

**MAMALA BAY STUDY**

**STUDY MANAGEMENT**

**PROJECT MB-1**

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# **1 INTRODUCTION**

## **1.1 Authorization**

In 1990, in an action before the United States District Court for the District of Hawaii, the Sierra Club Legal Defense Fund, representing the Sierra Club and Hawaii's Thousand Friends, filed suit against the City and County of Honolulu, alleging violation of the Clean Water Act (CWA) and the terms and conditions of the National Pollution Discharge Elimination System (NPDES). The suit contended that the City, although it had petitioned for a waiver from the secondary treatment provisions of the CWA as provided for in Section 301h of the act and had received provisional approval from the Environmental Protection Agency, had in fact failed to meet the national deadline for upgrading treatment to the secondary level. The Sierra Club et. al., maintained that the City was not exempted from the provisions of the act while final action by EPA was pending, while the City asserted its good faith intentions to comply with the requirements of the CWA, contending that its discharge to Mamala Bay through its Sand Island outfall did not degrade the waters of the Bay so as to pose unacceptable risks to public health and other beneficial uses.

Considering the merits of arguments on both sides of the issue and apparent uncertainties in factual evidence concerning the actual quality of Mamala Bay waters, the court issued a consent decree<sup>1</sup> requiring a thorough investigation of actual conditions in the Bay and alternative measures to control pollution originating from both point and non-point sources. The decree directed the establishment of the Mamala Bay Study Commission ("the Commission") and a contribution of \$8,000,000 to perform the investigation.

A second suit by the Sierra Legal Defense Fund, alleging that the City's Honouliuli Waste Water Treatment Plant bypassed untreated sewage in violation of the CWA, was decided in favor of the plaintiff. In addition to fines imposed by the court, the City was required to provide an additional \$1,000,000 for the Mamala Bay Study ("the Study"), and the existing Mamala Bay Study Commission was charged additionally to investigate specific effects of the Honouliuli discharge on the marine environment.

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<sup>1</sup> CIV. No. 90-00219, filed November 19, 1991

## **1.2 Commission Formation**

The Mamala Bay Study Commission, as stipulated by order of the court, was to consist of three individuals who by their scientific and technical backgrounds were qualified to direct the Study and who had no prior association with either of the parties to the litigation. Commissioners selected to direct the Mamala Bay Study and who have served throughout the study period are:

**Rita R. Colwell, Ph.D. Sc.D., President of the Maryland Biotechnology Institute,  
University of Maryland**

Dr. Colwell is a microbiologist and marine scientist, active in research and teaching. Her research has largely been focused on marine biotechnology and the molecular genetics of marine and estuarine bacteria including studies of the microbiology of Chesapeake Bay, coastal recreational waters and the deep ocean. Her leadership and participation in government, academia and industry have been instrumental in advancement of the biological sciences.

**Gerald T. Orlob, Ph.D., P.E., Professor Emeritus, Department of Civil and  
Environmental Engineering, University of California at Davis**

Dr. Orlob is a civil engineer whose experience in teaching, research, and professional practice has been largely devoted to water quality management. He has been responsible for the development and application of systems analysis techniques, including mathematical models of natural aquatic systems, to aid decision makers in selection of preferred alternatives for pollution control.

**Jerry R. Schubel, Ph.D., President, New England Aquarium; Professor Emeritus and  
formerly Dean and Director of Marine Sciences Research Center, State University  
of New York at Stony Brook**

Dr. Schubel is President and CEO of the New England Aquarium in Boston. Prior to assuming this position, he was Dean and Director of Marine Sciences Research Center at the State University of New York at Stony Brook for 20 years. Dr. Schubel's professional, research and teaching efforts have been dedicated to various aspects of coastal oceanography including estuarine research, and development and implementation of coastal zone management. He has served on numerous state and regional marine science and management advisory committees.

### **1.3 Study Administration**

The Mamala Bay Study Plan was conceived and administered by the Commission, comprised of Drs. Colwell, Orlob, and Schubel. The Commissioners were supported in overall management of the Study by four able assistants: Ms. Camilla Saviz at the University of California at Davis, Dr. William Straube at the Maryland Biotechnology Institute of the University of Maryland, and Mss. Shino Tanikawa and Jeanne Gulnick at the State University of New York at Stony Brook. Each assumed important roles in the execution of the Study. Ms. Saviz maintained records of work progress and the fiscal status of all contracted projects, and organized the editing and publication of the Study Report. Dr. Straube coordinated the work of the microbiology team and guided the workshop on this topic in Honolulu. Ms. Tanikawa developed the Mamala Bay Newsletters and coordinated graphics and design of the Study Report. Ms. Gulnick assisted during initial stages of the Study. All four assistants coordinated and reported on meetings of principal investigators.

