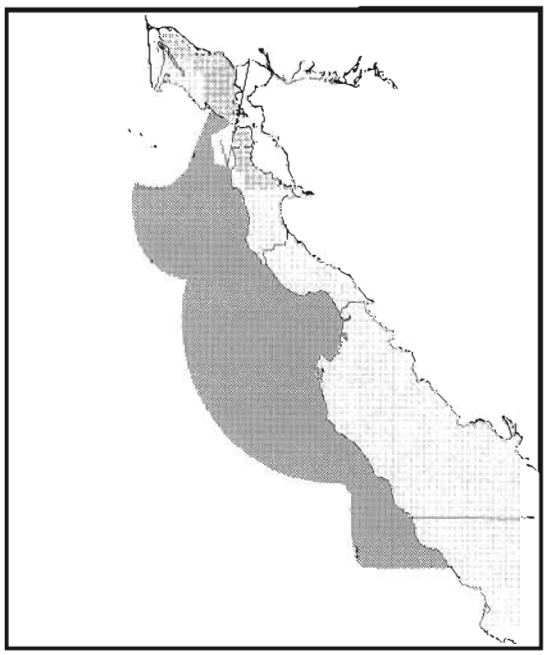
September 1993

SCIENTIFIC RESEARCH PLAN FOR THE MONTEREY BAY NATIONAL MARINE SANCTUARY



Prepared by the

MONTEREY BAY NATIONAL MARINE SANCTUARY
RESEARCH ADVISORY COMMITTEE

National Ocean Service, Office Of Ocean and Coastal Resource Management, Sanctuaries and Reserves Division

National Oceanic and Atmospheric Administration

U.S. Department of Commerce

Table of Contents

I. Introduction

The purpose of the Monterey Bay National Marine Sanctuary (MBNMS) is to enhance resource protection and preserve the natural beauty and bounty of the marine ecosystems within its boundaries (Figure 1). This can be accomplished by improving our understanding of the Sanctuary environment, resources and qualities; resolving management problems; and coordinating the flow of information among the research institutions, agencies and organizations in the area. Research results will be used for making management decisions about resource protection and to develop and improve education programs for visitors and others interested in the Sanctuary.

The opportunities for marine research within the Sanctuary abound. Past research studies have provided important baseline information about the area, and the diversity of habitat types and communities provides a wealth of opportunities for a variety of research programs. For example, the Monterey Canyon provides a unique opportunity to engage in deep-water marine research without extensive offshore voyages. The accessibility of extensive coastline makes feasible studies on the natural processes at the land-sea interface. Integrating the research program of the Elkhorn Slough National Estuarine Research Reserve (the waters of which are within the Sanctuary) with the deep sea and coastal research efforts underway will increase our understanding of the role of estuaries in coastal productivity. Finally, the marine research institutions within the area (Appendix A) provide an exceptional resource to draw upon in furthering our understanding, and thus the management of, the Sanctuary's resources.

Effective management of the MBNMS requires the inauguration of a research program that coordinates the existing research programs and addresses management issues. The Sanctuay Research Advisory Committee (Appendix B) is a forum for discussion of research programs, addresses management issues, and disseminates research information as widely as possible. NOAA's Sanctuaries and Reserves Division also can provide limited, yet long-term, logistical and financial support for research studies consistent with the goals of the Sanctuary program. Strategies for the research program to promote more informed management aim to:

- Compile existing data to describe the resources and provide baseline information;
- Encourage continual information exchange among the organizations and agencies undertaking research and making decisions that affect the Sanctuary;
- Establish a framework and procedures for administering a research program to ensure that projects are responsive to management concerns and that research results contribute to improved management of the Sanctuary;
- Encourage multidisciplinary studies that integrate research efforts in the coastal, estuarine, nearshore, open ocean, and deep sea ecosystems;

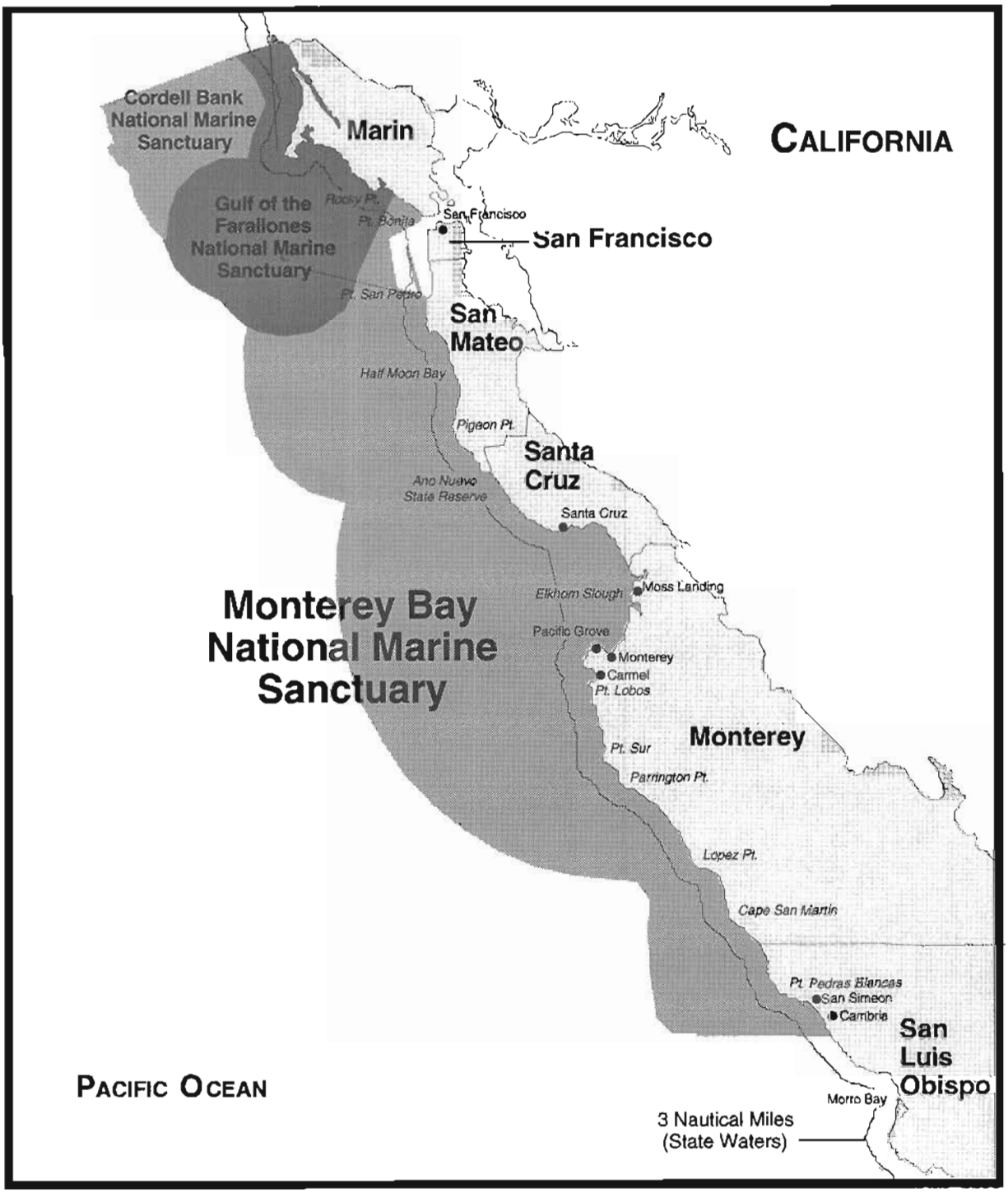


Figure 1: Monterey Bay National Marine Sanctuary

- Coordinate data collection on the physical, chemical, geological and biological resources and processes of the Sanctuary to target specific information needs and avoid duplication;
- Initiate a monitoring program to assess environmental changes due to natural and human processes;
- Identify the range of effects on the environment resulting from proposed or predicted changes in human activity or natural phenomena;
- Incorporate research results into an interpretive education program in a format useful for the general public; and
- Evaluate the effectiveness and efficiency of the research program and its integration with resource protection and education objectives.

Overall, the Sanctuary research program is intended to broaden our scientific understanding of the Sanctuary, develop research programs that enhance understanding, and provide management with the scientific information necessary to make informed decisions. The research program consists of five major project categories: (1) existing knowledge, (2) monitoring, (3) experimental studies, (4) modeling, and (5) information management. Each of these categories is described in more detail in Section III: Long-term Framework.

The Monterey Bay National Marine Sanctuary Research Advisory Committee has prioritized research topics for the Sanctuary. The committee appointed a number of its members as chairs of disciplinary subgroups. These chairs collected suggestions from experts in their fields to begin the prioritization process, the results of which are summarized in Appendix C. The remainder of this document explains the long-term research framework and short-term priorities of the Monterey Bay National Marine Sanctuary.

The Sanctuary research programs will emphasize a multidisciplinary, multi-institutional, integrative approach that engenders regional cooperation on basic and applied scientific issues. The large number of research institutions in the area provide an ideal framework for cooperative work among State, Federal, private agencies, and researchers. The educational institutions in the area will be useful in disseminating research results and training new researchers. The geographic location of the Sanctuary provides an excellent opportunity to pursue research that investigates the effects of human activities on the resources and the marine environment. The data collected from these studies will document the Sanctuary's value as a productive ecosystem and focus for public recreation, and provide the basis for estimating the effect of present and future land- and water-use practices on the Sanctuary's resources.

II. Potential Environmental Impacts

The primary objective of the National Marine Sanctuary Program is resource protection. The resources and qualities of the Sanctuary area are exposed to many potential impacts from natural and anthropogenic sources. Research and monitoring needs are evaluated relative to the perceived magnitude of these impacts. Any of these priorities may change as the perceived impacts and associated management issues change. The natural and anthropogenic impacts to the Sanctuary resources that will direct research and monitoring priorities (in no particular order) include :

Non-point Source Pollution

Non-point source pollution includes all contaminants entering the Sanctuary that have no defined or identifiable source. Examples include soil erosion; agricultural, silvacultural, and livestock runoff (e.g., pesticides, soil, fecal matter); runoff from bridges and streets (e.g., petroleum products); atmospheric deposition of volatilized pollutants (e.g., acid rain); and coastal development, construction, and maintenance runoff (e.g., petroleum products, fertilizers, solvents, cleaners, paint residue).

Point Source Pollution

Point source pollution includes all contaminants entering the Sanctuary from defined, identifiable sources. Examples include sewage outfalls (e.g., fecal matter, heavy metals); storm sewer outfalls (e.g., pollutants from streets and industrial areas); National Pollutant Discharge Elimination System (NPDES) permitted municipal/industrial outfalls (e.g., sewage treatment plants, desalination plant); dredge spoil disposal; and ocean dumping.

Commercial Activities

Some commercial activities conducted in the Sanctuary may affect Sanctuary resources. Examples include dredging, aquaculture, kelp harvesting, commercial fisheries and ecotourism.

Recreational Activities

Recreational activities conducted in the Sanctuary for personal enjoyment and relaxation may affect Sanctuary resources. Examples include tidepooling, fishing and boating (e.g., powerboats, personal motorized water craft, kayaks, anchoring).

Unpredictable Anthropogenic Events

This category includes all infrequent and unpredictable events that affect the Sanctuary and its resources. Examples include hazardous material or petroleum spills, ship groundings, and the introduction of new species.

Natural Perturbations

Although effects of natural perturbations may not be manageable, they still need to be studied. Understanding natural threats, and the changes they may cause, is useful for distinguishing and interpreting between natural and anthropogenic effects. Natural perturbations include severe weather conditions (e.g., severe storms, flooding), climatic change (e.g., sea level rise, El Niño-southern oscillation (ENSO)), geophysical events (earthquakes, tsunamis, undersea landslides) and natural biological phenomena (harmful algal blooms, other biotoxins).

III. Long-term Framework

The long-term objectives of the Sanctuary research program are not expected to change in the near future. This is a sequential framework with each of five categories of research relying on information from the previous categories.

A. Existing Knowledge

Gathering existing information on environmental conditions, communities, habitats, cultural resources and management practices in the Sanctuary provides a basis for comparison so that monitoring efforts can be designed to detect changes. From the studies we can profile the features and processes of the natural environment; determine abundance, distribution, and interaction of the living resources; determine distribution and status of historical resources; and describe the pattern of human activity in the Sanctuary from prehistoric times to the present. Examples of this type of study include: (1) descriptions of the environmental conditions, including existing geologic and physical oceanographic (e.g., ocean currents) information, including seasonal variations; (2) descriptions of the ecological communities, including lists of species and habitats; (3) descriptions of human interactions and their impacts on the ecosystem; (4) descriptions of the historical and cultural context and resources; and (5) collection and production of base maps of the MBNMS area. These studies will gather the existing knowledge on a factor or set of factors at a given point in time. It is expected that new studies will be initiated as gaps in information are identified and new factors require study.

B. Monitoring

Effective Sanctuary management requires an understanding of long-term changes in the status of the resources and their environment. Long-term monitoring is a way to detect and document these changes in environmental quality, ecology, and human activity and determine if changes in management strategies are needed. The primary purpose of the monitoring program will be to detect change, determine its causes, whether natural or anthropogenic, and develop and evaluate management strategies. Overall, the monitoring program will assist in our understanding of the general health of the Sanctuary. This program should include pollution monitoring studies and studies monitoring the population dynamics of species, in all habitats within the Sanctuary's boundaries. Indicator species and critical habitats should be identified and monitored to detect possible changes. Changes in the relative distribution of these species could indicate natural or anthropogenic threats to Sanctuary resources. Monitoring the natural functions of the land and sea interface, as well as human interruptions of those functions, will increase understanding of the relationships between ocean and terrestrial ecosystems. Results of the monitoring program will be applicable to basic scientific research as well as academic, educational and applied management goals. NOAA's Sanctuaries and Reserves Division may provide funding to support monitoring efforts, including augmenting funding of existing monitoring programs.

