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the monterey bay connection:

**a prospectus for scientific
excellence in the 1990's**



**U.S. Department of Commerce
National Oceanic and Atmospheric Administration**

June 1992



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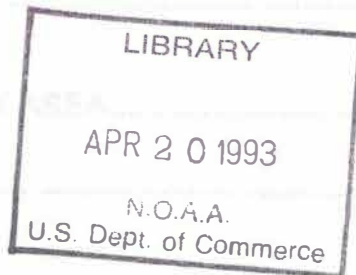
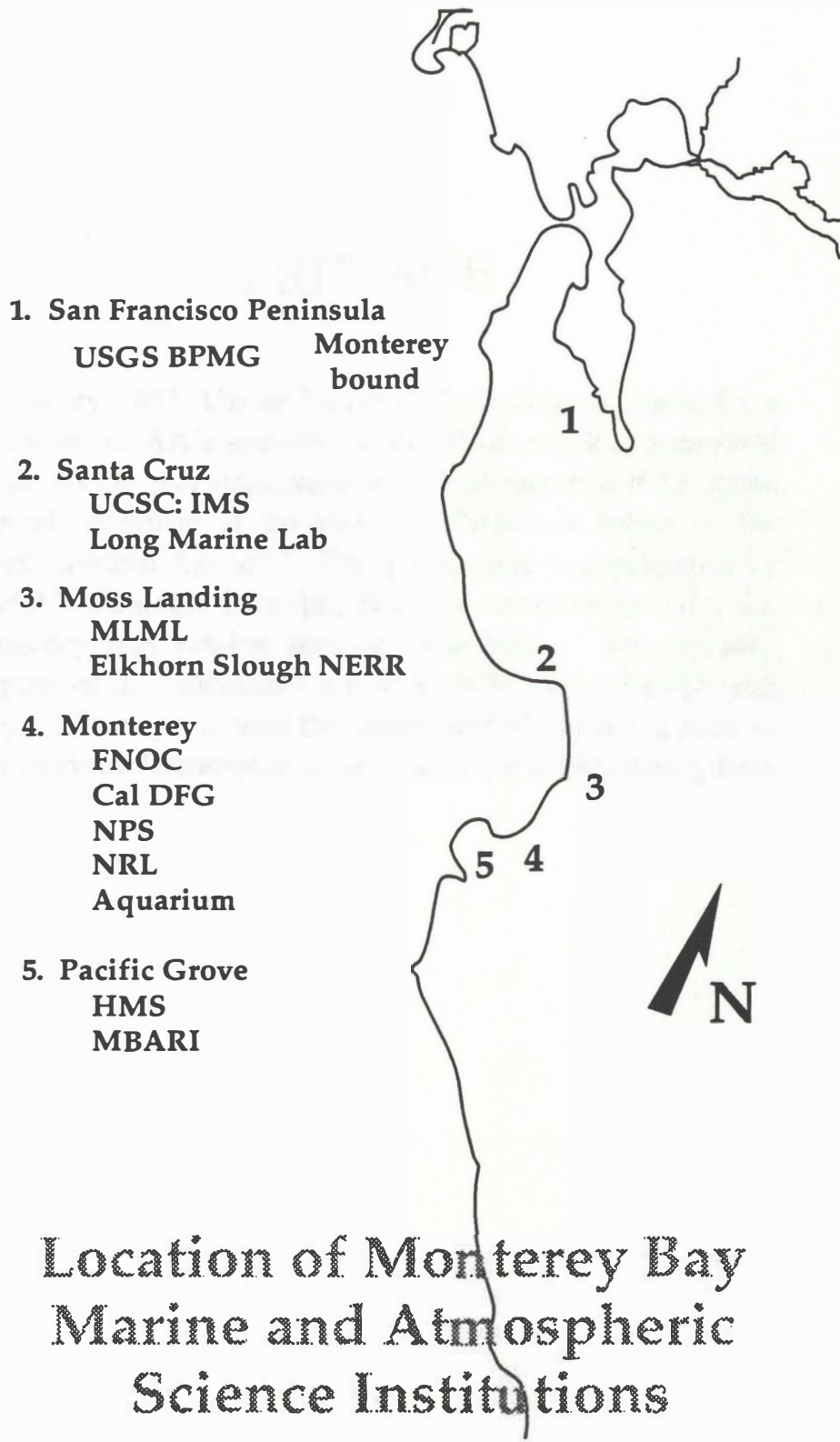


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PREFACE

In January 1991, Under Secretary John Knauss asked for a review of NOAA's activities in the Monterey Bay area from the perspective of opportunities in that region and the more general backdrop of the vision of NOAA's future as the "Earth System Agency." This prospectus was prepared by NOAA's Strategic Planning Staff, in consultation with the Monterey Bay marine science community. The primary purpose of this document is to inform NOAA scientists and program managers about the current and planned activities of the marine and atmospheric institutions around Monterey Bay.