Administration of funding provided for the Study was the responsibility of the Hawaii Community Foundation, with specific direction provided by Ms. Janis Reischmann. Ms. Janet Oshiro administered contractual relationships between the Foundation and study contractors, disbursement of payments to contractors, and investment of funds during the period of study.

Throughout the study period the Commission maintained an office within the Foundation offices, initially at 222 Merchant Street, Honolulu and later at 900 Fort Street Mall, Suite 1300, Honolulu. Administrative assistance at the office was provided for various intervals during the study by Mss. Julie Cone, Andrea Ferst, Veronica Carreira and Dawn Burton.

### **1.4 Commission Objectives**

The Mamala Bay Study Commission was formed for the purpose of organizing the Study, developing the Study Plan, selecting competent contractors to carry out specific tasks of the Study, administering performance of the contractors, and providing overall scientific direction leading to appropriate recommendations for improvement of water quality in Mamala Bay. Specific purposes of the Commission as set forth in the decree were:

- (a) To study point and non-point sources of pollution discharges into Mamala Bay,
- (b) To analyze the effects of these sources on the marine environment and public health (including recreation),
- (c) To make appropriate recommendations on how to reduce pollution levels and improve water quality in Mamala Bay.

The investigation to be undertaken, as directed by the Commission, was to be designed to resolve certain issues that had arisen between the litigants or that remained uncertain because of perceived deficiencies in prior studies. Among these were:

(a) To define properties of ocean circulation in Mamala Bay, including the effects on circulation of Trade and Kona winds and any other factors that determine the magnitudes and currents and transported contaminants that may adversely affect public health and the Bay's aquatic ecosystem.

(b) To characterize sewage plumes from the City's outfalls, including the extent of rise due to buoyancy, degree of dilution achieved and frequency of plume surfacing.

(c) To quantify point and non-point sources of pollution and their relative impacts in terms of loading, frequency in extreme events and proximity to sensitive areas of exposure to humans and aquatic ecosystems.

(d) To characterize the fates of indicator organisms and pathogens originating from point and non-point sources and to determine the detectability and survivability of these organisms in the marine environment.

(e) To assess the risks to public health from exposure to waters contaminated by point and non-point sources of pollution to Mamala Bay.

(f) To identify and quantify the effects on ecosystems of point and non-point sources of pollution of Mamala Bay.

(g) To identify and evaluate practical and implementable alternatives for the control of pollution in Mamala Bay.

## **1.5 Study Setting**

For the purposes of the Study, Mamala Bay was defined by the consent decree to include all ocean areas from Diamond Head to Barber's Point, Oahu. As defined by the Commission, the study area extended offshore of the Bay coastline and included all ocean waters and point sources of pollution that could directly impact the quality of the near-shore aquatic environment. In addition, the study area extended a sufficient distance inshore of the coastline to include significant non-point sources that could affect the quality of near-shore waters. These included sources within the Mamala Bay watershed such as the Ala Wai Canal. The limits of the study area and locations of different sampling sites are shown in figure 1.1.