Examples of environmental factors to be monitored include: (1) status and trends of

contaminants in Monterey Bay, such as those studies presently underway with the NOAA and State Water Resources Control Board Mussel Watch Programs; (2) environmental factors, such as wind, sea level, and temperature, collected by coastal stations, offshore data buoys, and satellites; (3) changes in the abundance over various life stages of invertebrates and fish; (4) fluctuations in the abundance of whale, pinniped and seabird species in the Sanctuary; (5) biological input of organics and fecal coliforms from pinnipeds; and (6) the fate of enteric pathogenic bacteria in Monterey Bay and West Coast waters in general.

Certain activities and their effects, both individually and cumulatively, should be monitored. These include: (1) commercial vessel traffic; (2) recreational activities; (3) sport fishing, commercial fishing and nature observation activity; (4) natural and anthropogenic (e.g., sand mining) erosion and sedimentation; (5) fishery/mammal interactions, such as the coincidental catch of sea otters and birds in gill nets, and the competition between sport divers and otters for abalone; (6) pesticide usage; (7) sewage discharge; (8) dredge spoil disposal; and (9) reoccurring road repair debris "side-casting" along the coast.

Another important component of the monitoring program is the assessment of the effectiveness of management strategies. Once new management strategies have been put in place, usually in response to a detected change in the environment or use of the Sanctuary, monitoring must continue to determine whether the management strategy is having the desired effect. In most cases, each new management strategy will require the design and implementation of specific monitoring activities to augment the long-term monitoring program envisioned by this plan.

C. Experimental Studies

Experimental studies will be encouraged to test hypotheses and understand natural processes. Additional experimental research should be conducted to fill in the data gaps identified during the compilation of existing knowledge. Because the Sanctuary is an ideal system for understanding natural processes, this research should result in better understanding of the oceanography, ecology, and environmental quality of the Sanctuary. This research will also address specific management concerns, such as appropriate uses of the Sanctuary and known impacts to natural resources.

Examples of experimental studies include: (1) manipulation of farming techniques to see how they influence water quality and abundance of organisms in the Sanctuary; (2) creation of harvest refugia to evaluate the effects on fishery resources; (3) effects of sea otters as major predators on kelp bed communities; (4) recovery rates of algae, invertebrates, marine mammals and sea birds associated with different cleanup methods after oil spills; (5) use of different types of armoring to mitigate coastal erosion; (6) possible effects of desalination plants; (7) wetland restoration options and performance standards to ensure success from an ecosystem perspective; and (8) dependence of anadromous and migratory species, throughout their life cycles, on Sanctuary resources. Results of these types of studies should be communicated to the Sanctuary Manager to be used to evaluate management strategies.

D. Modeling

Three types of modeling activities (numerical simulations, ecosystem models, and statistical models) will be used to interpret data, guide field programs, test hypotheses, and predict potential outcomes from proposed uses and thereby influence management decisions. Modeling efforts will be based on the information gathered from the baseline, monitoring and experimental studies. As more information is gathered in these endeavors the models will be modified and refined continuously. Modeling efforts can be used to analyze the causes and consequences of ecosystem changes and predict the effects of new and more intense human activity in the area. Unlike the monitoring program, some of these studies may be predictive, short-term and directly targeted to an immediate management issue. Examples of modeling studies include: (1) determining and predicting the effects on marine mammals from boating activity; (2) predicting the flow of an inadvertent discharge (such as a fuel spill) into the Sanctuary; (3) modeling the transport of sediment in the Sanctuary; and (4) estimating the impact of the loss of kelp habitats on higher trophic levels. These types of models are useful for determining effective management strategies. Once strategies are in place, monitoring information will determine their effectiveness and be used to refine the model.

E. Information Management

Information management is important to provide area researchers, educators and appropriate decision makers with the most up-to-date research results. Exchange of information will foster cooperative efforts among researchers, and will promote more effective Sanctuary management. Information exchange with other National Marine Sanctuaries will be encouraged so that various approaches to similar management problems can be shared. The Sanctuary research program may serve as a focal point to disseminate existing information and new research results. Examples of information management include: (1) developing a database system to catalog and distribute information; (2) creating an electronic information network to facilitate more timely and efficient information exchange; (3) establishing a geographical information system (GIS) to incorporate scientific and historical/cultural information gathered within the Sanctuary; and (4) incorporating the results of research projects and subsequent management decisions into the education and public outreach programs developed for the Sanctuary.

These priorities address the issues most vital to Sanctuary management as identified by the disciplinary subcommittees. Priorities will be reexamined on a biennial basis. Environmental perturbations that currently impact the Sanctuary resources (see section II), will help determine the most pressing management issues to be addressed. In addition to the current priorities there may be unexpected events, both natural and anthropogenic, that induce immediate research priorities. These may be to mitigate immediate threats to Sanctuary resources or to take advantage of and study unusual environmental conditions.

Current research priorities are listed below. Compilation of existing information and monitoring studies were given higher priority as these efforts are the basis for the other research categories.

A. Existing Knowledge

Site Characterization Document

The top priority under this category is to complete the site characterization document. The project should be funded in Fiscal Year 1994 and is expected to be completed and published within two years. The project will entail a comprehensive search of all published and unpublished literature associated with the Sanctuary, including, but not be limited to: government reports, theses, dissertations and other student reports, final reports of grants and other competitive awards, scientific literature, and books. The collected information will be synthesized into a comprehensive site characterization document describing the Sanctuary which will include:

- Descriptions of the environmental conditions that shape the Sanctuary. This includes existing geologic and physical oceanographic (e.g., ocean currents) information.
- Descriptions of the ecological communities. This should include lists of all species and habitats, including habitat descriptions and uses, and depictions of the geographical location of features and the known range of identified species.
- Descriptions of ecosystem functions. This should include a conceptual model of the ecosystems, specifically a graphic representation of interactions and energy flow between species groups and their habitats.
- Descriptions of human interactions and their known impacts on the ecosystem.
- Descriptions of the historical and cultural context and resources.
- Identification and descriptions of existing research and monitoring programs.
- Descriptions of management strategies for the Sanctuary. This will include activities such as an analysis of research, education, monitoring, water quality management, contingency planning, damage assessment and restoration needs. This section will focus on identifying the data gaps to determine the baseline information necessary to fully characterize the existing state of the Sanctuary.

Organism Distribution Studies

Existing information describing species-habitat relationships should be collected to provide a framework for understanding the distribution of organisms in the Sanctuary. A

comprehensive knowledge of the biodiversity, distribution, and movement of organisms and their dependence on environmental factors is needed for resource interpretation and protection. Species distribution should be correlated with physical, chemical, and seasonal factors; biological interactions; and habitats and physiographic features. These biological-physical-chemical relationships should be described for resident and migratory species. Data of this type have been collected by the numerous research institutions surrounding the Sanctuary, but gaps in our knowledge of Sanctuary ecology, particularly land-sea interactions, still exist.

Historical Context Study

A historical context study, including a general literature search, building on existing work, should be conducted to identify probable historical sites (including cultural, archaeological and paleontological sites) within the Sanctuary. This research may be followed by a field survey and archeological assessment to locate and evaluate the extent to which historical resources are based in the Sanctuary. These studies of historical resources will provide the fundamental information necessary to develop a strategy for historical resource management, education, and interpretation for the Sanctuary.

B. Monitoring

Circulation and Transport Studies

Because the Monterey Bay area is subject to a variety of natural and anthropogenic perturbations, the Sanctuary manager needs sound information on water circulation and material transport. This information can be used to improve our understanding of the dispersion patterns of possible oil spills and current land-source and ocean-source discharges into the Sanctuary, and for contingency planning. Circulation controls the fate of many substances in the Sanctuary. It affects larval recruitment, nutrient transport, and the fate of any pollutants, sediment or hazardous materials that enter the Sanctuary. Surface current measurements from CODAR (radar based) and drifters should be validated and used to fill gaps in existing circulation models of the Sanctuary area. Circulation and other water quality factors should be examined on varying spatial and temporal scales (tidal, seasonal and climatic) to determine the natural variation.

Basic physical oceanographic studies should focus on the interchange of water masses between Monterey Bay and the open ocean, local circulation within the Bay and Elkhorn Slough, and circulation at depth. To understand regional circulation, the Sanctuary program will encourage and support ongoing measurements, augment these programs with additional sites and measurements, and assist with the development and dissemination of information from existing monitoring stations such as NOAA tide gauges, current meters, thermistor chains and satellites.

Closely linked to circulation is the study of the transport of discharges and materials from sources to sinks throughout the Sanctuary. Sources, sinks and transport rates of sediments should be determined. The sediment entering Sanctuary waters comes from the coastline, rivers, and streams flowing into the ocean, as well as laterally through Sanctuary boundaries and submarine canyons. This transport of sediment contributes to coastal buildup, beach replenishment, and erosion. The fate of sediments, which provide recre-

ational areas, buffer the shoreline, and carry pollutants, is vital information needed for the management of the Sanctuary. It is hoped that ultimately this research will establish a firm scientific basis to apply management and possible regulatory measures that will reduce the impacts of activities that modify sediment flow in the marine environment.

It is important to understand how transport and retention mechanisms, which are affected by oceanographic and atmospheric processes and influenced by seafloor topography, influence the distribution of nutrients, primary producers, and young pelagic stages of marine organisms. Transport mechanisms affect the nearshore and coastal ecology of the Sanctuary, habitat use, and recruitment processes. An interdisciplinary approach to studying transport processes in the Sanctuary includes the efforts of physical, chemical and biological oceanographers, geologists, and fishery scientists. Results from transport studies will be useful in identifying significant species and areas of high productivity and diversity, are critical in ongoing recruitment modeling efforts, and are necessary in understanding predator-prey foraging dynamics.

Water Quality Monitoring

The Memorandum of Agreement (MOA) regarding water quality and discharges (Appendix D) outlines a Sanctuary water quality protection program that, among other issues, calls for the establishment of a comprehensive water quality monitoring program. This program should: (1) review the full array of existing water quality monitoring efforts in the area, looking for opportunities to synthesize data, avoid unnecessary monitoring efforts in the area, and better integrate monitoring efforts in the region; (2) determine the sources of pollution causing or contributing to existing or anticipated pollution problems in the Sanctuary; (3) determine the fate and effect of these pollutants; (4) evaluate the effectiveness of efforts to reduce or eliminate those sources of pollution; and (5) evaluate progress regarding maintenance of water quality standards and protection and restoration of degraded areas and living marine resources of the Sanctuary.

Significant Species

Selected species should be identified as potential indicators of environmental change and used in long-term monitoring programs. It is important to understand the population dynamics and habitat requirements of species that are significant members of the Sanctuary's ecosystems. As an example, this would include common and abundant prey of top-level predators (e.g., euphausids (krill), Euphausia pacifica , squid, Loligo opalescens, and juvenile rockfishes, Sebastes spp., and Engraulis mordax). Other potential candidates for a monitoring program include organisms that are particularly responsive to environmental perturbations or prey abundance. For example, anomalous warm water can be associated with rare occurrences of pelagic red crabs; leatherback sea turtles can indicate abundance of jellyfish (their preferred prey); and blue whales can indicate concentrations of euphausids. Some benthic organisms, such as the polychaete, Capitella capitata, and the white croaker, Genyonemus lineatus, are particularly abundant in areas of disturbance, such as outfalls.

Critical Habitats

Selected habitats should be identified as potentially important sites for the Sanctuary's living resources and used in long-term monitoring programs. Such habitats include: (1)

significant upwelling areas, which provide essential nutrients for primary production; (2) shelter or home sites, such as rock or kelp substrata; (3) reproductive sites, such as subtidal shale specifically used by squid, Loligo opalescens, for egg mass deposition; (4) nursery grounds, such as shallow, nearshore areas used by young-of-the-year flatfishes; (5) areas of harvest refugia from fishing activities, such as deep rocky outcrops in submarine canyons; (6) protected shorelines used by harbor seals, Phoca vitulina, and Stellar sea lions, Eumetopias jubatus, for pupping; and (7) undisturbed islands used by nesting seabirds and breeding pinipeds.

Biodiversity

The development of a national and international biodiversity program is a priority for the present Administration; President Clinton has made the U.S. a signatory to the Biodiversity Convention. As a result, the U.S. is developing a U.S. component of an international biodiversity program. The President also has announced the creation of a National Biological Survey (NBS) to identify and aid in the protection of endangered species, and address biodiversity. NOAA's Marine and Estuarine Biodiversity Initiative serves as the marine complement to the NBS.

The planet is experiencing an unprecedented loss and impoverishment of its biological wealth as measured by species extinctions and degradation of its ecological systems. By implementing the strategies in the Biodiversity Initiative, NOAA, by the year 2005, will be recognized as the national and international leader in marine and estuarine biodiversity research, conservation and management.

Given the overwhelming evidence that anthropogenic activities are contributing to a loss of species diversity and the resulting negative economic and ecological consequences of this, it is imperative for NOAA to take the lead and implement a comprehensive and coordinated program to enable a sustainable economic future for our Nation and a healthy environment for future generations.