Acknowledgments

This prospectus could not have been prepared without the thoughtful cooperation and assistance of a large number of people in the Monterey Bay community. Members of the area marine science community were exceptionally responsive and helpful. In particular, the comments and contributions of Bill Schramm, Drs. Jim Rote, Gary Sharp, Alec MacCall, and Andy Bakun were provocative, constructive, and forward-looking. The staffs of the NOAA Center for Ocean Analysis and Prediction, the NOS Ocean Applications Branch, the NMFS Enforcement Office-Monterey, NMFS Pacific Fisheries Environmental Group, and NMFS Tiburon Laboratory animated the process with detail and perspective. Members of the area marine science community were exceptionally responsive and helpful. They include:

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Executive Summary

The Monterey Bay area has a long tradition of marine and atmospheric science beginning with the founding of Hopkins Marine Station in 1892. The Bay itself and the submarine Monterey Canyon represent a unique region of ecological diversity and oceanographic complexity. It is a natural marine “laboratory” that can be considered to be a microcosm of the ocean itself. It is among the most intensely monitored and studied marine environments in the world.

Ten oceanographic and atmospheric institutions in the Monterey Bay area today involve nearly 1,200 people, some 400 of whom are students. These institutions represent a current annual investment of approximately \$77 million. Planned investments to expand these capabilities have been made by virtually all of the institutions. The Navy’s planned capital investment during the next several years is \$35 million alone. Also in the planning stage is a move from Menlo Park by the Branch of Pacific Marine Geology (U.S. Geological Survey) to Long Marine Laboratory at the University of California, Santa Cruz. Some marine scientists predict that Monterey Bay will achieve the status of Woods Hole, Massachusetts, as an oceanographic community.

NOAA has been active in the Monterey Bay area for more than two decades through its research into the relationships among marine ecosystems, fisheries, and ocean climate. More recently, NOAA presence in the Monterey Bay area has expanded in such fields as oceanographic data distribution, data visualization, and development of ocean models to improve marine prediction, as well as protection of marine habitat—through creation of California’s first estuarine reserve (Elkhorn Slough) in 1978 and the designation of the Monterey Bay National Marine Sanctuary in 1992. In FY 1994, NOAA will establish the National Institute for Marine Prediction as the next evolutionary step that builds upon the NOAA Center for Ocean Analysis and Prediction established in 1988. In conjunction with the modernization of the National Weather Service, NOAA will relocate the Weather Forecast Office for the Central California Coast at Monterey and begin operations there in FY 1994.

I. INTRODUCTION

Monterey Bay and the Marine and Atmospheric Sciences

Unique Marine Geography:

On the map of the West Coast of the United States, Monterey Bay stands out as a pronounced notch in the coastline 75–100 miles South of San Francisco. Almost semicircular in shape, Monterey Bay is twenty miles across from the Monterey Peninsula at the South to Santa Cruz at the North. It encompasses about forty miles of the coastline.

Monterey Bay's unique oceanographic characteristics stem from its proximity to major features of oceanic circulation and dramatic contours on its seafloor. Straddling subtropical and temperate climate zones, Monterey Bay experiences great variation arising from changes in winds and adjacent ocean currents. As a cause of significant biological productivity, upwelling of nutrients from deeper layers occurs as winds and currents shift throughout the year.

From February to September, northwest wind patterns push coastal surface waters offshore, and nutrient laden deep water flows to the surface on an episodic or pulsed basis. After a slackening of winds in the fall, upwelling decreases and biological productivity falls off. In winter, the north flowing Davidson current provides a warming influence, and significant upwelling does not resume until February as northerly winds shift again.

The Monterey Canyon, terminating at the center of the Monterey Bay coastline (Moss Landing), is the largest submarine chasm in the continental United States. Some 25 to 30 million years old as a geologic feature, the Monterey Canyon plunges to a depth of 90 meters within one kilometer of Moss Landing. Meandering 175 kilometers offshore, the Monterey Canyon, reaches a depth greater than three kilometers as it fans out to the deep seafloor. In no other location for marine research in the continental United States does such a deep marine oceanic environment come so close to shore.