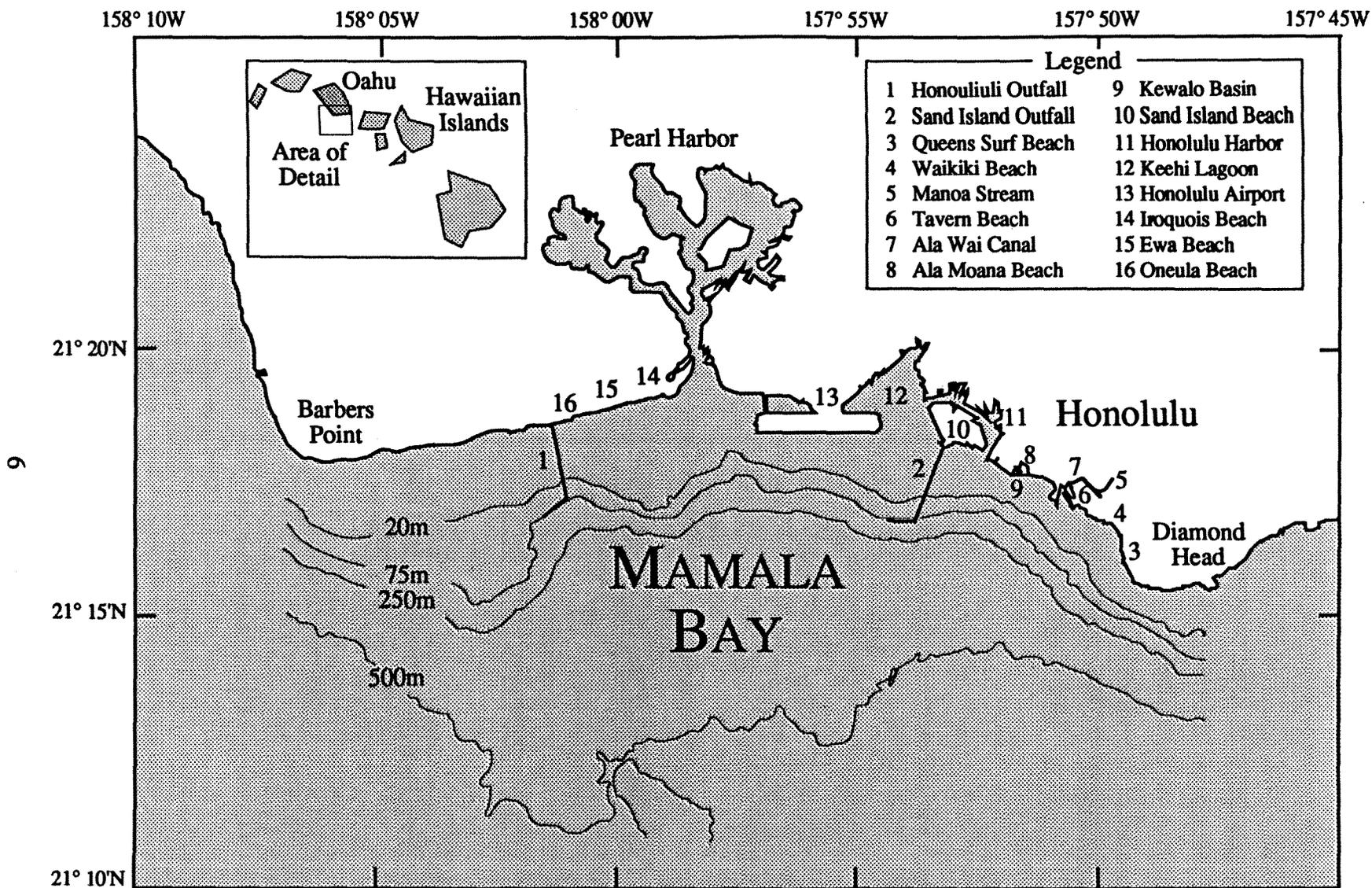


Figure 1.1 Mamala Bay Study Area

## **2 INTEGRATED COASTAL MANAGEMENT**

Realizing the complexity and the wide range of specific issues to be addressed in the Mamala Bay Study, and the fact that prior to this occasion there had never been a truly comprehensive assessment of a coastal water quality problem on the scale presented by Mamala Bay, the Commission decided to carry out the mandated study in the context of "Integrated Coastal Management," an approach that takes a holistic view of the coastal system to ensure that it meets society's goals and expectations. The approach places a high value on ecosystem integrity, on human health, and on those values and uses important to society. Integrated Coastal Management utilizes the most advanced scientific and technical knowledge to evaluate the threats (risks) to important values and uses, and to develop, evaluate and select among alternative strategies those that will reduce risks to acceptable levels.

The first step in applying the integrated coastal management process to Mamala Bay was identification of societal priorities. The next was to identify the major sources of threats to these priorities. This involved defining the zones of influence within which specific activities should have been managed to assure attainment and maintenance of priority qualities of Mamala Bay. This was followed by identification of specific hazards to the integrity of the bay and assessment of risks they imposed on human health and ecosystem viability.

Once the relative human health and ecological risks had been established, priority issues were identified. These became the bases for comprehensive comparative risk management analysis. The output of the analysis was an array of management alternatives, individually and in different combinations, and an assessment of what each of these could contribute to attainment of societal goals for the system by reducing risks to human health and the ecosystems of Mamala Bay.