The Biodiversity Initiative advances The Department of Commerce's ability to achieve sound environmental assessment, prediction and stewardship and maintain a diverse living marine resource base for the economic opportunities offuture generations. The Biodiversity Initiative brings together many of the research and stewardship goals embodied in other NOAA program initiatives, specifically recovering protected resources, rebuilding fisheries, assessing global change, and promoting healthy coastal ecosystems.

The Biodiversity Initiative calls for: (1) a five year demonstration project; (2) a comprehensive survey, research and monitoring plan; (3) a conservation and management strategy; (4) a sound infrastructure to support research and conservation; and (5) a data and information network.

The major benefits of the Biodiversity Initiative include:

- Advancing NOAA's ability to manage and conserve marine species and ecosystems before they become endangered and thus avoiding the crisis management mentality that often clouds the current listing process;
- Moving from species-by-species to ecosystem-level management, allowing for more

comprehensive resources management;

- Ensuring for future generations the opportunity to enjoy, explore, and use the ocean's vast potential;
- Regulating the factors that may threaten biodiversity and ecosystem functions;
- Helping NOAA carry out its legislative mandates for species and ecosystem protection and recovery;
- Enabling NOAA to meet international obligations resulting from the Biodiversity Convention and Agenda 21; and
- Maintaining the potential for significant advancement in basic and applied sciences, including food and nutrition, biotechnology, medicines, raw materials, and understanding global climate.

When possible, monitoring in the MBNMS should coordinate with NOAA's Marine an Estuarine Biodiversity Initiative.

C. Experimental Studies

Once the site characterization is complete some of the hypotheses regarding the environment can be tested using experimental studies. Studies can be designed to evaluate changes in the resources and environmental qualities of the Sanctuary area. Changes may be caused by biological impacts, such as inter- or intra-specific competition or predation, abiotic factors such as sea temperature rise from ENSO events, human activities such as fishing, or degradation of water quality by pollutants.

D. Modeling

Predictive studies include the development of adequate circulation models that would be used for pollutant tracking, emergency response procedures, stock management, etc. Work should progress toward the development of a 4-dimensional, data assimilation, quasi-operational model. Development of such realistic computer models, when updated with direct environmental measurements, could be of assistance with the management issues mentioned above. The Monterey Bay Modeling Group (Appendix E) has already developed ecological models, which should be built upon. Such models would be based on information collected under the first three components of the research program. Models will be improved continually as more information is gathered.

E. Information Management

A high priority for information management is the hiring of a research coordinator. That person should develop a computer bulletin board dedicated to receiving and disseminating information about research in the Sanctuary. This would foster cooperative work among institutions and disciplines, a primary goal of the Sanctuary research program.

The primary purpose of the MBNMS research program is provide a scientific basis for resource protection and management. This will be accomplished by compiling existing information and developing a focused research and monitoring program to address management concerns. The challenge lies in identifying the primary threats and perturbations to the Sanctuary resources and monitoring the appropriate indicators of those perturbations. When changes are detected, research projects will be initiated to determine the causes of changes, and models will be developed to predict future changes. Management strategies will be based on the results of monitoring, experiments, and models. From continued monitoring we can determine the effectiveness of any management strategies. Throughout this process, information will be provided to scientists and policy makers to improve our understanding of the environment and foster cooperative research. This process will provide Sanctuary management with the information to make sound, scientific decisions to ensure the continued health of the Monterey Bay National Marine Sanctuary.

Appendix A: Research Institutions in the MBNMS Area

National Oceanic and Atmospheric Administration (NOAA)
- National Marine Fisheries Service (NMFS)
  - Pacific Fisheries Environmental Group (PFEG)
    P.O. Box 831
    Monterey, CA 93942
    408-656-3311

  - Tiburon Laboratory
    3150 Paradise Drive
    Tiburon, CA 93920
    415-556-0565

- National Ocean Service (NOS)
  - Ocean Applications Branch (OAB)
    2560 Garden Road, Suite 101
    Monterey, CA 93940
    408-647-4211

U.S. Fish and Wildlife Service (USFWS)
- Piedas Blancas Field Station
  P.O. Box 70
  San Simeon, CA 93452
  805-927-3893

U.S. Geological Survey (USGS)
- Marine Division
  345 Middlefield Road
  Menlo Park, CA 94025
  415-354-3078

U.S. Navy
- Fleet Numeric Oceanography Center
  Monterey, CA 93943
  408-647-4451

- Naval Postgraduate School
  Monterey, CA 93943
  408-656-2673

- Naval Research Lab
  Monterey, CA 93943
  408-647-4731

California Department of Fish and Game (CDF&G)
20 Lower Ragsdale Dr., #100
Monterey, CA 93940
408-649-2870

Elkhorn Slough National Estuarine Research Reserve
1700 Elkhorn Road
Watsonville, CA 95076
408-728-2822

Marine Pollution Studies Lab
Granite Canyon Marine Lab
20 Lower Ragsdale Dr., #100
Monterey, CA 93940
408-649-0947

Moss Landing Marine Labs
P.O. Box 450
Moss Landing, CA 95039
408-755-8670

Monterey Bay Aquarium
886 Cannery Row
Monterey, CA 93940
408-649-6466

Monterey Bay Aquarium Research Institute (MBARI)
160 Central Avenue
Pacific Grove, CA 93950
408-647-3700

Cooperative Institute for Research in the Integrated Ocean Sciences (CIRIOS)
2560 Garden Road, Suite 101
Monterey, CA 93940
408-647-4215

Stanford University
Hopkins Marine Station
Pacific Grove, CA 93950
408-373-0464

California State University Consortium
Moss Landing Marine Laboratories
P.O. Box 450
Moss Landing, CA 95039
408-755-8670

University of California Santa Cruz
Institute of Marine Sciences
Long Marine Laboratory
Santa Cruz, CA 95064
408-459-2464

University of California Davis Marine Advisory Program
P.O. Box 440
Moss Landing, CA 95039
408-633-2092

Appendix B: MBNMS Research Advisory Committee

G. Cailliet	Moss Landing Marine Labs
H. Curl	NOAA, HAZMAT & Gulf of the Farallones NMS
A. DeVogelaere	Elkhorn Slough NERR
L. Ehret	Naval Postgraduate School
G. Greene	US Geological Survey
T. Grove	California Coastal Commission
J. Harvey	Moss Landing Marine Labs
C. Harrold	Monterey Bay Aquarium
T. Jackson	Monterey Bay NMS
D. Johnston	California Dept. of Fish and Game
D. Powers	Hopkins Marine Station
B. Robison	Monterey Bay Aquarium Research Institute
J. Roletto	NOAA, NOS, Gulf of the Farallones/Cordell Bank NMS
J. Rote	Moss Landing Marine Labs
W. Schramm	NOAA, NOS, Center for Ocean Analysis and Prediction
G. Sharp	CIRIOS
M. Silver	UCSC Institute of Marine Sciences
R. Starr	California Sea Grant
M. Stephenson	Marine Pollution Studies Lab (CDF&G)
F. Schwing	NOAA, NMFS, Pacific Fisheries Environmental Group
M. Yoklavich	NOAA, NMFS, Pacific Fisheries Environmental Group

Appendix C: Disciplinary Priorities

A. Ecological Interactions

Subcommittee chairs: Greg Cailliet, Moss Landing Marine Laboratories
Chris Harrold, Monterey Bay Aquarium

Eighty-five surveys were sent to scientists between San Luis Obispo and San Francisco with marine ecology interests within the MBNMS; 23 responses (27%) were received. The majority of the respondents work with invertebrates and fishes. The most common habitats in which they work are off-shore benthos, estuaries and rocky intertidal. Other floral and faunal groups and habitats were represented.

The surveys requested information about scientists' current research interests, and what they would propose as research priorities for the MBNMS. Five broad areas of ecological research were suggested by marine scientists. They are presented below from most to least frequently suggested.

Long-term monitoring was the most frequently suggested type of ecological research suggested, no doubt in response to the research guidelines of the MBNMS FEIS. Estuarine habitats were the most frequently targeted for monitoring programs, followed by subtidal reefs and kelp forests, epipelagic habitat, and the offshore benthos. Estuaries and subtidal reefs and kelp forests are likely to be most severely impacted by land-based human activity, while the epipelagic and offshore benthic habitats could be affected by marine-based activities such as commercial fishing. Monitoring studies were suggested to establish baseline data against which to assess ecosystem responses to such human-mediated disturbances as trawling, pollution from oil and radioactive wastes, and erosion and sedimentation. Key things that should be monitored are:

- Elkhorn Slough: It has been modified and is changing.
- near shore communities (the interface between land and water)
- continental shelf and soft bottom
- the canyon
- the kelp forests
- pelagic and midwater (mammals and birds)

The second research area suggested focused on production, trophic interactions, food webs, and the ecological impact of predation. Studies such as these are important in predicting the cascading ecological effects of both natural and human-induced disturbances.

The third type of research suggested was the use of the MBNMS to experimentally assess the effect of human activity on marine communities. This would involve comparing study sites in which human activity was regulated to unregulated sites. The MBNMS could provide the required regulatory clout to successfully control the level of human activity.

The fourth type of research suggested focused on interactions between recruitment of fish and invertebrates and oceanography. Understanding the factors that regulate recruitment patterns remains a central focus in both basic and applied marine research.

The fifth type of research suggested focused on life histories of invertebrates and fishes. The life histories of many types of commercial and sport fish species remain unknown, and those of many deep-sea and open ocean organisms have never been described. The many marine science institutions with life support systems in the MBNMS make this kind of research particularly well-suited for this area.

B. Geology and Physiography
Subcommittee chair: Gary Greene, US. Geological Survey

The Monterey Bay Marine Sanctuary has the most diverse and complex submarine physiography and geology of any marine Sanctuary in the United States. Within this Sanctuary is the Ascension-Monterey Canyon system and other submarine canyons, products of tectonic and sedimentary processes associated with the convergence of the Pacific and North American Plates. These physiographic features lie within the San Andreas fault system, the active tectonic boundary between the two plates and composed of a series of fault zones. Fault motion resulting from the collision of the two plates causes earthquakes, such as the 1989 Loma Prieta Earthquake, which in turn cause submarine landslides, generate tsunamis, form or constrict fluid migration pathways, create turbidity currents, and generally raise havoc with the biology, chemistry, geology, and physiography of the region.

Because physiography and geology play such an important role in not only influencing the oceanographic environment, but also in impacting society onshore through geological hazards, water quality, and the support of viable economic resources, the characterization of the physiography and geology in the marine Sanctuary should be of paramount concern. The major topics which should be studied are:

- Tectonics: faulting, tsunami generation, earthquakes
- Sedimentation: mass wasting, turbidity currents, canyon erosion, coastal bluff erosion
- Fluids: aquifers, salt water intrusion, dewatering (from plate convergence)
- Paleoclimatology: global warming, El Niño, upwelling, history through sedimentation

One of the first tasks of Sanctuary supported activities should be to characterize the physiography and geology of the Sanctuary. Although much work has been done in this regard, further study and characterization is necessary to comprehensively understand the seafloor environment of the Sanctuary. An initial step would be to participate and support the efforts of the Monterey Bay Modeling Group (an informal open consortium of oceanographic institutions around the bay composed of the USGS, MBARI, NPS, NASA/Ames, MBA/ US Army, and others) to process and make available the full resolution NOAA Seabeam bathymetric data for the Monterey Bay region. A detailed bathymetric map of the Sanctuary is a good starting point and would be useful in evaluating the physical, biological, and geological environment of the Sanctuary. Using the full resolution bathymetric data through visualization is also important and would be helpful in characterizing the seafloor of the Sanctuary.

Now with the availability of full resolution bathymetric data, multi-channel seismic reflection instruments, ROVs manned submersibles, and high resolution side-scan capabilities the geology of the Sanctuary can be mapped to the same resolution that is presently being done onshore. This type of information is germane to the understanding of earthquake periodicity, salt-water intrusion and water contamination through aquifer migration paths, fluid flow that supports unique biology such as the cold seep communities, and characterization of fisheries and other biological habitats. A major and continuing Sanctuary project should be the characterization of the seafloor geology and its application to the Sanctuary environment. Structural mapping and analyses of the major fault zones in the Sanctuary is desirable for the characterization of the potential earthquake and tsunami hazards of the region.

Since submarine canyons cut deeply into the continental shelf and slope, exposing the geological stratigraphy that records the geological history of the region, it is important to investigate canyon walls in the Sanctuary to determine the historical events that formed such a spectacular area. In doing this a model of canyon and continental margin origin can be defined and used to delineate anomalies in present day geological processes, that may upset the critical equilibrium of the Sanctuary environment. These studies should entail looking for paleoclimatic evidence that would assist in the evaluation of the green-house or global earth warming concepts, El Niño phenomenon, and fluctuations in up-welling and global ocean current shifts that are critical to biological diversity and potential extinction in the region.

Sedimentary processes active within submarine canyons, on the continental slope and shelf, and along the coastal zone need to be defined to properly manage the Sanctuary. Mass wasting, turbidity currents, fluid sapping, coastal bluff erosion, flooding, and littoral transport are critical sedimentary processes that need to be understood if detection of anomalous natural and man-made events are to be detected.

Geology and physiography should not be an entity of its own. It should be undertaken in an interdisciplinary manner with geologists, biologists, chemists, and physical oceanographers all part of a team charged with the task of characterizing the natural environment of the Sanctuary. A pool of experts exist in the region today that have worked successfully together in the past and are willing to undertake Sanctuary related scientific projects if properly supported.

C. Chemistry and Water Quality

Subcommittee chair: Mark Stephenson, Marine Pollution Studies Laboratory, California Department of Fish and Game

A poll was conducted of 49 researchers/institutions. Ten questionnaires were returned. The response was good for the pesticide groups, and State agencies, but poor for the trace metal and nutrient groups. the returned questionnaires were answered inconsistently between groups, but nevertheless, give a fairly good portrayal of the research that is currently being conducted and the priority of future research. I estimate that over half of the important research groups responded.