As a result of varying ocean circulation and pronounced submarine topography, Monterey Bay has one of the most diverse marine ecosystems in such a limited area. The intense biological productivity from seasonal upwelling is combined with the intersection of subtropical and temperate conditions to produce an ecosystem that is more complex than in subtropical or temperate conditions alone.

This combination of factors results in one of the richest faunas and floras in the world. Phytoplankton productivity rates are among the world's highest. The west coast of North America is famous for its diverse marine flora, and 80% of the seaweeds occurring between Puget Sound and southern California can be found in the vicinity of Monterey Bay. The phytoplankton and attached algae, exemplified by massive kelp forests, support one of the most diverse temperate marine faunas existing anywhere. Habitats include mudflats with abundant shellfish in Elkhorn Slough, clean sand beaches around the arch of the Bay, invertebrate-rich rocky reefs at either end of the Bay, subtidal kelp forests, and the deep waters of the canyon, which harbor diverse planktonic and nektonic animals. These algae and invertebrates, in turn, support many species of vertebrate predators.

Large local populations of marine fishes are present throughout the year, along with rare species occurring usually in association with marine canyons. Many fishes of economic importance, such as squid, anchovy, salmon, sablefish, rockfish, flatfish, and albacore are available seasonally in the Bay and support local commercial fisheries. Numerous species of shore birds occur in the Slough's salt marshes and along the Bay's beaches and rocky intertidal areas, while pelagic sea birds are found regularly over the center of the Bay. Several species of marine mammals also inhabit local waters. California sea lions and harbor seals occur throughout the region. Just north of Monterey Bay is Año Nuevo Island, a breeding site for Steller sea lions and elephant seals. California sea otters inhabit the kelp forests north and south of the Bay. The spectacular migration of the California gray whale occurs in the area each winter. Porpoises often accompany research vessels in the mid-bay region. Numerous other species, including humpback, blue, and killer whales, also occur in the Bay at less frequent intervals.

A Rich Marine Science Tradition:

Because of the special oceanographic attributes of Monterey Bay, marine science history has been made there. As the oldest marine laboratory on the West Coast, and the second oldest in the United States, the Hopkins Marine Station at Pacific Grove is this year celebrating a centennial of marine biological achievement recognized around the world. Although the adventures of "Doc" Ricketts before World War II have been enshrined in folklore and literature to an extent far more than those of most marine scientists, the seriousness of his work and contribution to marine science should not be underestimated. Since World War II, laboratories and educational programs of the University of California and California State University have sustained continuous programs of research focused in the Bay and its relation to oceanography of the west coast. California's Department of Fish and Game has conducted research and management activities in the Monterey Bay area since the 30's.

The Navy enriches the mix with the Naval Postgraduate School, graduating 50 – 100 U.S. and foreign students in the ocean/atmospheric sciences every year. The Naval Research Laboratory - Monterey is the nation's premier government lab in the field of marine weather forecasting. As a location for the research and routine prediction of the physical characteristics of the ocean and atmosphere, the Navy's Fleet Numerical Oceanography Center is the only oceanographic center that routinely predicts the integrated global atmosphere and ocean environment for defense and civil applications 365 days a year.

Perhaps the most unusual marine science innovation in Monterey is the Monterey Bay Aquarium and the Monterey Bay Aquarium Research Institute (MBARI). Founded by industrialist David Packard, the Aquarium and MBARI, while operationally separate, nevertheless represent a unique blend of public education and interpretation of marine science, application of the most advanced techniques for marine science observation and sampling, and the maintenance of a working environment for marine scientists unfettered by the burden, normally faced by academic and government laboratory scientists, of having to prepare formal research grant proposals every year.

Unlike other geographical centers for marine science in the United States (Woods Hole, Massachusetts; Narragansett, Rhode Island; Miami, Florida; La Jolla, California; Seattle, Washington), Monterey Bay is also the location of significant atmospheric research, education, and operational prediction capabilities at a combined level of effort of approximately \$18 million per year.

Monterey Bay's Future in the Marine and Atmospheric Sciences:

The position of Monterey Bay as a source of leadership in the marine and atmospheric sciences is virtually assured for several reasons. First, each of the institutions engaged in marine or atmospheric science plans major advances in the 1990s that have already been approved for implementation.

Second, a strong commitment to cooperation and coordination of effort has evolved among the institutions in the area. The normal tendencies toward competition or insularity often experienced between separate research organizations does not seem to exist in the Monterey Bay area. One factor that brings this cooperative spirit about is the shared vision of leaders of the institutions and their effort to communicate frequently.