Certain steps in the integrated coastal management process were based initially on existing data and information, but where these were found to be insufficient, the Study was to provide the means to expand the information base. In designing the Study, the Mamala Bay Commission required the utilization of all relevant information available through the study's data base or developed within study projects and free exchange of information among all participants. Teamwork among key scientists and decision makers is intrinsically a part of the integrated management process. All principal investigators were charged to be active in implementing the process, exchanging results of research

and field investigation, and transforming the output of studies into management strategies. Most of the team activity actually took place in technical workshops, principal investigator meetings, and research seminars organized and facilitated by the Commission. Key personnel from all projects participated in a series of workshops conducted approximately semi-annually over the three-year period of the Mamala Bay Study. Additionally, information exchange was implemented through frequent interaction among Study project groups as necessary and through a study-supported data base and electronic bulletin board.

### **3 MAMALA BAY STUDY PLAN**

#### **3.1 Objectives**

Having adopted the conceptual framework for the Study --Integrated Coastal Management-- the Commission proceeded with development of a Study Plan. A condition of the consent decree required preparation of a detailed work plan, schedule, and estimated budget for the investigation it considered necessary for assessment of environmental impacts of pollution on Mamala Bay. This plan was developed by the Commission and made available in July 1992 to the public and all parties who might have an interest in participating in the Study. It defined a series of interrelated projects organized to address and resolve the important issues outlined in the consent decree, as well as certain others that the Commission considered essential to formulation of a practical and implementable pollution control plan for Mamala Bay. The principal objectives of the Study Plan are described briefly below.

The overall goal of the Mamala Bay Study was to develop a water quality management plan for Mamala Bay. To achieve this goal the Study had to provide a sound scientific basis for selecting appropriate actions to protect and enhance the environmental quality of Mamala Bay. This required meeting at least the following specific objectives:

1. To collect, collate, and organize of all relevant basic data and scientific information on factors affecting the environmental quality of Mamala Bay,
2. To identify locations and characterize quantities and qualities of all important point and non-point sources of pollution to Mamala Bay and to determine their relative contributions as functions of seasonal changes in surface runoff and wastewater discharges through outfalls,
3. To obtain a quantitative description of the hydrodynamics of interaction between wastewater plumes discharged from ocean outfalls and the ambient ocean environment, including a description of the density structure in the initial mixing zones at the Sand Island and Honouliuli outfalls,
4. To obtain a quantitative description of the three-dimensional ocean current system of Mamala Bay, including seasonal variability of drift and wind-driven currents,

tidal effects on currents, and oceanographic mechanisms affecting transport, dilution, and dispersion of polluting substances in Mamala Bay,

5. To characterize microbiological components of the polluting wastewaters, using techniques to quantify concentrations of indicator organisms and pathogens and to assess the viability and persistence of human pathogenic bacteria and viruses in the ocean environment,

6. To simulate the transport and fate of polluting substances and microorganisms (bacterial and viral pathogens) of sewage origin in the ocean environment and to estimate the potential for exposure by contact with contaminated water in areas of recreational use,

7. To estimate the concentration of disease-producing microbiological organisms in discharges from point and non-point sources and to assess their persistence in the ocean environment and potential transport to receptors,

8. To assess risks to public health by exposure to contaminated ocean waters,

9. To determinate impacts of wastewater discharges on indigenous aquatic flora and fauna, including potential changes in the benthic habitat, and

10. To develop alternatives for improvement of water quality in Mamala Bay and guidelines for monitoring the efficacy of implemented management strategies.

### **3.2 Study Management**

The Study was carried out under the overall direction of the Mamala Bay Study Commission, the responsibilities of which included the following:

1. Prepare a detailed study plan and estimated budget,
2. Select areas of scientific study,
3. Define scope of investigation(s),
4. Allocate budget to various tasks and projects,
5. Solicit interest of qualified investigators,
6. Prepare and advertise requests for proposals,
7. Review proposals of potential contractors or consultants,
8. Select and hire supporting staff, contractors, and consultants,
9. Prepare and publish interim study reports,
10. Organize and conduct scientific seminars and technical workshops,
11. Manage overall Study progress,
12. Hold public briefing on study findings,
13. Compile the Study report and evaluate findings of all component projects,
14. Select qualified individuals to conduct a peer review of the Study report, and
15. Make appropriate recommendations on actions to improve the water quality of Mamala Bay.

The Commission assumed the responsibility to assure completion of the study in a timely and cost-effective manner.