The results indicate that non-point source pollution was a high priority. These types of pollutants include pesticides, and PAHs. Most researchers mentioned pesticide run-off into Elkhorn slough. also rated high priority were boat related pollutants (Cu, TBT, oil), watershed scale modeling pollutants (budgets, inputs, fate, etc.), remediation of pollution problems, water quality education, investigations of potential sources of pollutants, oil spills, and effects of pollutants on invertebrates and vertebrates. High priority items from San Francisco and San Mateo Counties included radioactivity, dredge spoil dumping, and road fill. Monitoring of long-term trends of pollutants was considered to be of secondary priority but in subsequent conversations at the research advisory committee meeting many felt that this may be of high priority to researchers in the future but none of the researchers indicated concern for this issue in this poll.

Research topics of medium or low priority include metals, bacteria, domoic acid, human food contaminants, food web contaminants, development of molecular toxicological techniques, effects of pollutants on vertebrates, public policy development, and improved information coordination and communication.

Research topics that were of the lowest priority were air pollution, sewage, power plant discharges, hazardous waste site run-off, dredging, nutrients and anoxia in harbors. as mentioned before, however, dredging and dredge spoil dumping are high priority in San Francisco and San Mateo counties.

Eight research groups responded to the poll, indicating a fairly representative sampling of the institutions within Monterey Bay. Input from Ed Ueber was useful in obtaining additional input on sanctuary priorities from San Francisco and San Mateo Counties. Most of these groups are currently obtaining State research funds. There is little Federal funding of water quality research or monitoring within Monterey Bay. The Sanctuary could be an asset if it could facilitate obtaining Federal funding.

A list was generated from the questionnaires regarding the current research within the Sanctuary. The Mussel Watch Program, the Bay Protection Program, and the alternative Management Approaches to Agriculture in Elkhorn Slough Program, are the three programs reported from the questionnaire that are conducting research within the Elkhorn Slough Reserve. In addition, the Elkhorn Slough Foundation has a volunteer program in which nutrients, temperature, salinity and a few other parameters are measured. AMBAG also has several programs which impact the Elkhorn Slough Reserve.

The current water quality studies reported within the Sanctuary are:

- Mussel Watch: Contaminants in Mussels (DFG, UCSC, MLML, State Water Board)
- Bay Protection: contaminants and toxicity in sediments (DFG, UCSC, MLML, State Water Board)
- Domoic Acid: Domoic acid in seafood species (UCSC)
- Ocean Bathing: Bacteria study in Santa Cruz (Santa Cruz County Health)
- Paralytic Shellfish Poisoning: Paralytic shellfish poisoning in mussels (Santa Cruz County Health)
- Water Quality Monitoring: Bacteria and nutrient monitoring in coastal streams (Santa

Cruz County Health)
- Alternative Management Approaches to agriculture in Elkhorn Slough: reducing pesticide run-off (Elkhorn Slough Foundation, Nature Conservancy, Monterey County Agriculture and Historical Land Conservancy, UCSC)
- Marine Bioassay Program: Development of marine toxicity tests of effluents (DFG, UCSC, State Water Board)
- Oil Dispersant Study: Effectiveness of Oil Spill Dispersants (DFG, UCSC)
- Organic Contaminant Sampling: Development of semi-permeable membranes to sample organic contaminants (UCSC)

D. Physical Oceanography and Meteorology
Subcommittee chair: Frank Schwing, National Marine Fisheries Service

A goal of research within and adjacent to the Monterey Bay National Marine Sanctuary is to understand the dynamics controlling the circulation of Monterey Bay and the coastal ocean adjacent to the Bay. The circulation is controlled by several physical processes- including local and non-local wind stress and curl, solar heating and air-sea heat exchange, coastline and bathymetric orientation, flow-bathymetry interactions and fluctuations in the California Current and Undercurrent- and is intimately linked with the biological structure and variability of the Bay and coastal ecosystems, and transport of water and material through the Sanctuary. Possibly the Sanctuary's most unique feature is the Monterey Submarine Canyon, which may have a major influence on the region's circulation. Several smaller canyons within the Sanctuary's boundaries may act to complicate the flow. Another feature of importance to the region's circulation, hydrography, sedimentation and water quality in the Golden Gate, which connects the Sanctuary directly to San Francisco Bay.

Ocean scientists still lack crucial information about many fundamental components of the system, despite the fact that the Monterey Bay area has been a center of research by numerous scientific institutions for several decades, and do not even have an unambiguous conceptual understanding of the region's hydrodynamics. It is therefore necessary to design and carry out a systematic study of the Bay's circulation, utilizing the resources and including the participation of scientists from the multitude of laboratories and facilities presently operating in the area. The designation of the Monterey Bay Sanctuary may serve as a catalyst for this research.

Such a research program must include—
• RETROSPECTIVE ANALYSIS— A survey of historical meteorological, oceanographic and satellite data, with a special focus on those data most recently collected by presently active research programs
• FIELD STUDIES— The development and implementation of a coherent, coordinated field observation program, taking advantage of the numerous resources available in the area
• ASSESSMENT— An assessment and synthesis of existing historical observations and new results into a characterization of the region and a conceptual model of its circulation and hydrodynamics
• MODELING— Theoretical and model studies to help diagnose the important dynamical processes that affect the flow, to assist in planning future field studies, and facilitate Sanctuary management

• COORDINATION & APPLICATION— Linkages to critical scientific problems in other disciplines, and application to important Sanctuary management issues

Retrospective data analysis is necessary to evaluate gaps in knowledge, develop hypotheses to be tested with field studies and modeling, and suggest priorities and sites for sampling. Modeling also has some feedback to field studies, i.e. direct observations focus theoretical studies toward specific regions and processes that merit examination, and provide more realistic model forcing conditions. Likewise, assessment of recent findings and results must be done periodically to incorporate new advancements and redefine gaps in our knowledge.

The list of needed research activities is far larger in scope than any single program or agency can expect to support. The following activities are of highest priority in terms of support of the Sanctuary,
based on their need, and the relative return to the Sanctuary for the cost in money and personnel. They can be completed in the first 1-3 years of the program, and will be activities that the Sanctuary Office can present as significant accomplishments.

- Maintain existing monitoring sites in Sanctuary
- Augment these sites with critical measurements based on assessment of present knowledge
- Support the development of numerical models of circulation, to support management needs
- Establish electronic bulletin board for ship schedules and field activities
- Develop list of data sets available from Sanctuary, with point of contact or source
- Support retrospective analysis of data from Sanctuary
- Develop list of topics and geographical areas where there are gaps in knowledge of Sanctuary circulation
- Develop conceptual model of circulation and boundary layer meteorology for Sanctuary, based on existing observations
- Attract NOAA, other research programs and initiatives to use Sanctuary as field program site
- Emphasize utility of Sanctuary as test ground for new technology

The success achieved from these short-term accomplishments will set the stage for achieving a long-term goal— a 4-D, data assimilation, quasi-operational circulation model of the Sanctuary, which includes biological and chemical components.

A. Current Physical Oceanography and Meteorology Activities in the Sanctuary

1. Teaching classes, collecting field data for thesis research
2. Field research programs
    a. Hydrographic survey
    b. Current moorings and surveys
    c. Coastal and nearshore meteorology
    d. Tides and waves
    e. Drifter studies
3. Long-term environmental monitoring

a. OASIS buoys (MBARI)
b. Pt. Sur Transect (NPS)
c. Pacific Grove, Santa Cruz, Farallon (temperature, salinity)
d Monterey, Santa Cruz NOS water level gauges (tide, long wave)
e. NDBO meteorology and surface ocean buoys
f. MBA met/ocean station
g. Coastal and nearshore meteorological stations
h. Beach and bluff recession in Monterey Bay (NPS)
i. Nearshore directional wave spectra (NPS)

4. Coastal and nearshore oceanography studies
    a. Ocean fronts
    b. Tidal analysis
    c. Dynamics of coastal upwelling centers
    d. Interactions between California Current and coastal circulation
    e. Wind-wave coupling
5. Coastal meteorology studies
    a. Marine boundary layer dynamics, topographic effects
    b. Air-sea interactions
    c. Regional impacts of ENSO
    d. Coastal fog development
6. Satellite and aircraft studies
    a. AVHRR
    b. Ocean color
    c. SAR
7. Coastal ocean modeling
8. Role of transport processes on productivity and recruitment
9. Sediment transport studies
10. Production of environmental time series and indices
11. Current measurements with new technologies
    a. Acoustic Doppler current profiler.
    b. CODAR surface current observations
    c. Acoustic tomography studies

B. **What needs to be done**

1. Synthesis of what is known about regional circulation
    a. Retrospective data survey
    b. Site characterization
    c. Conceptual model of circulation
2. Integration of existing, ongoing long-term multiple data sets
    a. Proxy series for investigating environmental linkages
    b. Model forcing fields
    c. Climate change studies
    d. Clearinghouse for data resources
3. Circulation studies in Sanctuary
    a. Long-term (lyr+) current measurements of Bay's circulation
    b. Drifter studies of circulation; comparison with CODAR
    c. Verify CODAR technology; intercomparison with OSCAR

d. Material transport across Sanctuary boundary (land & ocean)
e. Circulation and material transport in Monterey Canyon
f. Linkage between surface and Canyon circulation
g. Current measurements outside of Bay
h. Develop climatology of regional circulation

4. Coastal meteorology studies
    a. Dynamics of mesoscale marine atmosphere
    b. Air-sea exchange (heat, gas)
    c. Mesoscale climatology of region
    d. Dynamics of marine boundary layer
5. Continued development of numerical ocean circulation models
    a. Process studies with diagnostic models
    b. Develop and improve model forcing fields
    c. Improve open boundary conditions
    d. Link to large-scale models (regional, basin, GCM)
    e. Couple with biological models
6. Wind-wave coupling studies
7. Observe wind, buoyancy forcing, horizontal pressure gradients
8. Develop remote sensing time series (SST, color, SAR, altimetry)
9. Sediment distribution and budgets (transport, suspension, deposition)
10. Impact of freshwater discharge into Sanctuary
11. Maintain, upgrade existing measurement facilities
    a. Maintain long time series- Pt. Sur, Santa Cruz, Monterey, Pacific Grove, Farallon Is., Granite Canyon
    b. Maintain existing NDBO coastal meteorology buoys off Santa Cruz, Half Moon Bay, San Francisco, Cape San Martin
    c. Establish precise leveling of tide gauges
    d. Upgrade NOS next generation tide gauge (Monterey)
        i) Include temperature and salinity observations
        ii) Allow access to, and storage of, data sampled at high frequency (O(lOsec))
        iii) Allow automated, direct access to data in near-real time via modem or satellite
    e. Maintain nearshore monitoring
        i) Beach and bluff recession
        ii) Nearshore directional wave spectra
        iii) Nearshore winds (3+ sites)
        iv) Long wave and tidal measurements (3-5 sites)
12. New measurement sites and instrumentation
    a. Install automated coastal temperature recorders
    b. Install telemetered meteorological buoys inside the coastal boundary layer (<nm offshore)
    c. Multi-level, high frequency (>lHz) sensors at air-sea boundary; include temperature, wind, humidity, wave, current
    d. Install additional coastal telemetered or recording meteorology units (potential sites- Granite Cayon, Santa Cruz, Moss Landing, Año Nuevo, Pillar Pt., Farallon Is.)

e. Additional coastal CODAR sites
f. Testing, application of new technologies
    i) CODAR (surface currents)
    ii) Fluorometer/scatterometer sensors (SeaWiFs ground-truth)
    iii) Coupled acoustic/optic units (plankton biomass, etc.)
    iv) Acoustic tomography
    v) LIDAR (stock size)

E. Land Margin Interactions

Subcommittee chairs: Andrew DeVogelaere, Elkhorn Slough National Estuarine Research Reserve
Gary Griggs, Institute of Marine Sciences, UC Santa Cruz

The subject of land-margin interactions was loosely defined as physical coastal processes, example topics being coastal erosion and sediment transport. Some topics which fit into this category also fit into others (e.g. ecological interactions or chemistry and water quality).

Ongoing studies in the Sanctuary include:

Rikk Kvitek: The relative impacts of human disturbance (clam and bait harvesting) versus erosion on mudflat community structure in the Elkhorn Slough, 1993-1996, Elkhorn Slough (seed funding by Sea Grant and additional proposals are being written to EPA, NSF and Sea Grant); Rates of tidal scour, erosion, and the loss of the Elkhorn Slough salt marsh, Elkhorn Slough (funding by SRD with additional sources being sought; with Gary Green and Gary Griggs)

Ed Thorton: Sediment transport by wave and currents in Monterey Bay (ONR); Change in coastal morphology (ONR); Wave alignment as related to the Monterey Bay Canyon (US. Army Corps of Engineers)

Gary Griggs: Effect of seawalls on beaches, 1987-1994, Rio del Mar Beach (US. Army Corps of Engineers); Littoral sand budget and transport paths and processes for the Santa Cruz littoral cell and northern Monterey Bay, 1986-present, San Francisco to Santa Cruz Harbor (California Department of Boating and Waterways with assistance from USGS); Shoreline erosion along northern Monterey Bay, 1993, San Lorenzo River to New Brighton State Beach (US. Army Corps of Engineers); Erosional losses of Elkhorn Slough Salt Marshes, 1993-1994, Elkhorn Slough (Funding proposals being submitted)

Jeff Cole/ Tom Kendall Santa Cruz Harbor and vicinity erosion study (U.S. Army Corps and local sponsors)

John Dingler: Beach changes in California, beaches of Monterey (Department of Parks and Recreation, Cal Boating); Sand transport between San Francisco Bay and Monterey Bay, Golden Gate to Monterey Bay (USGS)

Necessary future funding projects (a) what are they? (b) why are the important? (c) how

MBNMS could be a model system.