Third, the citizens of the Monterey Bay area have firm ethical commitments to understanding and protecting the marine environment that is a shared thread between the communities. Public support is strong.

The outlook for Monterey Bay as a leading area for the marine and atmospheric sciences provides an unprecedented opportunity for NOAA to advance its mission in the 1990s. In no other part of the country does NOAA face such a large array of potential partnerships for mutual benefit. The following sections of this prospectus describe these opportunities to form cooperative connections that can greatly leverage NOAA's planned investments in many priority areas set forth in NOAA's Strategic Plan.

II. PROFILES OF THE MARINE AND ATMOSPHERIC SCIENCES COMMUNITY IN THE REGION

Status and Outlook

This section describes the organizations that are active in the marine and atmospheric sciences around the Monterey Bay area. Descriptions include organizational mission, history, major programs, resources available, and future outlook. In the aggregate, these organizations represent an annual investment of \$77 million, involving nearly 1,200 people (See Table 1).

A. Fleet Numerical Oceanography Center (FNOC) (Monterey, CA)

Mission:

FNOC is the Navy's primary real-time numerical prediction center processing global and regional-scale oceanographic/atmospheric models and applied products. Operating 24 hours a day, 365 days a year, FNOC provides atmospheric products and services to the Department of the Navy and oceanographic services to the Department of Defense (DoD). In addition, through intergovernmental agreements, FNOC products also serve a broad spectrum of civil interests. FNOC maintains one of the world's most complete global real-time databases of conventional and remotely-sensed oceanographic and atmospheric observations in support of its global prediction mission. The supercomputer models employed by FNOC are presently loosely coupled, extending from the bottom of the ocean to the top of the atmosphere. Present goals are to achieve fully coupled air-ocean models by the mid to late 1990s.

History:

FNOC began as the Navy Numerical Weather Problems Group in 1958 in Suitland, Maryland. The group moved to Monterey in 1958 to take advantage of meteorological expertise and second generation computer resources available at the Naval Postgraduate School. It acquired its own computer resource in 1961, and was redesignated the Fleet Numerical Weather Central. In 1979, as Navy interests focused on the ocean and ocean prediction capabilities grew, the command was redesignated with its present title of Fleet Numerical Oceanography Center.

Major Programs:

FNOC is organized into six departments: Data, Models, Fleet Applications, Computer Systems, Communications/Technology Integration, and Supply/Fiscal. These departments manage all major command responsibilities including the receipt, decoding and management of incoming meteorological and oceanographic data; implementation, evaluation, maintenance and quality

Operating Budget and Personnel

	<u>\$Million</u>	<u>Personnel</u>
Fleet Numerical Oceanography Center	19.0	295
Naval Research Laboratory--Monterey	7.4	66
Naval Postgraduate School (Oceanography and Meteorology Departments)	5.8	182
Branch of Pacific Marine Geology (USGS)	20.0	172
California Department of Fish and Game	3.9	57
Hopkins Marine Station	3.5	71
Moss Landing Marine Laboratories	3.0	150
Institute of Marine Sciences (UCSC)	5.5	130
Monterey Bay Aquarium Research Institute	8.5	75
Research Division, Monterey Bay Aquarium	0.6	12
TOTAL	\$77.2 million	1,190

1992 Capital Expenditures

Fleet Numerical Oceanography Center	\$35.0 million
Monterey Bay Aquarium Research Institute	<u>13.0 million</u>
	\$48.0 million

Table 1 1992 Resources of Monterey Bay Marine and Atmospheric Institutions

control of oceanographic, atmospheric and applications models; and operation and maintenance of computer systems and communications links. The command lacks only internal research and development resources, which are provided by external Navy activities.

Command data sources include the DoD Automated Weather Network , Global Telecommunication System access via a dedicated link with the National Meteorological Center (NMC), Navy communication systems providing atmospheric and oceanographic observations from ships, shore facilities and allied forces worldwide, and extensive global satellite coverage via the Defense Meteorological Satellite Program and NOAA/NESDIS links. FNOC is the center of excellence for SSM/I processing on the Navy/NOAA/Air Force Shared Processing Network (SPN).

