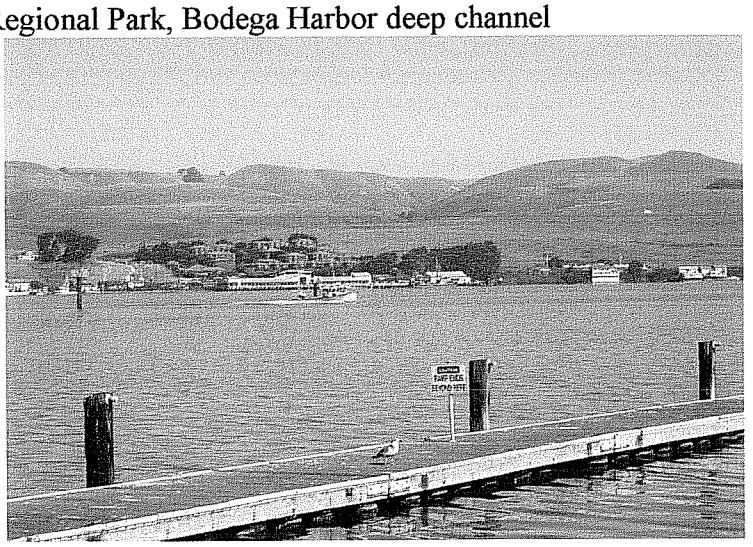
The six sampling locations were selected based on the tidal circulation study conducted in May 2003, and are illustrated as follows:

1. Campbell Cove Sediment and 2. Campbell Cove ocean water knee deep



3. Gaffney Point about knee deep

4. Westside Regional Park, Bodega Harbor deep channel



5. Campbell Cove, deep channel

6. Seal Rock, Bodega Bay

Results of indicator bacteria were mostly non-detect to low for Gaffney Point, Westside Regional Park and Campbell Cove deep channel, and varied from non-detect to moderate concentrations at Seal Rock.

Striking results were found in the Campbell Cove sediment concentrations that had significant concentrations of Total Coliform, E.coli and Enterococcus. Surf zone samples in knee-deep water at Campbell Cove varied from very low to exceeding State AB 411 standards. The results are illustrated in the Table below with bacteria readings per 100 ml:

Date	Total Coliform *Sediment*	Total Coliform *Ocean Water*	E. coli *Sediment*	E.coli *Ocean Water*	Enterococcus *Sediment*	Enterococcus *Ocean Water*
10/2	5,794-19,863	<10-86	4,884-17,329	<10-10	8,664->24,192	<10-65
10/7	2,755->24,192	86-3,255	2,613->24,192	74-2,755	Not reported	Not reported
10/9	3,255-11,199	<10-3,654	1,421-6,488	<10-1,722	6,131-14,136	<10-1,658
10/14	13,300->241,920	52-624	6,630->241,920	31-359	11,450-23,590	<10-189
10/16	1,000-17,100	30-41	1,000-14,800	20-41	3,100-13,400	41-158

For background purposes, on October 27, 2003 Environmental Health staff collected sediment samples during the last scheduled sampling event at the AB 411 beaches. All of the sediment samples came back mostly non-detect with the exception of Campbell Cove that were significantly elevated.

Environmental Health staff conducted a spatial sampling of sediment at Campbell Cove on October 28, 2003 to determine if fecal contamination was limited to the immediate influence of the creek flow from the "Hole-in-the-Head" or if the entire stretch of beach was contaminated. Sediment samples were collected at the center of the creek in-flow to the ocean and at 10 yards and 20 yards on either side of the creek. Results indicated that all sediment samples were significantly contaminated.

A sample of the water from the culvert originating from the "Hole-in-the-Head" pond was analyzed for fecal bacteria contamination and for general mineral and nutrient concentrations to determine if the pond water is a potential source of contamination or source of nutrients that would promote bacterial growth. The bacteria results for the creek were low with 52 Total Coliform/100 ml, <10 E.coli/100 ml and 10 Enterococcus/100ml. Results for general mineral and nutrients indicate the freshwater flow is not contributing nutrients to the sand/sediment.