1. a. Sources, sinks and transport rates for sediment into and through Monterey Bay Sanctuary

b. The sources of coarse-grained or littoral material to the shoreline of the Sanctuary is important in that it is these beaches which provided both the recreational area for the millions of visitors annually, and also buffer the shoreline from wave attack. It is important to understand what are the major sources for these sands to insure that the supply is not cut off. The finer-grained sediments can carry pollutants or contaminants from terrestrial runoff.

c. The entire coastline of the Sanctuary is an appropriate study area although major sediment sources are limited to the coastal streams including San Francisco Bay.

2. a. Rate of erosion of the margins of the Sanctuary.

b. Much of the Sanctuary margin is undergoing erosion. The erosion rates vary from centimeters to meters per year and may impact public or private property, and may endanger houses, utilities, or other developments. Thus the margin is constantly changing, and projected sea level rises will have additional, but as yet undetermined, impacts. Already, a major portion of the shoreline of northern Monterey Bay has been armored (e.g. 29% of Santa Cruz County coastline, 57% of the City of Capitola).

c. The shoreline of Monterey Bay is critical, and the remainder of the coastline should be evaluated on first order level to identify particular critical locations.

3. a. The effects and possible solutions to tidal scour and erosion in the Elkhorn Slough.

b. This unique area of the Sanctuary is part of the last remaining 10% of wetlands in California. The marsh habitat is commercially important for fisheries and provides necessary feeding stops along the Pacific Flyway. This habitat is also extensively used by recreational boaters, naturalists, and hunters. Although The Elkhorn Slough salt marshes have persisted for at least 5000 years, this important habitat is now being lost at an alarming rate.

c. This unique problem caused at least in part by the opening of the Moss Landing harbor in 1946 may provide a model to understand potential effects of sea level rise. The role of the Loma Prieta earthquake in the erosion process is a unique event that has not been studied.

4. a. Determining erosion rates in southern Monterey Bay; coastal dune recession and beach erosion

b. Beaches are a primary recreation resource, and there are ongoing questions of sand mining effects.

c. Monterey Bay is unique in its permanent rip currents with an experimentally useful gradient of strength form Monterey to the Salinas River.

5. a. Relationship between restoration of tidal inundation to formerly diked wetlands and groundwater intrusion.

b. Salt water intrusion is one of the most controversial issues in the area.

c. The historical change in ground water flow and its link to anthropomorphic causes are clear.

6. a. Developing a comprehensive bathymetric survey of Elkhorn Slough.

b. This information would allow some prediction regarding the equilibrium point in the process of erosion. Perhaps the solution to the erosion problem is to "leave it alone" rather that take the route of modifying the habitat further (a metal wall at the highway 1 bridge has been proposed by the Army corps) and risking other environmental problems.

c. see #3.

The National Science Foundation currently funds the Land Margin Ecosystem Research (LMER) program. They are currently on a five year funding cycle. These are multi-institutional, multi-disciplinary projects funded for about $400,000 a year. A possible project for this area would be the impact of agriculture. SRD, NOS, etc. can endorse this.

F. Communications and Information

Subcommittee chair: Gary Sharp, CIRIOS

Because not everyone is on the same computer network, it is recommended that ECONET be used by the Sanctuary. It is easy to use, inexpensive, and universal. The ecological community around the world (80% in the non-science community) uses it.

Because most oceanographic information doesn't belong to any one person, some sort of data management system is needed which would bring data sets into public access. As other funding sources don't require that data become public, there is a lot of proprietary information. There are different problems with old archived data such as QA/QC. High resolution data sets must be organized so that people can use them (GIS).

G. Human Impact

Subcommittee chair: Tami Grove, California Coastal Commission
Terry Jackson, MBNMS

- Extractive activities: oil/gas development; kelp harvesting; minerals mining; sand/gravel mining
- Vessel activities: navigation conflicts; discharges; catastrophic events (oil spills, hazardous materials discharges, vessel groundings, shipwrecks)
- Harbors: dredging; dredge spoil disposal; runoff (including bottom paint sloughing); discharges; docks/piers/jetties
- Industrial, commercial, residential development: coastal watershed development; road/bridge construction, maintenance, and repair; desalination plants; energy facilities; industrial plants; dams and other water flow diversions; sewage disposal (treatment plants and septic tanks; seawalls; groundwater withdrawals
- Agriculture and silviculture: row cropping, livestock grazing, confined animal facilities, etc.; road construction; timber harvesting; fire management, mosquito abatement, etc.
- Recreational activities: diving; surfing; boating/kayaking; intertidal collecting; hiking, bird watching and related activities
- Military activities
- Aircraft activities

Clearly, many important resource questions relative to the Sanctuary are raised by these activities:

- What type of environmental impacts such as sedimentation, shoreline erosion, noise, air/water borne pollutants, salt water intrusion, marine debris, wetland fill, etc. result from these activities and what is their relative degree of impact?
- How do these activities individually or cumulatively degrade habitats due to displacement, pollution, species disturbance, etc.? Can these degraded habitats be enhanced or restored?
- How is species abundance and diversity being affected by these activities? What are other "ecosystem" effects of these activities?
- Are there potential indicators to assess the status and patterns of change in the marine and coastal environment in order to monitor or predict the effects of these activities?

There is a regional research board which is part of a system set up by Sen. Mitchell of Maine. Members are from NOAA, EPA and State of California. They are working on a research plan for the area. Jim Rote will work closely with them.

T. Grove has spoken with John Foster, Department of Parks and Recreation's underwater archaeologist, Peter Pelkofer, State Lands' shipwreck and historic maritime resources program, and Jim Allan, UC Berkeley's Institute for Western Maritime Archaeology about involving them in cultural and historical resources research. There are a large number of shipwrecks reportedly within the Sanctuary boundaries. Written reports have been prepared on some of these wrecks. the top priority for research in this area is to complete a literature search and prepare reports for the remaining wrecks. Following this, the process of locating confirmed sites should be begun, so that an assessment of their historical, archaeological and cultural potential can be made.

H. Fisheries

Subcommittee chairs: Mary Yoklavich, National Marine Fisheries Service
Rick Starr, California Sea Grant Extension Program

Five types of research were identified as being important to fisheries in the Sanctuary:

1) Species-habitat associations. This includes describing and delineating habitats within the MBNMS, identifying critical habitats for harvested species, and describing the spatial and temporal distribution, habitat use, and abundance of resident and migratory species. In this region we also have a unique opportunity to describe and study submarine canyon species and habitats.

2) Understanding relationships between fisheries and ecosystem processes. This includes relating species distribution to oceanographic conditions and developing appropriate models (e.g., recruitment, transport mechanisms and ocean conditions), and developing programs to integrate chemical, physical, and biological monitoring as related to fisheries.

3) Effects of fishing on structure of fish and invertebrate assemblages and life history characteristics, including species, size and age composition. Also included in this category is

evaluating the use of refugia (natural, designated, or artificial) to enhance fisheries and increase population stability.

4) Trophic interactions. This includes understanding prey-predator relationships.

5) Improving fishery management practices. This includes increasing understanding of life history characteristics of harvested species, and developing and maintaining long-term regional fisheries databases.

MEMORANDUM OF AGREEMENT

BETWEEN

THE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION,

THE
U.S. ENVIRONMENTAL PROTECTION AGENCY,

THE
CALIFORNIA ENVIRONMENTAL PROTECTION AGENCY

THE
CALIFORNIA STATE WATER RESOURCES CONTROL BOARD,

THE
CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD,
CENTRAL COAST REGION,

THE
CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD,
SAN FRANCISCO BAY REGION,

THE
CALIFORNIA COASTAL COMMISSION,

AND THE
ASSOCIATION OF MONTEREY BAY AREA GOVERNMENTS

TABLE OF CONTENTS

I. PURPOSE OF MOA

The purpose of this Memorandum of Agreement (MOA) is to provide an ecosystem based water quality management process that integrates the mandates and expertise of existing coastal and ocean resource managers and protects the nationally significant resources, qualities and compatible uses of the Monterey Bay National Marine Sanctuary (Sanctuary or MBNMS).

II. AUTHORITY

A. NOAA

Title III of the Marine Protection, Research, and Sanctuaries Act of 1972, as amended, (MPRSA), 16 U.S.C. §§ 1431 et seq., National Program Regulations at 15 CFR Part 922 and the Monterey Bay National Marine Sanctuary regulations at 15 CFR Part 944 as administered by the National Oceanic and Atmospheric Administration (NOAA).

B. U.S. EPA

The Federal Water Pollution Control Act, as amended, (Federal Water Pollution Control Act or Clean Water Act (CWA)), 33 U.S.C. §§ 1251 et seq., gives the U.S. Environmental Protection Agency (U.S. EPA) authority to regulate both point and non-point (e.g., stormwater) sources of pollution. In addition, title I of the MPRSA (33 U.S.C. §§ 1401 et seq.) section 102 gives U.S. EPA authority to permit non-dredged material for the purpose of dumping into marine waters.

C. State and Regional Boards

The State Water Resources Control Board (State Board or SWRCB) and the California Regional Water Quality Control Boards (Regional Boards or RWQCBs) are established by the Porter-Cologne Water Quality Control Act, Division 7 (commencing with Section 13000) of the California Water Code. The State and Regional Boards are the state agencies with primary responsibi-lity for water quality control in California. The Act provides a statewide program for water quality control administered regionally within a framework of statewide coordination and policy. The Act contains a complete regulatory framework for the regulation of waste discharges to both surface and ground waters. It also provides for the adoption of water quality control plans and implementation of these plans by adoption of water discharge requirements for the discharges of waste that could impact State waters. Extensive enforcement mechanisms are available to ensure that requirements are met.

The Water Code also provides the necessary authority for the State to operate the National Pollutant Discharge Elimination System (NPDES) permit program in California in lieu of U.S. EPA. The law is codified in Chapter 5.5, Division 7 of the Water Code. As a result, the issuance of a California NPDES permit under State law satisfies the requirements

of the Federal Water Pollution Control Act.

The State Board's jurisdiction and responsibilities include but are not limited to: (a) overseeing Regional Board regulation of discharges into State waters under the California Porter-Cologne Water Quality Control Act; (b) developing water quality standards; (c) adopting and approving water quality control plans; (d) overseeing Regional Boards' issuance, compliance monitoring, and enforcement of all NPDES permits in California including NPDES general permits and permits for Federal facilities; (e) overseeing Regional Boards' implementation and enforcement of National Pretreatment Program requirements except for NPDES permits incorporating variances granted under Federal Water Pollution Control Act Sections 301(h) and 301(m) and permits to dischargers for which EPA has assumed direct responsibility; (f) designating "Areas of Special Biological Significance (ASBS):, under State Board Resolution No. 74-28, for the purposes of protecting areas of high biological productivity and ecological sensitivity; (g) adopting standards and regulations for waste disposal sites; (h) implementing Toxic Substances Monitoring (TSM) and State Mussel Watch Programs; (i) administering the State's Water Quality Planning Program pursuant to CWA Section 205(j); (j) issuing or denying Water Quality Certification for any Federally licensed or permitted project which may result in discharges to navigable State waters pursuant to CWA Section 401; (k) developing and implementing the State Nonpoint Source Management Program pursuant to CWA Section 319; and (1) working with the California Coastal Commission (CCC) and the San Francisco Bay Conservation and Development Commission (BCDC) in developing and implementing a Coastal Nonpoint Pollution Control Program pursuant to the Coastal Zone Act Reauthorization Amendments of 1990, Section 6217.

The jurisdictional boundaries of the California Regional Water Quality Control Board, San Francisco Bay Region (Regional Board 2), are described in Water Code Section 13200(b). The jurisdictional boundaries of the California Regional Water Quality Control Board, Central Coast Region (Regional Board 3), are described in Water Code section 13200(c).

The Regional Boards have jurisdiction and are responsible for: (a) regulation of waste discharges into State waters; (b) adoption of water quality control plans for the watershed basins within each region; (c) issuance, monitoring, and enforcement of NPDES individual and general permits and other waste discharge requirement orders within each region; (d) adoption and enforcement of pretreatment standards; (e) issuance, monitoring, and enforcement of requirements for waste disposals to land; and (f) taking all other planning and regulatory action necessary to assure protection of water quality within the regions.

D. California Coastal Commission

Pursuant to the California Coastal Act of 1976 and the Federal Coastal Zone Management Act (CZMA) of 1972, as amended, the California Coastal Commission (CCC) has jurisdiction and is responsible for: (a) administering the California Coastal Management Program (CCMP); (b) receiving grants from the Federal Government in support of the coastal management program; (c) implementing, through the CCMP's broad planning and regulatory framework, a comprehensive set of specific policies for the protection of coastal resources and the management of orderly development throughout the State's coastal zone;

and (d) reviewing, for consistency with the CCMP, all activities within or outside of the coastal zone that affect land or water uses or natural resources of the coastal zone and that are conducted, permitted, or funded by the Federal government. In addition, pursuant to Section 6217 of the Coastal Zone Management Act Reauthorization Amendments of 1990, the CCC is responsible for developing, in conjunction with the SWRCB, a coastal Nonpoint Pollution Control Program for submission to the Administrator of U.S. EPA and the Secretary of Commerce for approval.