Key FNOC products include:

- Global and regional atmospheric analyses and forecasts (up to five days) of meteorological parameters (pressures, isobaric heights, winds, moisture);
- Global and regional ocean analyses and predictions of surface and subsurface temperature fields, ocean fronts and eddies, ocean circulation, sea states;
- Tailored products and tactical applications — for specific weapon/sensor systems and platforms;
- Antisubmarine warfare support— acoustic sensor performance, subsurface temperature/sound velocity, ambient noise;
- Electromagnetic/Electro-optical system performance predictions;
- Optimum Path Aircraft Routing services;
- Numerically derived High Wind/Sea and Tropical Cyclone Warnings;
- Numerical Optimum Track Ship Routing guidance;
- Search and Rescue Forecasts;
- Submarine-launched Ballistic Missile strategic support products;
- Sea ice analyses and forecasts; and
- Support to DoD R&D interests.

FNOC carries out its mission responsibilities through both direct fleet support and more extensively, through Navy regional ocean centers located worldwide that tailor products to specific regional needs. FNOC also exchanges information for certain mutual support and backup needs with both NMC and the Air Force Global Weather Central (AFGWC), and participates in the aforementioned SPN with NOAA/NESDIS and AFGWC for the processing and distribution of satellite information and sensor data.

Resources:

Annual operating budget (1991): \$19.0 million

Personnel:	Naval Officers	45
	Enlisted Staff	70
	Civilian	180

Outlook for the 1990s:

FNOC has firm plans for a multi-year, multi-million dollar system upgrade with the objective of creating an “open systems environment” in hardware, software and communications. The centerpiece of this system upgrade will be the acquisition of a Cray YMP-C90 supercomputer. Other system improvements include:

- Construction of a new building at the FNOC site;
- Installation of modular, workstation and microcomputer based external communications system;
- Installation of a “Permanent File Computer System” (Cray YMP-2E) and an Automated Archival System followed by the Cray YMP-C90 supercomputer in late 1992;
- Conversion from a product-oriented to a data-oriented environment by incorporating state-of-the-art database management systems and techniques;
- Installation of a site-wide local area network (LAN), giving command and collocated Navy and NOAA activities access to data bases and Class VII computer power;
- Conversion of software from existing CDC mainframes to Cray YMP-C90 (numerical models), or to workstations and microcomputer (applied products and distribution procedures);
- Development of continuous data assimilation models;
- Conversion to high density mass storage systems for archives;
- Implementation of sophisticated data compression techniques for efficient communications; and
- Incorporation of artificial intelligence and expert systems to reduce labor-intensive functions and streamline personnel needs.

These system improvements are intended to lead toward fully coupled global ocean and atmospheric models and to the implementation of global ocean models capable of analyzing and predicting thermal structure and circulation down to the scale of mesoscale eddies. These advances in data distribution and modeling will respond to the increasingly demanding challenges of modern

naval warfare, as well as provide the nation with access to tools and databases for monitoring and studying global climate change.

Opportunities for Cooperation with NOAA:

The planned advances in FNOC capabilities open new and promising opportunities for expanded cooperation between Navy and NOAA interests. Under the auspices of Navy-NOAA Memoranda of Agreement, increasing cooperation and exchange are foreseen in the areas of numerical ocean modeling, information systems, and database management technologies. Navy unique unclassified databases and ocean fields could also be made available to collocated NOAA activities for further distribution to non-DoD agencies and authorized civilian users. NOAA, in turn, hopes to make use of FNOC numerical model output to initialize NOAA's coastal (EEZ scale) models as they are developed, and to provide coastal model output to the Navy for high resolution tactical applications.

The planned modernization and relocation of the San Francisco National Weather Service Weather Forecast Office (WFO) to the Navy's FNOC site further expands Navy-NOAA collaboration. Access to a site-wide LAN will provide the WFO access to the FNOC operational database and FNOC access to operational WFO products and satellite imagery.

Further, the increased sophistication of real-time ocean data management available at FNOC provides the potential for efficient national archiving of oceanographic data at the Monterey locale.

FNOC is also a member of the informally constituted "Monterey Interagency Environmental Group", a collection of seven Navy and NOAA entities on the Monterey Peninsula that meets on environmental matters.

B. Naval Research Laboratory—Monterey (NRL - Monterey)
(Monterey, CA)

Mission:

NRL - Monterey is the principal Office of the Naval Research Laboratory, performing integrated R&D, testing and evaluation in atmospheric science and related technologies to improve and support Navy systems and operations. The Atmospheric Sciences Division of NRL - Monterey conducts R&D directed towards providing objective local, regional and global environmental analyses and prediction techniques, and provides planning, modeling and evaluation services for determining the effect of environmental elements on naval weapon systems.