## **4 STUDY PROJECTS**

Because the Mamala Bay Study was clearly a multi-disciplinary investigation, it was unlikely that any single organization would be able to address all of the issues of concern. Execution of the study program required the expertise of scientists and engineers from many disciplines, coordinated and directed by the Commission. In recognition of the complexity of issues and the unique talents required to address specific goals, the Study program was divided into discrete projects. These were assigned separately or in groups to best serve the overall mission of the Study.

Specific projects that comprised the Mamala Bay Study and the individuals and organizations responsible for the work are described briefly as follows, in the order found in the Study report:

### **MB-1 Mamala Bay Study Management**

Commissioners: R. R. Colwell, G. T. Orlob, and J. R. Schubel

The Commission provided overall scientific and technical direction to the Study, developed the Study Plan, prepared requests for proposals, selected review panels, approved contractors, coordinated project work, organized and conducted workshops, conducted public briefings, and prepared the Study report.

### **MB-2 Mamala Data Base**

Garcia and Associates (formerly BioSystems, Inc.); Dr. W. J. Kimmerer

This project resulted in the development of a data base that provided a repository for factual data and information relevant to water quality of Mamala Bay. It included both historic data as well as data collected by other study participants and made these available through an electronically accessible bulletin board. Upon completion of the Study, the data base was moved to the University of Hawaii for future maintenance and public accessibility via the Internet.

### **MB-3 Pollutant Source Identification**

Kinnetic Laboratories, Inc., Lahaina, HI; Mr. M. Stevenson

The goal of Project MB-3 was to provide quantitative measures of point and non-point sources and their relative contributions to pollution of Mamala Bay to be used in near-field and far-field modeling of contaminant transport in Mamala Bay. Sources were

characterized in terms of key quality constituents, loadings imposed on receiving waters, and time series of polluting episodes over the period of the Study.

#### **MB-4 Plume Modeling**

Georgia Institute of Technology, Atlanta, GA; Dr. P. J. W. Roberts

This project provided quantitative estimates, based on both field and model studies, of the near-field behavior of sewage plumes originating from the diffusers of the Sand Island and Honouliuli outfalls. Determinations were made of initial dilutions, plume thickness, trapping heights and frequency of surfacing of the plumes, which were then provided as input to the far-field models of pollutant fate and transport.

#### **MB-5 Modeling Transport and Fate of Pathogenic Organisms in Mamala Bay**

HydroQual, Inc., Mahwah, NJ; Drs. A. F. Blumberg and J. P. Connolly

Three-dimensional hydrodynamic and pollutant fate models of Mamala Bay were used to determine the concentrations and frequencies of occurrence of indicator bacteria and other pollutants of sewage origin from either point or non-point sources at various locations in Mamala Bay. The hydrodynamic model utilized ocean current and tidal measurements to provide estimates of velocities and depths throughout the bay which were then used to drive a model of the transport and fate of pollutants for a one year period. The models provided a basis for determining risks to swimmers and bathers of contracting diseases related to exposure to pollutants discharged from point and non-point sources.

#### **MB-SP3 Ala Wai Canal Dye Study**

HydroQual, Inc., Mahwah, NJ; Dr. J. P. Connolly; Kinnetic Laboratories, Inc. Lahaina, HI; Mr. M. Stevenson

A dye study was conducted in the Ala Wai Canal to evaluate transport of the discharge into Mamala Bay. This project was added as a necessary component for calibration and verification of the hydrodynamic and water quality models. Results are documented in the MB-5 project report.

#### **MB-6 Ocean Current Measurements**

Science Application International Corporation; Drs. E. Waddell and P. Hamilton

Ocean conditions of tidal oscillation, current velocity and direction were continuously monitored at a minimum of eleven sites in Mamala Bay and around Oahu

throughout approximately 18 months of the Study. Some instrumentation was relocated as necessary to obtain more detailed descriptions of the current structure at different sites, for example, near the mouth of the Ala Wai Canal. Data, augmented with data from state, local and federal agencies, were provided as input to the far-field hydrodynamic model and the near-field plume model, and also served for model calibration.

**MB-SP2 Plume Dynamics and Dispersion in Mamala Bay, Hawaii**

University of Southern California, Los Angeles, CA; Drs. B. H. Jones and T. D. Dickey

This project was added to the Study with the objective of performing an in-situ tracer study to develop a better understanding of dispersion and dilution characteristics of the effluent plume discharged from the Sand Island outfall. Results were used for comparison with the plume model developed by project MB-4 and the pollution fate and transport model developed by project MB-5.