The Coastal Act grants the CCC authority to issue Coastal Development Permits (CDPs) for any development in the coastal zone until local governments adopt CCC-approved Local Coastal Programs (LCPs). The Commission works with local governments to design LCPs that reflect local coastal issues while meeting the statewide goals and policies of the Coastal Act. Upon certifying a LCP's compliance with Coastal Act requirements, the CCC delegates most permitting and related monitoring and enforcement responsibilities to the local jurisdiction. Several well-defined regulatory responsibilities delineated by the Coastal Act and the CZMA, however, permanently reside with the CCC. Included among these is the aforementioned "Federal consistency" review authority. Distinct sets of State and Federal standards and procedures for determining consistency with the CCMP apply to Federal agency activities, Federally funded activities, and non-Federal activities that require Federal licenses or permits, including oil and gas exploration, development, and production on the Outer Continental Shelf.

E. Association of Monterey Bay Area Governments

The Association of Monterey Bay Area Governments (AMBAG) is a Council of Governments, created as a voluntary agency established by agreement among its members pursuant to a joint powers agreement, and established among its members as an area-wide planning and water quality management organization and is responsible for: (a) serving as the Metropolitan Regional Clearing House to review and comment on Federal grant applications and proposed Federal projects and other environmental documents and plans prepared pursuant to CEQA and NEPA, (b) creating a Non-Point Source Water Quality Management Plan pursuant to its designation by the State in 1975 under Section 208 of the Federal Water Pollution Control Act,
(c) managing Federal transportation funds, general transportation, reviewing transportation projects or capital improvements in major urban areas and annually endorsing a Transportation Improvement Program and Regional Transportation Plan pursuant to its designation as a Metropolitan Planning Organization (MPO) by the State of California, (d) preparing an air quality plan to ensure consistency with Federal Clean Air Act, National Air Quality Standards, (e) preparing a regional hazardous waste management plan in accordance with Tanner Legislation (AB 2948, 1986), and (f) preparing a 5-year plan of housing needs for each city and county within its jurisdiction.

III. SCOPE

This agreement shall apply to the following permits, plans, research, and monitoring efforts within all California waters to achieve the purpose of this MOA:

A. National Pollutant Discharge Elimination System (NPDES) permits (which include stormwater associated with industrial activity and stormwater from urban areas) issued under Section 13377 of the California Water Code (Hereafter "NPDES permit"),

B. Waste Discharge Requirements (WDR) issued under Section 13263 of the California Water Code,

C. California Ocean Plan, Enclosed Bays and Estuaries Plan, Inland Surface Water Plan, relevant Basin Plans, and CWA 208 Plans,

D. Non-Point Source (Hereafter "NPS", when abbreviated) Pollution Planning and Control Measures including Management Plans prepared under Sections 319 and 208 of the CWA and under Section 6217 of the Coastal Zone Act Reauthorization Amendments of 1990, and

E. Research and monitoring toward the development of a Sanctuary Water Quality Protection Program, as outlined in Section VII of this MOA.

IV. POLICY FOR INTERAGENCY COORDINATION

A. NOAA Role:

- Provide its Sanctuary data and reports to the signatory agencies semiannually.

- Ensure holistic, uniform protection is provided to all Sanctuary resources and qualities.

- Provide comprehensive ecosystem perspective.

- Consider cumulative impacts from multitude of projects.

- Consider multiple use and conflict resolution between potentially competing user groups and other Sanctuary activities, e.g., research and education projects and other permitted activities.

- Provide experience and perspective from National System of sanctuaries, e.g., examples and models of approaches and methods to address similar issues from other sites.

- Build up data-base on what is going on in Sanctuary area via tracking and filing of existing permits to see if problems exist. Begin to address potential or perceived problems early on and then work cooperatively to address issues.

- Provide recommendations on conditions or objections to discharge permits based

upon potential injury to Sanctuary resources and qualities and compliance with applicable criteria.

- Work with all signatory agencies of this MOA to integrate NOAA criteria, goals, and objectives into water quality plans, i.e., Basin Plans, California Ocean Plan, Enclosed Bays and Estuaries Plan, Inland Surface Water Plan, CWA 208 and 319 Plans, and CZMA NPS management measures.

- Provide comments on impacts on Sanctuary resources and qualities, impacts on compatible uses of the Sanctuary, and impacts on NOAA's management of the Sanctuary.

- Identify, in consultation with U.S. EPA, a specific threat of significant injury or significant injury to the Sanctuary resources or qualities. NOAA provides evidence and informs U.S. EPA, the RWQCB, the discharger (for existing permits), or the permit applicant.

- Work with U.S. EPA, the discharger or applicant, and RWQCB to address the threat of significant injury or significant injury to the Sanctuary.
- Utilize the "Process for Elevation" (see Section VIII of this MOA) when it deems appropriate.

- Provide certifications in accordance with this MOA.

B. U.S. EPA Role:

- Work with the State Board and the Regional Boards to assure that all Section 402 NPDES permits are issued in a timely manner, protective of water quality, and that full compliance is achieved with all the terms contained therein.

C. State Board Role:

- Provide expertise on water quality issues.

- Work with NOAA and Regional Boards to determine if it is necessary to develop criteria in addition to that already promulgated by the State and Regional Boards or to take other specific actions in order to protect Sanctuary resources and qualities.

- Work with NOAA and Regional Boards in developing criteria that are scientifically sound to ensure proposed criteria are acceptable for adoption by the State Board as water quality objectives or standards in the respective water quality control plans.

- Oversee all Regional Boards' NPDES permits and other waste discharge requirements.

- Review and provide responses to all petitions filed by NOAA and recommendations made by the Joint Review Board during the "Referral Process" (See Section VIII.B. of

this MOA).

- Work with the California Coastal Commission (CCC) and the San Francisco Bay Conservation and Development Commission (BCDC) in developing and implementing a Coastal Non-Point Pollution Control Program pursuant to the Coastal Zone Act Reauthorization Amendments of 1990, Section 6217.

D. Regional Boards' Roles:

- Issue NPDES and Waste Discharge Requirements permits in accordance with applicable State and Federal laws.

- Coordinate procedure to comment on permits as outlined in Section V of this MOA and fulfill Regional board duties described in Sections V and VIII of this MOA.

- Work with NOAA and State Board to determine if it is necessary to develop criteria in addition to that already promulgated by the State and Regional Boards in order to protect Sanctuary resources and qualities.

- Work with NOAA and State Board in developing criteria that are scientifically sound and to ensure proposed criteria are acceptable for adoption by the State Board as water quality objectives or standards in the respective water quality control plans.

- Provide expertise on water quality issues.

- Coordinate with NOAA and all other appropriate agencies on development and implementation of nonpoint source control activities.

- Provide NOAA with data and reports from Regional Board contracts or activities within the Sanctuary.

- Regional Board 3 work with CCC to provide to NOAA the final report on the Coastal Zone Management Act Morro Bay Nonpoint Source pilot program (including status, accomplishments, and potential applicability to the Sanctuary).

E. California Coastal Commission Role:

- Evaluate effects of proposed activities (including discharges) on coastal land and water uses and natural resources in the coastal zone to determine if the proposed activities are consistent with the CCMP. Such evaluations particularly will be guided by the policies set forth in the Coastal Act, an integral component of the CCMP. These policies include, but are not limited to, the following:

  Public Resources Code Section 30230 which provides that "[m]arine resources shall be maintained, enhanced, and where feasible, restored. Special protection shall be given to areas and species of special biological or economic significance..." and that "[u]ses of the marine environment shall be carried

out in a manner that will sustain the biological productivity of coastal waters and that will maintain healthy populations of all species of marine organisms adequate for long-term commercial, recreational, scientific, and educational purposes...;"

Public Resources Code Section 30231 which directs that biological productivity and water quality shall be "maintained and, where feasible, restored through, among other means, minimizing adverse effects of waste water discharges and entrainment controlling runoff, preventing depletion of ground water supplies, and substantial interference with surface water flow, encouraging waste water reclamation, maintaining natural vegetation buffer areas that protect riparian habitats, and minimizing alteration of natural streams...;"

Public Resources Code Section 30233(a) which limits dredging and filling in coastal waters to situations where "there is no feasible less environmentally damaging alternative," and where feasible mitigation measures have been provided to minimize adverse environmental effects, and where it is related to specific listed purposes;

Public Resources Code Section 30233(b), which states that "Dredging and spoils disposal shall be planned and carried out to avoid significant disruption to marine and wildlife habitats and water circulation. Dredge spoils suitable for beach replenishment should be transported for such purposes to appropriate beaches or into suitable long shore current systems."

Public Resources Code Section 30240 which mandates the protection of environmentally sensitive habitat areas "against any significant disruption of habitat values" and against impacts from adjacent development which would "significantly degrade" the area; and,

Public Resources Code Section 30262 which sets forth specific policies applicable to the Commission's regulation of oil and gas development.

- Cooperate with NOAA, EPA, SWRCB, RWQCBs and other Federal, state, and local agencies to promote timely issuance of permits and plans relevant to the MBNMS.

- Provide coastal zone management experience from a statewide perspective on the development of regulatory, planning, educational, and other programs which will be included in the overall management of the MBNMS.

- Ensure that the goals and objectives for protection of the MBNMS's resources are appropriately incorporated in the Monterey Bay segment of the California Coastal Nonpoint Pollution Control Program to be submitted to NOAA and U.S. EPA for approval.

F. Association of Monterey Bay Area Governments Role:

- Consider publication of a Monterey Bay Sanctuary Newsletter that circulates summaries of, and provides review comments on, proposed activities and developments within the Regional Metropolitan Clearinghouse area of projects, studies, plans, and permits which could impact directly or indirectly the Sanctuary.

- Ensure that the interests of local cities and counties are represented during the discharge permitting and planning review process.

- Ensure that any proposed projects or developments are reviewed, when applicable, for consistency with the 208 nonpoint source water quality management plan.

- Provide all parties to the MOA an opportunity to update the area's 208 plan (now 14 years old) in order to document what has been implemented since the late 1970's, and what nonpoint source water quality problems remain to be resolved particularly as they affect the Sanctuary.

- Participate with other agencies in nonpoint source water quality planning issues pertinent to the Sanctuary, including but not limited to 205(j) planning projects, such as the Elkhorn Slough Uplands Water Quality Management Plan, the Urban Runoff Water Quality Management Plan for the Monterey Bay Region, the Coastal Aquatic and Marine Projects Information Transfer System (CAMPTIS), and other non-point source planning efforts such as the Coastal Nonpoint Pollution Control Program under Section 6217 of the Federal Coastal Zone Act Reauthorization Amendments of 1990.

V. PROCEDURES AT THE INITIAL DECISION-MAKING LEVELS

A. General:

1. Parties agree to work together and review proposed permits and plans in parallel to avoid delays in issuance of the permit or plan.

2. NOAA agrees to provide a reasonable basis for objections or recommended terms and conditions based on evidence of a significant threat of injury to Sanctuary resources, qualities, compliance with applicable criteria, and effects on other compatible uses of the Sanctuary.

3. The Regional Board staff will make every effort to resolve conflicts between NOAA and the Regional Board during the scheduled comment period.

4. If conflicts are not resolved during the comment period, the Regional Board may take action on the permit or plan. The effective date of any

new permit that is not consistent with all of NOAA's comments will be no earlier than 45 days from the date the Regional Board adopts the permit. If NOAA has objections after Regional Board adoption of the permit or plan, NOAA may appeal the decision in accordance with the process for elevation outlined in Section VIII of this MOA.

B. Existing Permits (NPDES/WDR):

Copies of all current permits for discharges originating in:

* all of the counties of Monterey, Santa Cruz and San Benito,

* those portions of San Luis Obispo County which fall within the Salinas River drainage or which drain into the Pacific Ocean northerly of the southern boundary of the Sanctuary,

* those portions of San Mateo County which drain directly into the Pacific Ocean,

* those portions of the City and County of San Francisco which drain directly into the Pacific Ocean, and

* those portions of Marin County southerly of the northern boundary of the Sanctuary which drain into the Pacific Ocean

will be sent within 90 days of the effective date of Sanctuary designation, by the Regional Boards to NOAA with a listing of expiration/review dates, as well as the Regional Boards' schedule for mailing of draft permits for existing dischargers. NOAA will use information obtained pursuant to this paragraph in its efforts to implement a Sanctuary monitoring plan. Regional Boards will also provide copies or summaries of existing monitoring data for the last three years for each discharger.

Discharges outside the Sanctuary shall not be prohibited for failure to notify NOAA within 90 days of sanctuary designation.

NOAA will review existing permits and NOAA will report to the Regional Boards on any conflicts between Sanctuary protection and the quality of discharges as soon as a conflict is documented by NOAA.

NOAA may request a Regional Board review and commensurate hearing to consider permit revision or enforcement action by the Regional Board at any time data warrant such action. The Regional Boards will determine whether data warrant the reopening of a permit subsequent to a hearing. NOAA bears the burden of demonstrating threat of injury which would justify revision of permits by the Regional Boards before a regular five-year review. Such demonstration will be based on State or Federal laws, regulations, and

standards. NOAA will make every attempt to minimize requests for "mid-permit life" revisions by evaluating all available data during the regularly scheduled five-year review intervals. Any revisions must be consistent with EPA regulations on reopening permits.

Provided the provisions of this Section V.B are adhered to by the Regional Boards, NOAA will certify within six months of receipt the existing valid permits it receives copies of.

C. Existing Plans

NOAA will review and provide comment on the California Ocean Plan, Enclosed Bays and Estuaries Plan, Inland Surface Water Plan and Regional Board Basin Plans during the regularly scheduled review period.