History:

NRL—Monterey was formerly the Atmospheric Directorate of the Naval Oceanographic and Atmospheric Research Laboratory (NOARL), and before that, the Naval Environmental Prediction Research Facility (NEPRF); both NEPRF and NOARL were field activities under the Chief of Naval Research in Washington, D.C. NEPRF's status and designation changed in November 1989 when it was combined with two other R&D organizations—the Naval

Ocean Research and Development Activity, and the Institute for Naval Oceanography, (both at the Stennis Space Center, Mississippi) — into a single corporate naval ocean sciences laboratory, NOARL. NRL - Monterey is the only scientific center in the Navy to be wholly dedicated to atmospheric research.

Major Programs:

The goals of NRL - Monterey's work are to improve the quality of forecasting techniques and products available to the fleet; to increase the Navy's knowledge of the environments in which it operates; to develop techniques for assessing the effects of atmospheric conditions on ship and air platforms, and on shipboard, airborne and land-based naval communications, sensors and weapon systems; and to improve techniques for the processing, display and utilization of environmental satellite data in support of fleet operations.

NRL - Monterey is a full service DoD research and development facility, initiating programs in Basic Research and Exploratory Development and seeing them through to Advanced and Operational Development and finally into operational implementation. NRL - Monterey augments the work of its in-house staff with grants and/or contracts to a broad base of universities, private research establishments and other government laboratories.

NRL - Monterey has two research branches divided into four sections: Data Base Development, Prediction Systems, Forecast Guidance, and Naval Systems Support. Their areas of geophysical research range from the air-sea interface through the earth's atmospheric boundary layer to the lower stratosphere. The technical activities are the following:

- **Data Base Development:** Develop, test and implement data assimilation techniques for central-site utilization, and nowcasting procedures using workstation technology to integrate satellite information.
- **Prediction Systems:** Develop, test and implement numerical computer models of atmospheric analysis and prediction on scales ranging from marine planetary boundary layer or air/sea interaction phenomena, through regional phenomena (e.g., tropical cyclones, mid-latitude storms), to global weather, primarily for use on the large main-frame computers at FNOC.
- **Forecast Guidance:** Develop, test and implement techniques, forecast aids and applications guides that define the impact of the environment on naval operations and provide environmental information and guidance to tactical planners and commanders by such means as synoptic forecasting guides on a regional scale; statistical techniques and artificial intelligence for weather analysis/forecasting; and studies of regional phenomena to support operational forecasting, development of decision aids, and understanding of problems unique to specific regions.
- **Naval Systems Support:** Develop, test, and implement numerical, synoptic and/or statistical weather forecast techniques, tactical decision aids, and command and control aids for use by fleet meteorologists, primarily on-site at locations world-wide using directly observed data, satellite information, and/or FNOC computer model forecasts; support weapon systems developers to account for environmental effects on systems performance.

Resources:

Annual operating budget (1991): \$7.4 million

Personnel:	Naval Officers	4
	Enlisted Staff	6
	Civilian Staff	56

Outlook for the 1990s:

Highlights for NRL - Monterey's activities include:

- ***New versions of the Navy Operational Global Atmospheric Prediction System (NOGAPS):*** NRL - Monterey will incorporate advances to reduce systematic errors, and refine the model's cloud parameterization, radiation and cumulus convection interactions. These changes will accompany the evolution of the Navy's global atmospheric prediction system to higher resolution. NOGAPS is competitive with any operational model in the world and is an excellent research model for coupled ocean/atmosphere research. NOGAPS' forecasts drive most of the FNOC applications programs, including prediction of ocean winds and waves, ocean thermal (acoustic) structure, and optimum routes for both ships and aircraft.
- ***Advances in the Tactical Environmental Support System (TESS):*** NRL - Monterey will adapt minicomputer technology for shipboard environmental applications such as ingest and display of satellite data, management of environmental databases, execution of applications programs dependent upon environmental data, interfacing with the Navy communications network, and dissemination of environmental products to warfare spaces and to other ships/platforms.
- ***Evolution of the Naval Environmental Operational Nowcasting System (NEONS):*** NEONS, based on the Hewlett Packard 835 computer system, has three purposes at NRL - Monterey. First, it will form the basis of a nowcasting system that blends conventional and central-site numerical fields with satellite data. Second, it will form a test bed upon which development of the TESS project will occur; both TESS and NEONS use the EMPRESS database management and the UNIX operating systems. And third, NEONS is a design forum for a relational database structure common to both meteorological and oceanographic data.
- ***Arctic Planetary Boundary Layer Studies:*** NRL - Monterey is participating in a five-year ONR research program (FY1990-94) to study the physics of air/sea/ice interaction in the Arctic. The overall objective of the program is to improve understanding of processes leading to formation and closing of Arctic ice leads and their impact on atmospheric motions. Studies will involve surface-based remote sensing of atmospheric turbulence and satellite observation of regional feedbacks. Numerical model simulations of coupled air/sea/ice systems will seek regional models for operational prediction, incorporating feedbacks from the underlying ice/water surface.