SCDHS staff collected animal fecal droppings that were submitted to the Institute for Environmental Health E. coli library for the following birds and animals:

- Sea lion
- Harbor seal

- Raccoon
- Dog
- Deer, black tail
- Western Sea Gull
- Godwitt
- Willit
- Cormorant
- White Pelican
- Brown Pelican

On December 16, 2003, SCDHS received the California Department of Parks and Recreation's Assessment Report on mammals and birds at Campbell Cove State Beach area to develop a database for possible subsequent sampling of unknown fecal material (Copy in Appendix).

Additional project sampling was conducted utilizing ribotyping fingerprinting analysis through the services of the Institute for Environmental Health. A report from the Institute for Environmental Health revealed avian and marine mammals as the predominant source of fecal bacteria contamination at Campbell Cove (Copy in Appendix).

No students were hired or used during the project, so there are no timesheets to submit.

ABATEMENT MEASURES

Campbell Cove Vault Privy Dye Test

Fluorescein dye was added to the vault privy at Campbell Cove and monitored for several weeks in December 2002. A slight increase in fluorescence in one sample of the water from a culvert downslope of the privy prompted another test with more frequent sampling. The vault privy overlooking Campbell Cove beach was charged with 1 liter of 10% fluorescein dye again on April 1, 2003.

Staff from BML, SCDHS, and NCRWQCB collected water samples from the stream at the culvert from the "Hole-in-the-Head" pond located adjacent to Campbell Cove beach, and from the harbor at Campbell Cove Beach. Sample collections began on March 17, 2003 and continued on a daily basis through April 30, 2003, and on May 5 and 6, 2003. Water samples were stored in the dark and returned to NCRWQCB for fluorescence measurement with a Turner Model 10 ® fluorometer.

Fluorescence readings stayed relatively constant in the culvert water and fluctuated more widely in the harbor water. Two large peaks were observed in the harbor water samples on two separate occasions, both a result of high turbidity. The peaks were not characteristic of a dye leak from the vault. A dye leak from the vault would rise to a peak, then slowly taper off over a long period of time.

The data is summarized below:

- Fluorescence readings ranged from:
  - culvert – 67-82, with 90% less than 76
  - harbor – 56-430, with 90% less than 110
- Culvert readings varied without pattern over the six weeks
- Harbor readings fluctuated between 56 and 110 most of the time. Two large spikes, each on a single day were associated with elevated turbidity:
  - 270 on March 28
  - 430 on April 14

These observations do not support a hypothesis that the vault privy leaks and is contaminating either the stream that flows through the culvert or the harbor. The two spikes in fluorescence in the harbor were caused by elevated turbidity, and are not indicative of a vault leak. Therefore, staff has eliminated the vault privy as a source of bacterial contamination at Campbell Cove. Fluroescein dye was placed in the vault privies at Doran Park, the Jetty Privy and the Jetty Campground Privy. No dye releases were detected.

Based on the dye studies of these vault privies, no contracts were executed with the State of California Parks and Recreation or with the County of Sonoma Parks and Recreation Department.

PROJECT ACCOMPLISHMENTS

The goals of the project as outlined in Contract 01-078-550-1 for tidal circulation study and identification of the source of the fecal bacteria contamination at Campbell Cove State Beach have been met, but not met for source abatement measures. Campbell Cove itself could be a source for contaminants found there. As with the tidal flats, dye released near shore had a tendency to hug the shoreline, dispersing alongshore but not offshore. Also, dye released in the center of the cove at flood tide dispersed more or less radially, and some became entrapped in the eelgrass nearshore while the main patch advected up the channel. If there was a contaminant source at or near the shoreline it is possible that contaminants could persist in the boundary layer for longer than one tidal cycle. One scenario in which this could occur is if there were a persistent source along the shoreline that introduced fecal bacteria contaminants steadily, then, the slow flushing of these ankle-deep waters would allow them to persist or accumulate overt time.

The project included an investigation of tightness testing for vault privies in the vicinity of the beach utilizing a dye test that revealed the vault privies are not a source of fecal bacteria contamination, which was also corroborated by the ribotyping study. In addition, bacteria sampling on numerous occasions of the freshwater flow from the culvert draining onto the beach was always clean of fecal bacteria. A general mineral analysis of

this freshwater flow also revealed there were no nutrients (e.g., phosphorus and nitrogen) that would add to bacterial growth in the beach sediment.