All parties agree to make every effort to build upon existing regional, local, and State water quality control plans.

D. Non-Point Source Pollution

All parties recognize the significance of nonpoint source (NPS) pollution to the health of the Monterey Bay ecosystem, and whereas there is currently a lack of data and information to adequately control NPS pollution all parties agree to:

Focus pertinent ongoing NPS pollution efforts such as CWA 205(j) studies, municipal and industrial stormwater permitting (Section 402, CWA), 208 plans, 319 programs, and NOAA water quality research efforts to develop adequate prevention and management measures for protection of the Sanctuary. Management of significant contributions to nonpoint source pollution to Monterey Bay shall be addressed through the ongoing development of the State's Coastal Non-Point Source Pollution Control Program under Section 6217, and the Bay Protection and Toxic Cleanup Program.

Work together to incorporate those controls and measures determined necessary to protect the Sanctuary into the California Ocean Plan, Enclosed Bays and Estuaries Plan, Inland Surface Water Plan and appropriate Basin Plans once adequate prevention controls and management measures have been determined.

E. New and Revised Permits

Regional Boards will require applicants for new and revised permits ("revised permits" include renewals) for discharges originating in the geographic areas described in Section V.B of this MOA to submit applications simultaneously to NOAA as well as the Regional Board. Further, if NOAA provides reasonable evidence of a significant threat of injury to Sanctuary resources or quali-

ties from a proposed or on-going discharge originating outside those geographic areas but originating anywhere in San Luis Obispo County, the relevant Regional Board will require the applicant for that new or revised permit to submit an application to NOAA as well. Regional Boards will make every effort to ensure that applicants for revised permits submit applications at least six months before expiration of current permits.

No additional applications will be required by NOAA, however NOAA may seek, through the Board, additional information from the applicants in accordance with State law. Regional Boards will draft permits according to the schedule submitted to NOAA, incorporating all criteria which the Regional Board determines to be applicable (e.g., State Ocean Plan, Enclosed Bays and Estuaries Plan, Inland Surface Water Plan, Basin Plans, Federal regulations) as agreed upon in the 1989 National Pollutant Discharge Elimination System (NPDES) MOA between the U.S. EPA and the SWRCB. Regional Boards will mail draft permits to NOAA and all other concerned agencies for comment 90 days before scheduled adoption of the draft permit by the Regional Board. No permit may be renewed or otherwise issued allowing the discharge of primary-treated sewage within the Sanctuary. However, as the City of Watsonville is in the process of obtaining a CWA 301(h) waiver renewal as the Sanctuary designation is being finalized, the City of Watsonville may be allowed a one time renewal with a timeline for compliance with secondary standards requirements. This one time renewal allows the City of Watsonville until November 1, 1998 to achieve secondary treatment. The signatories of this MOA will cooperate with and where possible assist the City of Watsonville to achieve secondary treatment of sewage.
NOAA will review and comment on any draft new or revised permits and EIRs/EISs during the publicly noticed comment period. NOAA will review draft permits, monitoring summaries, and any other applicable data, and provide comments to the Regional Board no later than 30 days prior to the scheduled date of Regional Board adoption of the permit. Agendas are sent to Regional Board members two weeks before the meeting (one week for Regional Board 2). All comments should be based upon State or Federal laws, regulations, and standards which will be specified in the comments.

The Regional Board shall consider and address all comments and shall modify the proposed permit to incorporate those comments with which the Regional Board agrees and shall prepare a written response to each NOAA comment that is not accommodated. If the Regional Board adopts a revised permit which is not consistent with all of NOAA's comments, the permit will be effective upon expiration of the current permit. If the Regional Board adopts a new permit which is not consistent with all of NOAA's comments, the effective date of the permit will be no earlier than 45 days from the date the Regional Board adopts the permit. However, the permit could be affirmed, amended or overturned in accordance with Section VIII, the Procedures for Referral.

Valid permits that are consistent with all of NOAA's comments will be deemed by NOAA, through notification to the permittee, to have met paragraph (a) of 15 C.F.R. § 944.11. Valid revised permits that are not consistent with all of NOAA's comments will be deemed by NOAA to have met such paragraph (a) on an interim basis as of their effective date and will be deemed by NOAA to have met such paragraph (a) on a final basis upon NOAA notification to the permittee that Sections V.E and VIII of this MOA have been complied with. Valid new permits that are not consistent with all of NOAA's comments will be deemed by NOAA to have met such paragraph (a) upon NOAA notification to the permittee that Sections V.E and VIII of this MOA have been complied with. Such notification shall be sent by NOAA within 10 working days following NOAA receipt of written notice of the action by the RWQCB or SWRCB, as appropriate. If NOAA fails to act within this time period, the subject permit shall be deemed to have met such paragraph (a).

No permit may be issued allowing the disposal of dredge material within the Sanctuary other than at sites designated as of the effective date of Sanctuary designation.

With regard to the combined sewer overflow component of the City and County of San Francisco's sewage treatment program, as approved by the San Francisco RWQCB and U.S. EPA: a buffer zone has been created encompassing the anticipated discharge plume in order to protect Sanctuary resources and qualities from the discharge. The parties to this MOA agree that the MPRSA and its implementing regulations do not apply to the buffer zone. The buffer zone extends from Point San Pedro (37° 35' 39.9577" N latitude, 122° 31' 11.0433" W longitude); to 37° 36' 59.4490" N latitude, 122° 36' 56.2934" W longitude; to 37° 46' 01.2422" N latitude, 122° 38' 56.4737" W longitude; to Point Bonita (37° 49' 05.9481" N latitude, 122° 31' 42.3981" W longitude). The shoreward boundary of the buffer zone extends from Point San Pedro north along the coast following the mean high tide line to Point Lobos and thence in a straight line to Point Bonita.

F. Consistency Review Procedures

California Coastal Commission shall conduct its consistency review in accordance with the NOAA-approved CCMP.

VI. INTEGRATION AND COORDINATION OF RESEARCH AND MONITORING EFFORTS

- All parties to this MOA agree that a higher degree of resource protection may be necessary for the Sanctuary.

- All parties to this MOA agree to conduct, coordinate, and integrate any joint research, monitoring, and permit review oversight. The results of these efforts will be used to develop a more specific water quality management plan and to provide a

higher degree of resource protection for the Sanctuary.

VII. SANCTUARY WATER QUALITY PROTECTION PROGRAM AND DEVELOPMENT OF SANCTUARY CRITERIA

A. Sanctuary Criteria

- Criteria are proposed values which are intended to provide a nonregulatory, scientific evaluation of the ecological effects of pollutants. EPA has published numerical criteria for priority pollutants under CWA Section 304(a). The Section 304(a) criteria or other proposed values become water quality objectives after adoption by the State Board pursuant to the provisions of the California Porter-Cologne Water Quality Control Act. These objectives, once they are combined with beneficial uses and approved by EPA, become water quality standards pursuant to the CWA.

- NOAA shall consult with the State Board and the Regional Boards to determine if it is necessary to develop criteria in addition to those already promulgated by the

  State Board and Regional Boards in order to protect Sanctuary resources and qualities and compatible uses.

- Any necessary specific criteria will be developed for the Sanctuary to implement the purposes of Title III of the MPRSA. These criteria will be developed in a Water Quality Protection Program process (see below under Part B of this Section).

B. Water Quality Protection Program

- All signatory agencies agree to work together to develop a comprehensive water quality protection program for the Sanctuary.

- The purposes of such water quality program shall be to—

  (A) recommend priority corrective actions and compliance schedules addressing point and nonpoint sources of pollution to restore and maintain the chemical, physical,and biological integrity of the Sanctuary, including restoration and maintenance of the resources, qualities and compatible uses of the Sanctuary; and
  (B) assign responsibilities for the implementation of the program among the Governor, the Secretary of Commerce, and the Administrator of U.S. EPA or designees in accordance with applicable Federal and State laws.

  The program shall under applicable Federal and State laws provide for measures to achieve the purposes described above including—

  (A) adoption or revision, under applicable Federal and State laws, by the State and the Administrator of applicable water quality standards for the Sanctuary, based on water quality criteria which may utilize biological monitoring or assessment methods, to assure protection and restoration of the resources and qualities of the Sanctu-

ary;
(B) adoption under applicable Federal and State laws of enforceable pollution control measures (including water quality-based effluent limitations and best management practices) and methods to eliminate or reduce pollution from point and nonpoint sources;
(C) establishment of a comprehensive water quality monitoring program to (i) determine the sources of pollution causing or contributing to existing or anticipated pollution problems in the Sanctuary, (ii) evaluate the effectiveness of efforts to reduce or eliminate those sources of pollution, and (iii) evaluate progress toward achieving and maintaining water quality standards and toward protecting and restoring any degraded areas and living marine resources of the Sanctuary;
(D) provision of adequate opportunity for public participation in all aspects of developing and implementing the program;
(E) identification of funding for implementation of the program, including appropriate Federal and State cost sharing arrangements; and
(F) provision to ensure compliance with the program consistent with applicable Federal and State laws.

In the development and implementation of the program appropriate State and local government officials shall be consulted either directly or via AMBAG.

VIII. PROCEDURES FOR REFERRAL

A. General:

1. In the vast majority of cases, the concerns of the different parties to this MOA will be addressed at the Initial Decision-making levels.

2. If concerns have not been resolved at the Initial Decision-making levels, the dispute could be referred to higher level officials within each agency for resolution.

3. If resolution is not reached at Initial Decision-making levels, the following process is available to NOAA.

B. Process for elevation:

1. If the RWQCB permit does not, in the opinion of NOAA, adequately act to relieve the threat of significant injury or significant injury to the Sanctuary, i.e., the threat of significant injury or significant injury is still occurring and there is not underway a NOAA-approved (in consultation with U.S. EPA) action plan to adequately reduce or eliminate the threat of significant injury or significant injury to the Sanctuary, NOAA may file an appeal with the SWRCB within 30 days of the RWQCB action (ref: Section 13320 of the California Water Code). The SWRCB shall act to confirm, amend or overturn the decision of the RWQCB within 45 days of the appeal being filed by NOAA.

2. If, after the SWRCB acts to confirm, amend or overturn the decision of the RWQCB, in the opinion of NOAA, the SWRCB has not adequately acted, i.e, the threat of significant injury or significant injury to the Sanctuary is still occurring and there is not underway a NOAA-approved (in consultation with U.S. EPA) action plan to adequately reduce or eliminate the threat of significant injury or significant injury to the Sanctuary, NOAA may file an appeal with the MBNMS Joint Review Board (JRB) within 30 days of the SWRCB's action. The JRB shall consist of the Administrator of NOAA (or designee) and the Secretary of California EPA (or designee).

3. After considering information received from NOAA, the SWRCB, the RWQCB, other public agencies and the public, the JRB shall recommend to the SWRCB the confirmation, amendment, or overturning of the decision of the SWRCB. The JRB shall make such recommendation within 30 days of receipt of the appeal to it.
4. The SWRCB shall act to confirm, amend or overturn its decision within 60 days of receipt of the JRB's recommendation.

IX. RIGHTS OF APPEAL OR PETITION UNDER FEDERAL OR CALIFORNIA STATUTE OR REGULATION

This MOA is not intended to limit any rights of appeal or petition of any signatory to this MOA existing under Federal or California statute or regulation.

X. MODIFICATION PROVISIONS

This MOA shall become effective upon signature by all parties hereto.

Any amendment to this MOA shall only be in writing and shall become effective only upon the signature of all signatory agencies. Any amendment to this MOA shall be published in the Federal Register.

An individual signatory agency may withdraw from this MOA only if the Procedures for Referral in Section VIII have been exhausted on at least one occasion and the resolution of the subject dispute is not acceptable to the withdrawing party. Upon notice that a party is considering withdrawing, NOAA shall publish a notice in the Federal Register stating the reasons for withdrawal and soliciting public comment. If the subject party ultimately decides to withdraw, it shall give the other parties at least 90 days notice of intent to withdraw, and NOAA shall publish a notice in the Federal Register announcing the withdrawal.

This MOA shall become invalid only if NOAA or the SWRCB withdraws in accordance with the above procedures.

Gertrude M. Coxe, Director
Office of Ocean and Coastal Resource Management
National Oceanic and Atmospheric Administration

June 29, 1992

Harry Seraydarian, Director
Office of Water, Region IX
U.S. Environmental Protection Agency

May 29, 1992

James Strock, Secretary
California Environmental Protection Agency

May 29 1992

Walt Pettit, Executive Director
State Water Resources Control Board

5/29/92

Steven Ritchie, Executive Officer
San Francisco Regional Water Quality Control Board

5/30/92

William Leonard, Executive Officer
Central Coast Regional Water Quality Control Board

5/29/92

Peter Douglas, Executive Director
California Coastal Commission

6/30/92

Nicolas Papadakis, Executive Director
Association of Monterey Bay Area Governments

Appendix E: Monterey Bay Modeling Group

The Monterey Bay Modeling Group (MBMG) is an *ad hoc* computer modeling group composed of a core of scientists and computer engineers attached to the U.S. Geological Survey (USGS); the Monterey Bay Aquarium Research Institute (MBARI); Moss Landing Marine Laboratories (MLML); Lockheed, Sunnyvale; the Naval Postgraduate School (NPS), Monterey; and NASA/Ames Research Center, Mt. View. The group is in flux and expanding with the possibilities of incorporating additional computer expertise from other organizations such as Jet Propulsion Laboratory (JPL), Pasadena; National Oceanographic and Atmospheric Administration (NOAA); Monterey Bay Aquarium (MBA); and the computer group at the University of California, Santa Cruz (UCSC).