**MB-7 Microbiology**

The primary goal of this project - actually a group of five sub-projects and two special studies - was to characterize quantitatively the incidence of indicator and pathogenic organisms in the waters of Mamala Bay. The several investigators each addressed unique issues, such as those related to techniques of sampling and identification, the relationships between indicators and pathogens, and the survival of various microbial species. Field studies were carried out collaboratively with all team members contributing. Special studies and investigators were:

**MB-7 Characterization of the Microbiological Quality of Water in Mamala Bay**

University of Hawaii; Dr. R. Fujioka

Objectives of this project were to evaluate concentrations of standard indicator organisms and alternative fecal indicators in water and sediment and to identify potential sources of these organisms. A special supplemental study was carried out to assess the potential impacts of the Ala Wai Canal on indicator organism incidence on adjacent bathing beaches.

**MB-7 Overall Impact of Sand Island Outfall on the Incidence of Pathogens in Mamala Bay**

University of Arizona; Drs. C. Gerba and I. Pepper

This study included assessment of the occurrence and quantification of bacterial, viral, and protozoan pathogens in water and sediment, estimation of decay rates and identification of sources. Findings of one component of this project, carried out to assess public health risks associated with various levels of exposure to viral and protozoan contaminants, is documented in a separate report titled "Risk of Swimming-Acquired Illnesses in Mamala Bay," and located immediately following this MB-7 report.

**MB-7 Molecular Investigation of the Effect of Pollution on Pathogenic and Indigenous Bacteria in Mamala Bay**

University of Maryland; Dr. R. T. Hill

Objectives of this project included using molecular techniques to evaluate impacts of pollution sources on the incidence and survival rates of bacterial pathogens, as well as effects on indigenous bacterial communities.

**MB-7 Microbial Aspects of Point and Non-point Source Pollution in Mamala Bay**

University of Hawaii; Dr. M. R. Landry

The focus of this project was on the effects of protozoan grazing, sunlight exposure, and swimmers' contact on the incidence of indicator organisms in the near-shore areas of Mamala Bay.

**MB-7 Coliphage and Indigenous Phage in Mamala Bay**

University of South Florida; Drs. J. H. Paul and J. B. Rose

This project provided an evaluation of the distribution of phages infecting marine and coliform bacteria near outfalls, in near-shore beaches and along the Mamala Bay shoreline, and an assessment of their usefulness as indicator organisms.

**MB-7 Viability of *Cryptosporidium parvum* in Marine Waters**

University of South Florida; Dr. J. B. Rose

Objectives of this project were to use containment chambers designed specifically for in-situ aquatic studies to evaluate the ability of *C. parvum* to survive or remain viable

in marine waters and sediments in Mamala Bay. Study results contributed to evaluation of public health risks as a result of recreational use of Mamala Bay waters.

MB-SP4 Molecular Detection of *Staphylococcus aureus* in waters of Mamala Bay, Hawaii

University of Maryland; Dr. R. T. Hill; University of Hawaii; Dr. R. Fujioka

This special project was added to evaluate the presence of *Staphylococcus aureus* associated with contamination from point and non-point sources in Mamala Bay. Field sampling programs were conducted from September 1995 to November 1995.

MB-9 Ecosystem Response

The primary goal of this project was to identify receptors and resources in Mamala Bay and to quantify the impacts of pollutant discharges from the ocean outfalls and other contaminant sources on benthic and pelagic communities in Mamala Bay. The project was completed by several investigators at the University of Hawaii, each examining a different component of the Mamala Bay ecosystem, but collaborating on field studies with other team members participating in the Study. Field sampling sites were also coordinated with the modeling and current measurement components of the Study to ensure compatibility among the different Study sites. Special studies and investigators were:

MB-9 Definition of Indicator Species for Pollution Monitoring in Mamala Bay

University of Hawaii; Dr. J. H. Bailey-Brock

This study provided an evaluation of sediment-dwelling benthic organisms to identify species suitable for use as indicators of enrichment by treatment plant effluent. In addition to nutrient enrichment, studies of benthic communities were performed to compare effects of sediment grain size, food availability and seasonal variability.

MB-9 Impact of Point and Non-Point Source Pollution on Coral Reef Ecosystems in Mamala Bay

University of Hawaii; Dr. R. W. Grigg

The focus of this project was on detection and quantification of the impacts of point and non-point sources of pollution on coral reef ecosystems in Mamala Bay. The corals were studied at cell, population and community levels to detect any variation in

calcification and growth patterns, species abundance and diversity, and community structure.