Opportunities for Cooperation with NOAA:

NRL - Monterey is a comprehensive atmospheric research organization that has a primary focus on global and mesoscale weather, especially involving the marine environment. When the NWS Weather Forecast Office is moved to Monterey and collocated with NRL, a mutually beneficial connection will be made: a \$7 million Navy research arm working with a NOAA operational weather office. This association will provide a unique working environment, especially for mesoscale marine meteorology.

C. Naval Postgraduate School (NPS) (Monterey, CA)

Mission:

NPS's general mission is "to conduct and direct the advanced education of commissioned officers, and to provide such other technical and professional instruction as may be prescribed to meet the needs of the Naval Service, and in support of the foregoing, to foster and encourage a program of research in order to sustain academic excellence." Through the Departments of Oceanography and of Meteorology, NPS offers broad spectrum M.S. and Ph.D. degree programs and conducts significant research in conjunction with other Naval organizations and external research organizations such as the University Corporation for Atmospheric Research.

History:

The Department of Meteorology was created in 1946, and during its 45 year history has produced some 2,500 graduates. Established in 1968, the Department of Oceanography has produced more than 1,200 graduates.

Major Programs:

The Department of Oceanography offers three distinct curricula for the M.S. and Ph.D. degrees in Physical Oceanography. These curricula are air-ocean sciences, operational oceanography, and physical oceanography. The overall research goal of the Department of Oceanography—improving ocean prediction — is pursued through four theme areas: acoustical oceanography, coastal and nearshore oceanography, ocean modeling, and air/sea interaction.

The Department of Meteorology offers M.S. curricula that focus on numerical weather prediction, geophysical fluid dynamics, analysis of atmospheric systems, tropical meteorology, boundary layer meteorology, and remote sensing. At the Ph.D. level, advanced study is available in the additional areas of mesoscale meteorology, atmospheric turbulence, air/sea interaction and satellite remote sensing.

Several shared NPS facilities and programs provide support to the Departments of Oceanography and Meteorology. These include:

- ***Physical Oceanography Observing Laboratory*** : The Oceanography Department has acquired the capability for long term (six months) moored current meter measurements. Equipment includes 30 Aanderaa current meters, two acoustic shear profilers, three tomographic transcribers and 15 acoustic releases. This provides the Department with the capability of testing dynamical ideas regarding boundary layers and coastal processes, describing circulation features, and testing and validating numerical models and advanced assimilation methods. First deployment was in the region of Pt. Sur. Future capability will include surface meteorological observations and telemetry of oceanographic data to NPS for classroom use.
- ***Interactive Digital Experimental Analysis Laboratory***: The Meteorology and Oceanography Departments have acquired the ability to display and manipulate satellite data, access real-time data, and interrelate high resolution remotely-sensed data with conventional surface and near-surface air/ocean and upper air observations. This is done with a cluster of minicomputers, large disk storage, links to environmental data, and analysis and graphics workstations. Twelve workstations are presently on line. An SMQ/11 (satellite downlink) has been delivered.
- ***Oceanography Computer Graphics Instructional Laboratory***: This laboratory provides students with the ability to display and graphically analyze oceanic data and modeling results. It is used throughout the Oceanography curriculum. Equipment includes 12 Tektronix color graphics terminals which are connected to the NPS IBM mainframe via coaxial cable. Color printers are available to each user. The Tektronix terminals are currently being replaced by workstations.
- ***Marine Atmospheric Measurements Laboratory***: This facility, located at Fort Ord, uses a 944 MHz radar wind profiler, a radio-acoustic sounding system and a phased array SODAR to support research into air-sea interaction, boundary layer turbulence, atmospheric aerosols, and mesoscale meteorology in coastal regions.

NPS is also a member of the University Corporation for Atmospheric Research (UCAR), University National Oceanography Laboratory System (UNOLS), and has access to the National Science Foundation's *R/V POINT SUR* which is operated by the Moss Landing Marine Laboratories.

Resources:

Annual operating budget (1991): \$5.75 million

Personnel:	Faculty/Staff	82
	Students (Graduate)	100

Outlook for the 1990s:

In tandem with the planned advances in operational oceanography at FNOC, and the deployment of sophisticated new weather observation technologies in the United States and abroad at DoD bases (such as the next generation Doppler radar in conjunction with modernization of the National Weather Service), NPS will face demanding challenges in the 1990s in both research and education.