The source abatement phase of the project is still a current need. Ribotyping identified avian and marine mammals as the source of fecal bacteria contamination. This raised the question of what is the relative risk to human health from these sources of fecal bacteria contamination.

The project group submitted a Project Questionnaire to utilize Prop 13 funds to conduct a pathogen study of ocean water/sediment at Campbell Cove to detect pathogenic viruses, bacteria and protozoa associated with avian and marine mammals. In addition, the group planned to study bird and marine mammal surveys of this beach to determine the effect the freshwater flow of water from the "Hole-in-the-Head" had on attracting these animals. The end result would have been a project to construct a diversion of the freshwater source away from the beach so as to reduce the source of fecal bacteria residue. In their letter of April 15, 2004, the SWRCB mentioned this pathogen study did not qualify for funding because it is not a capital improvement project and did not meet the goals of the Clean Beaches Initiative program.

Whereas a lot was learned about tidal circulation and the specific source of bacterial contamination being avian and marine mammals, the outcome of the project does not result in preventing or reducing non-point source pollution. Based on the results of this project, the SCDHS, NCRWQCB, BML and State Parks and Recreation have determined two actions need to be taken:

1. Notification to the public is needed to advise about sand/sediment being subject to periodic bacterial contamination due to bird and/or marine mammal waste with a notice that digging or disturbing sand/sediment may pose health risks (Copy in Appendix). This notice will be permanently posted at appropriate locations at the beach. SCDHS will continue to monitor Campbell Cove as part of its AB 411 beach sanitation monitoring program and post the beach with warnings or closures to avoid contact with ocean water as based upon sampling results.

2. Request will be made of the State Department of Health Services to determine the relative risk to human health from avian and marine mammal fecal bacteria contamination and report findings to SCDHS for further determination of risk assessment at Campbell Cove from birds and marine mammals. A copy of this report will be sent to the State Department of Health Services as part of this request.

APPENDIX

List of Deliverables in Contract 01-078-550-1

Project Survey Form

Notice of Exemptions

Laboratory Invoice for Institute for Environmental Health

Study Reports

- Assessment Report of Animal Species at Campbell Cove
- General Mineral/Nutrient report for the "Hole-in-the-Head"
- Bodega Harbor Circulation Study
- Turbidity/Salinity/Tide Charts
- Microbiological Source Tracking Ribotyping Report

Public Notice for Sand/Sediment

List of Deliverables in Contract 01-078-550-1

SONOMA COUNTY-LIST OF DELIVERABLES IN CONTRACT 01-078-550-1

Task	Deliverables	Due Date	Submission Date (s)
1.2	Quarterly Progress Reports (QR)	6/1/04	8/15/02; 11/7/02; 2/11/03; 5/1203; 8/7/03; 11/12/03; 2/9/04
1.5	Contract Summary Form	8/9/02	8/14/02
1.6	Subcontractor Documentation	6/1/04	See Tasks below
1.7	Project Survey Form	6/1/04	5/26/04
2.1	Required Permits	8/1/02	N/A
3.1	QAPP	8/1/02	3/27/03
4.1.1	Contract with BML	3/1/04	3/26/03
4.1.2	Receipt for two ADCP	3/1/04	10/6/03
4.1.4	Summary of initial findings-ADCP	3/1/04	See Task 1.2 (8/11/03 QR)
4.2.1	Contract with BML	3/1/04	3/26/03
4.2.3	Summary of initial findings-Dye study	3/1/04	See Task 1.2 (8/11/03 QR)
4.3.1	Student timesheet with summary	3/1/04	N/A
4.3.2	Laboratory invoices-circulation study	3/1/04	5/26/04
4.4.1	Contract with SP and laboratory	3/1/04	11/18/03
4.4.2	Conduct sampling collection-ribotyping	3/1/04	See 11/18/03 QR
4.4.3	Laboratory analysis with a summary	3/1/04	3/29/04
4.5.1	Draft interim report	3/1/04	See Task 1.2 (8/11/03 QR)
4.5.2	Final interim report	3/1/04	3/9/04
5.1.1	Results of testing at Campbell Cove	12/31/03	See Task 1.2 (2/18/03 QR)
5.1.2	Results of testing at Doran Park	12/31/03	See Task 1.2 (2/18/03 QR)

Remaining contents of Final Report are in Master File for reference.