**MB-9 Shallow Marine Community Response to Point and Non-Point Sources of Pollution in Mamala Bay, Oahu. Part A: Fish and Coral Communities**

University of Hawaii; Drs. E. A. Kay, J. H. Bailey-Brock, R. E. Brock

Objectives of this project included quantification of the response of benthic and fish communities to point and non-point source discharges in Mamala Bay based on observation of communities at specific sites presumed to receive varying contaminant loads from polluting sources.

**MB-9 Shallow Marine Community Response to Point and Non-Point Sources of Pollution in Mamala Bay, Oahu. Part B: Micromolluscan Assemblages and Algal Biomass**

University of Hawaii; Drs. E. A. Kay, J. H. Bailey-Brock, R. E. Brock

As a companion to the Fish and Coral Community study (Part A) described above, this study was performed to evaluate the impacts of pollutants discharged from point and non-point sources on micromollusks and benthic algae.

**MB-9 Effects of Sewage Discharges and Stream Runoff on Phytoplankton Communities and Water Quality in Mamala Bay**

University of Hawaii; Drs. E. Laws and D. Ziemann

Goals of this project included determining the effects of nutrient enrichment due to discharges from the Sand Island and Honouliuli outfalls on phytoplankton productivity, biomass and composition, and their contributions to dissolved inorganic nitrogen and phosphate concentrations in Mamala Bay. Objectives also included characterization of nutrient and chlorophyll concentrations at recreational beaches and other locations throughout Mamala Bay to determine the impacts of sewage discharges and stream runoff on water quality in those locations.

**MB-9 Temporal Variability in Macrobenthic Community Structure and the Effect of Freshwater Runoff**

University of Hawaii; Drs. S. A. McCarthy, E. A. Kay and J. H. Bailey-Brock

This project was carried out to evaluate the temporal variability in community structure and biomass of shallow, soft-bottom macrofauna communities in Mamala Bay

and their response to freshwater runoff events. Spatial variability based on exposure to freshwater runoff was also examined.

**MB-9 Recruitment Patterns of Marine Benthic Invertebrates in Mamala Bay: A Process-Oriented Measure of Ecosystem Response to Pollution**

University of Hawaii; Dr. C. R. Smith and Mr. P. E. Parnell

This project was conducted to assess the effects of pollutants discharged from the outfalls and from non-point sources including the Ala Wai Canal, Pearl Harbor and Keehi Lagoon on the availability of planktonic larvae of marine invertebrate and the recruitment of macrobenthos.

**MB-10 Environmental Impacts on Receptors and Resources**

Project MB-10 consisted of five sub-projects, each of which required analyzing and consolidating results of other Mamala Bay Study projects to assess impacts of pollution sources on environmental resources and aquatic life and to evaluate the effects on public health and recreational use of Mamala Bay waters. The investigators, in collaboration with other Study principal investigators, developed a set of management strategies and alternatives based on Study findings. Component studies and investigators were:

**MB-10 Management Alternatives and Management Measures for Waste Discharges to the Mamala Bay Ecosystem**

PRC Environmental Management, Inc., Honolulu, HI; Dr. K. Courtney; Kinnetic Laboratories, Inc., Santa Cruz, CA; Dr. J. M. O'Connor

The objectives of this project included developing specific recommendations for reducing the quantity of pollutants discharged into the Bay and for improving inflow water quality based on analysis of historical and current point and non-point source contaminant discharges to Mamala Bay and evaluation of results presented in other Mamala Bay Study projects.

**MB-10 Identification of Stressors of Concern in the Mamala Bay Ecosystem**

Kinnetic Laboratories, Inc., Santa Cruz, CA; Dr. J. M. O'Connor

This project was conducted to identify stressors and receptors of concern in Mamala Bay. The sources, distribution and effects of physical, chemical and biological

stressors were identified, including characterization of heavy metal and pesticide concentrations discharged to Mamala Bay.

**MB-10 Effects of Effluent from the Barber's Point and Sand Island Outfalls on the Mamala Bay Ecosystem**

Romberg Tiburon Center, Tiburon, CA; Dr. W. J. Kimmerer; Kinnetic Laboratories, Inc., Santa Cruz, CA; Dr. J. M. O'Connor

This project focused on evaluating effects of sewage discharges on water quality, sediment quality, flux of organic material to the sediments, sediment loading and benthic species' abundance and composition in Mamala Bay. Analyses were based on several years' data and published reports together with data and information developed by the Mamala Bay Study.