The objectives of MBMG are multifold and cross the spectrum of the oceanographic sciences including geology, biology, and physical and chemical oceanography. Present expectations are to compile and computer process pertinent digital data available for the Monterey Bay region, and fill data voids by digitizing analog data and adding to the computerized data base. We envisage the generation of computerized three-dimensional physiographic models of the Monterey Bay evirons upon which subseafloor and water column data can be overlain. Ultimately, it is anticipated that a oceanographic scientific data base archival and retrieval system using the 3-d computerized physiographic model can be developed and networked for use by multidisciplinary interests including scientists, engineers, planners, managers and especially the general public. The basic objectives are listed below:

1. To process, refine, and standardize all digital bathymetric data vailable for the Monterey Bay region.
2. To generate hard copies of bathymetric maps of the canyon and bay at various scales and contour intervals.
3. To supply digital bathymetric data for use in computerized navigation systems, such as being used on *Pt Lobos*, for use with *Ventana.*
4. To develop three-dimensional computer models that can be used to form physiographic perspectives, both in the computer and on hard copy.
5. To apply the geological data base to the computerized bathymetry.
6. To apply biological, hydrographic, chemical and other oceanographic data to the model.
7. To develop a scientific data archival and retrieval system using the 3-d computerized physiographic model.
8. To develop systems by which scientific data can be networked and simplified for multidisciplinary use.
9. To produce a computer animation of the origin and geological history of the Ascension-Monterey Canyon system.
10. To produce an educational video or film depicting the geological, biological, and physical processes active in Monterey Canyon.
11. To develop computer animated models of mass wasting in Monterey Canyon that can be used for predicting future events.
12. To model seismic events and relate to fault plane motion in 3-d.
13. Develop methods that are quickly applicable to other areas.

Present Status

The MBMG has been operating semi-formally for about two years. The ideas for its formation and operation was stimulated when NOAA/NOS released to the public the digital Seabeam bathymetric data of the Monterey Bay region, including Monterey Canyon. The USGS with the assistance of a volunteer from Lockheed has been processing the originally released 250 m grided data for use in 3-d perspectives and animation. Recently, NOAA/NOS has provided full resolution digital Seabeam data, which is presently being processed to evaluate and correct anomalies within the data set. At this stage bathymetric maps of various scales and contour intervals can be produced for any area of Monterey Canyon (quality varies depending on original data quality). In addition, net-mesh, contour perspective diagrams, and slope maps of selected areas within the canyon can be constructed from the bathymetric data base.

Basically the overall plan consists of:

1. processing and refinement of full-resolution data;
2. inclusion of shallow water data;
3. refinement of present 2-d capabilities to 3-d representation;
4. integration of accessory data;
5. networking;
6. integration of time-lapse and real time data; and
7. animation and visualization through virtual reality.

This plan is outlined in a chronological fashion and essentially represents mile-stones for the group. Today we are working on 1, 2, and 3, above, and will shortly be undertaking 4. Although number 7 is envisioned as a long-range accomplishment, we are in the process of initiating animation and inputting data into virtual reality. Further description of these goals is discussed below.

Short-term Future Plans

Immediate plans are to finalize the processing of anomalies within the NOAA full resolution Seabeam data-set. Data voids will be identified and attempts made to fill these voids through digitizing analog data, depending upon availability of man power. Generally, areas shallower than 500 m are not represented by the NOAA Seabeam data and need to be filled in with analog data. Small scale maps of selected areas (i.e.; Soquel Canyon, "cement block site", cold-seep community sites, San Gregorio fault zone) will be produced for MBARI's, MLML's, and USGS's use in ongoing biological and geological studies. In addition, digital bathymetric data for use on the Pt. *Lobos (Ventana)* navigation system will be ported over.

Initial contact has been made with NASA/Ames, and discussions about applying Monterey Canyon bathymetric and geologic data to Virtual Reality (the virtual simulation of the real world in a computer environment) were had with Michael McGreevy and Lewis Hitchner. Since that time, Cindy Ferguson has been working with both inputting high resolution data into virtual reality and initiating animation of a Soquel Canyon landslide. Digitized geologic data will be applied to the bathymetric base and analog geologic data will be digitized (depending on availability of assistance) for inclusion into the computer.

Modification of geology will be made compatible with the NOAA full resolution Seabeam data set; Soquel Canyon area will be the prototype locality. In addition, downslope sediment distribution maps showing paths of sediment transport will be attempted.

Long-term Future Plans

Geology - A detailed and complex geologic and geophysical data set exists for Monterey Canyon. This data set includes the following:

1. Detailed sea floor geomorpholgy based on interpretations of Seabeam bathymetric data at a scale of 1:100,000 and 1:50,000 (NOAA/USGS).
2. Shallow water contour maps and boat sheets (NOAA, USGS, MLML).
3. Sea floor and subsurface geology and structure based on interpretations of seismic reflection profiles and sea floor samples (USGS).
4. Seismicity data outlining the earthquake history of the MontereyBay region (USGS)
5. SEAMark side-scan sonar data (Lamont).
6. GLORIA side-scan data (USGS); marginally useful.
7. Rock samples and Video of canyon wall geology obtained with ROVs and submersibles (MBARI/USGS/NOAA/ MLML).
8. Conventional side-scan sonar and seismic reflection profiles (MLML/USGS).

Much of the bathymetric and geologic data have been interpreted and compiled onto maps. Newly acquired data that are available publicly will be compiled and used to modify the published maps and then digitized for insertion into the computer model.

Available digital geologic data will be formatted and used to develop geologic models. The intent is to image in 3-d the geologic structure (faults and folds), lithologies (contacts and rock types), isopachs of tertiary sediment and sedimentary rocks, structural and erosional contour surfaces, modern day processes (earthquakes, landslides, turbidity current paths, etc.), and ground water basins (aquifers, sites of salt water intrusion, hydrologic pathways, etc.). Ultimately, a computer animation of the Neogene tectonic history of the Ascension-Monterey Canyon system (central California margin) is planned to illustrate the geologic origin and development of Monterey Canyon and the Monterey Bay region. In addition, 3-d computer modeling is anticipated for illustrating the modern day geological processes active in the canyon, such as mass wasting and turbitity current events. Presently, known landslides (deposits and scarps) are being analyzed and computer modeling of their movement will be reconstructed. This type of analysis should lead to predictive models that can be used to determine future areas of mass wasting and paths of sediment transport within the canyon.

Eventually real-time imaging of earthquakes, landslides, and turbidity current events could be done within the computer model and could be accessible to multiple work stations and monitors for the general public. These real-time events would be tied to historical events so that chronological replays could be run and related to modern day events. Real-time data would be accessible from the fiber-optic data cables that are presently being planned for emplacement in Monterey Bay or from the Navy listening station at Pt. Sur (NPS, MBARI, NOAA).

An educational and public interest documentary film or video depicting Monterey Canyon ' s formation and present day activity is envisioned. This documentary would include computer animation of its tectonic development, computer "fly through", comparing it with the Grand Canyon of the Colorado River (through video footage), transitions to video segments of the canyon's walls and floors showing geology and biology, computer animation of present day dynamic processes, and an overall visualization of the Monterey Bay region and its spectacular setting (see script of Grand Canyon Suite). Although this documentary would have a geological base, biology and the dominant physical processes of the canyon would be depicted as well.

Biology - A biological data set of Monterey Canyon exists primarily in the form of video taken from ROVs and submersibles (MBARI, MLML, NOAA, USGS). No true biotope maps exist, but species lists and other tabalized data are available (MLML, MBARI, NOAA, Scripps, Hopkins, UCSC). A current topic is the existence and variety of "cold-seep" communities that are found in Monterey Canyon. Their location and distribution lends itself nicely to computerization and this information is expected to be applied to the computer model. In addition, fluids that support these communities are related to the geologic structure and hydrology of the Monterey Bay region and can be modeled in 3-d. The intent is to collect and compile geologic and hydrologic data in the vicinity of the "cold-seep" communities that can be used in the computer model to image the active processes that are critical to the existence and evolution of these communities.

Benthic fauna and flora within the canyon are related to several different physical parameters such as lithology, currents, temperature, salinity, pH, and oxygen. Distributions and concentrations of these parameters can be imaged in the computer model and related to the types and diversities of the benthic communities. The intent would be to show the distribution and flux of these communities in relation to the dynamics of the various parameters that affect these communities.

Physical Oceanography - A physical oceanographic data set exists in the form of maps depicting currents, predominant wave and wind directions, and tsunami pathways (NOAA, USGS). Current strengths and directions, as well as statistics on wind, waves, and longshore drifts have been reported in the literature and listed in tables (NOAA, USGS, MLML, MBARI, NPS). The dynamics of these water column and atmospheric data can be imaged in the computer model and used to construct historical and predictive events.

Chemical Oceanography - A chemical oceanographic data set for Monterey Bay exists in the form of tables and lists in publications. (MLML, NOAA, MBARI). It is questionable whether a diagnostic data set exists that can be readily applied to computer at this time. However, chemical distribution and flux within Monterey Canyon and Bay could be imaged in the computer model. Such things as oxygen, pH, $C0_2$, Fe, methane, salinity, and other chemical constituents should be compiled in the form of concentrations and distributions and related to other chemical and physical oceanographical fluxes. Many of the chemical constituents are directly related to geological, physical and biological processes and could be applied to computer generated models of these processes.

Data Management - A tremendous amount of oceanographic data exists for the Monterey Canyon and Bay and there is no single method by which these data can be accessed. In addition, increased amounts of data are continuously collected in the region and need to be integrated into a archival and retrieval system. The ideal situation would be to compile the presently available data into a computer system that is readily accessible to scientists and other interested people. As new data become available, they could be placed into the computer system to update the data base. The computer modeling discussed here could be used as the Monterey Bay regional oceanographical data base system.

The eventual outcome of MBMG is to establish a three-dimensional oceanographic computer system such as Virtual Reality to archive and retrieve data available for the Monterey Bay region. We not only envision 3-d computer model representations of data interpretations, but the access to raw data that would be the basis of interpretations. The computerized model could be used as a 3-d map to locate and retrieve data. For example, a site of interest on the canyon wall or floor could be selected and the computer asked to indicate or illustrate all or specific kinds of data available for the site. If video or still camera photographs exist for the site they could be visualized on the computer screen. Interpretative scenarios of data could be made available in formats useful to scientists of different disciplines or to non-scientists. Real-time events such as those discussed above under geology could be displayed within the model and be accessible at any time.

The computer modeling and data library should be networked to all interested and participating oceanographic organizations within the Monterey Bay area for their use and input. The network should also extend to incorporate cooperative institutions outside of the bay area (i.e., Stanford, USGS, NASA/Ames, Lockheed, Hewlett-Packard, JPL, etc.) and could be connected to the USGS's seismographic network and the San Francisco Bay Area Regional Geologic Database (BARD).

Education - The MBMG's computer model is ideally suited for educational purposes and public awareness. Monitors for use in depicting historical and real-time geological and oceanographical events can be positioned at the Monterey Bay Aquarium, schools, and museums where the public can access them. Computer animated modeling scenarios of submarine canyon formational and modifying processes, biological activity, and physical dynamics can be shown at the above public institutions and elsewhere for the purpose of illustrating oceanographic sciences and informing the general public on the results of marine investigations. The proposed documentary (see Geology above) would not only be of interest to students of science, but would be enjoyable for the general public as well. This is frontier science and engineering; therefore, methodologies established in developing this computer model would be educationally pertinent to computer scientists and data managers.

Meetings

The first meeting of the MBMG was held at MBARI March 17, 1992. Three other meetings have been held since, at NASA/Ames, USGS, and MBARI. The basic framework of the group was discussed at these meetings and is reflected in the various sections described above. The intent of the group was to pursue computer modeling of the canyon and to

establish long range goals of using the model for archiving and retrieval of data, to produce computer animations of the canyon history and processes, to produce computerized canyon fly-throughs incorporating underwater video, and to establish a computer data network for transferring oceanographic information and scenarios to participating institutions and the general public. All of this is reflected in the discussion given above.

Participants:

<u>Core Group</u>		
Gary Greene	(USGS/MLML) Coordinator	Geologist
Bruce Robison	(MBARI)	Biologist
Chuck Baxter	(Hopkins, MBARI)	Biologist
Jim Barry	(MBARI)	Biologist
Mike Lee	(MBARI)	Computer Eng.
Clint Steel	(USGS)	Computer Eng.
Michael Hamer	(USGS)	Computer Eng.
Michael Genzmer	(USGS/Lockheed) Volunteer	Computer Eng.
Pete Brewer	(MBARI, Director)	Chemist
Michael McGreevey	(NASA/Ames)	Computer Eng.
Carolyn Degnan	(USGS)	Geophys./Comp. Eng.
Bruce Gritton	(MBARI)	Software Eng.
Don Brutzman	(NPS)	Computer Eng.
Tom Chase	(USGS)	Geologist
Jaci Tomulonis	(MBA)	Exhibit Developer
Natasha Sraley	(MBA)	Exhibit Researcher
Robert Hall	(US EPA)	

<u>Possible Future Participants</u>		
Lewis Hitchner	(NASA/Ames)	Computer Scient.
Gary Sharp	(CIRIOS)	Biologist
Kevin Hussey	(JPL)	Computer Eng.
Patrick Mantey	(UCSC)	Computer Eng.
Lora Martin	(UCSC)	Sci. Development
Khosrow Lashkari	(MBARI)	Engineer
Wolfgang Baer	(Nascent Technologies)	Engineer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