**MB-10 Proposed Monitoring Plan to Assess Environmental Quality in Mamala Bay and the Mamala Bay Watershed**

Kinnetic Laboratories, Inc., Santa Cruz, CA; Dr. J. M. O'Connor

The principal goal of this project was to develop the basis for a monitoring program aimed at gathering data and information for future evaluation of the condition of Mamala Bay. Specific recommendations were made towards development of a program to monitor the quality of treatment plant influent and effluent and discharges from non-point sources. A plan was devised for assuring and controlling the quality of data gathered.

**MB-10 Infectious Disease Public Health Risk Assessment for Mamala Bay**

Eisenberg, Oliveri, and Associates, Oakland, CA; Drs. A. W. Oliveri and R. C. Cooper

Primary objectives of this project included application of a quantitative microbial risk assessment model to estimate the level of risk associated with exposure to Mamala Bay waters in the near-shore region and identification of parameters important in assessment of public health risks and development of water quality management and monitoring programs for Mamala Bay. Potential changes in risks to public health were also evaluated based on order-of-magnitude variations in pathogen concentrations in near-shore areas from sources other than recreational users of Bay waters.

**MB-11 Water Quality Management in Mamala Bay**

**Mamala Bay Study Commission and project Principal Investigators**

Objectives of this project were to identify and assess alternative management strategies developed as a result of Study findings and to recommend actions to improve and enhance water quality in Mamala Bay. This project also included a sub-component:

**MB-11A Wastewater Management Strategies in an Integrated Coastal Management Plan for Mamala Bay**

**Consulting Engineers, Cambridge, MA: Dr. D. R. F. Harleman**

This project was developed specifically to devise management strategies for improving the quality of effluent discharged at the Sand Island and Honouliuli wastewater treatment plants. Assessments were based on treatment plant performance evaluations and comparison of the effectiveness of upgrade processes including chemically enhanced primary treatment, secondary treatment, disinfection, dissolved air flotation and preaeration. This project included a sub-component:

**MB-SP1 Point Source Characterization and Control Options for Mamala Bay**

**Consulting Engineers, Cambridge, MA: Dr. D. R. F. Harleman**

This project was added as a necessary component to the Study to evaluate existing and future wastewater treatment processes and their effects on pollutant discharges and to examine the engineering and economic aspects of step-wise changes in reducing pollution from point source discharges to Mamala Bay. Results are reported in appendix 8.2 of the project MB-11A report.

**MB-12 Mamala Bay Study Report**

**Mamala Bay Study Commission and project Principal Investigators**

Results of the Mamala Bay Study are documented in a series of technical and scientific reports prepared by the principal investigators that collectively address the issues set forth in the Court's decree. These have been assembled to form the Mamala Bay Study Report with supporting appendices and a peer review and a public comment report. The executive summary, authored by the commissioners, presents the basis for the Study, a review of principal findings, conclusions reached, and recommendations of the Mamala Bay Study Commission for protection and enhancement of the water quality of Mamala Bay.

## **5 MAMALA BAY STUDY REPORT**

**This Mamala Bay Study report was prepared in order to document in detail the scientific investigations conducted during the course of the Study and to present the conclusions and recommendations of the Commission in response to the consent decree. Chapter MB-1, prepared by the Mamala Bay Study Commission, describes the background for the Study, the charge to the Commission under the consent decree, the specific objectives of the Study and its organization, and brief descriptions of the various projects and responsible contractors. Chapters MB-2 through MB-10, MB-11A, MB-SP2 and MB-SP4 present the results of investigations contracted by the Commission, authored by the responsible principal investigators, each with their independent conclusions and recommendations. Chapter MB-11, Water Quality Management in Mamala Bay, was prepared by the commissioners themselves, drawing on results of contracted studies and the counsel of principal investigators. Conclusions and recommendations are those of the Commission alone.**

## **6 ACKNOWLEDGMENTS**

The Mamala Bay Study Commission is pleased to acknowledge the contributions of the many individuals and agencies who have facilitated this first comprehensive investigation in the concept of Integrated Coastal Management. We especially wish to express our appreciation to our able assistants, Mss. Camilla Saviz, Shino Tanikawa and Jeanne Gulnick and Dr. William Straube, for their invaluable expeditious and conscientious attention to the many technical and administrative details of the Study. It could not have been completed in a timely manner without their dedication.

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