In the case of research, new atmospheric and marine prediction capabilities in operational use will require significant applications research to validate and refine new models as they are used in practice to simulate the "real world." This is especially the case with the deployment of new observation systems that require a long period of practical use to achieve the full potential of all the benefits of improved observations. For example the new Doppler weather radar has never been operated for a sustained period over coastal waters, so that the potential benefits of the new system have not yet been explored.

In parallel with NPS's marine and atmospheric research in the 1990s, its primary advanced education function will be called upon to train the professionals who will perform the research and operational tasks of tomorrow. The highly sophisticated "hands-on" teaching aids found in the laboratories described above will be matched by few institutions around the world as the goals of improved marine and atmospheric prediction are pursued in the 1990s.

Opportunities for NOAA Cooperation:

The Navy's marine and atmospheric prediction mission in Monterey (serving Department of Defense requirements) mirrors NOAA's marine and atmospheric prediction responsibilities for the civil sector directly. In particular, NPS's research and educational activities in the 1990s can dovetail closely with NOAA's programs in both marine and atmospheric areas. The recently created CIRIOS (Cooperative Institute for Research in the Integrated Ocean Sciences) is a Navy-NOAA mechanism between NPS and NOAA to promote such collaboration.

During the 1990s, the NPS/NOAA will focus on three themes: 1) data assimilation, modeling and prediction; 2) data collection and dissemination; and 3) coastal ocean processes with emphasis on Monterey Bay, the Gulf of the Farallones and the adjacent California Current System. In connection with the siting of the new NWS Weather Forecast Office at the NPS Annex in 1993, the Navy (FNOC, NRL - Monterey, and NPS) could work with NOAA to make the Central California Coast an ideal test bed for an "ocean weather system" (data collection and assimilation, modeling and forecasting) that could truly maximize the benefits from the Navy and NOAA investments in this area.

An obvious opportunity for collaboration with NOAA lies in postgraduate education. Historically, NOAA Corps officers have attended the Naval Postgraduate School, and civilian employees of NOAA have also been admitted. Given the breadth of scientific activities in the Monterey Bay area, this educational dimension could be important in the development of NOAA's future human resources.

D. Branch of Pacific Marine Geology (U.S. Geological Survey) (Menlo Park, CA)

Mission:

The United States Geological Survey (USGS) is the nation's premier geological research organization. With 12,000 employees and a FY 1991 budget of \$507 million, the Survey supports a wide variety of geological, geophysical, and oceanographic research. The USGS Office of

Energy and Marine Geology has about 600 employees and a FY 1991 budget of \$70 million. The Office has responsibility for marine research ranging from shorelines and coastal hazards to seismic imaging of the seafloor and studies of global climate change.

The Branch of Pacific Marine Geology (BPMG), centered in Menlo Park, California, is responsible for marine research along the Pacific margin of the United States, but also undertakes collaborative research throughout the Pacific region, including Central and South America, East Asia, as well as the Arctic and Antarctic.

History:

Since its inception, BPMG has been located in the San Francisco Bay area. The Branch was created in 1966 when USGS Director William Pecora established the Office of Marine Geology and Hydrology, which evolved shortly into BPMG. In the summer of 1966, scientific and operational personnel were housed in the Hiller Building and adjacent facilities on Willow Road in Menlo Park. During the latter half of the 1960's, growth in the branch occurred as a direct result of increased research in offshore minerals along the U.S. west coast and through a variety of projects that resulted from the 1969 Santa Barbara oil spill.

In the mid-1970s the capabilities of BPMG to carry out its Offshore Geologic Framework program were greatly enhanced by acquisition of two deep-draft oceanographic research vessels, the *R/V SAMUEL P. LEE* (207 ft.) and the *R/V SEA SOUNDER* (186 ft.). The *R/V SAMUEL P. LEE* was obtained from the U.S. Navy in 1974 on a long-term, no cost lease arrangement with the understanding that the vessel would be maintained by USGS for purposes for geological and geophysical research.

The *R/V SEA SOUNDER* was used by BPMG principally in geological, geophysical, and geochemical studies of the continental shelves around Alaska, California, Oregon, and Washington from 1976-1979. This ship was released from service by USGS in 1980 primarily because of lack of funding to support maintenance and operations. The *R/V SAMUEL P. LEE* served the Branch successfully for 18 years and is being returned to the Navy in 1992. The BPMG is currently searching for a replacement vessel and is exploring the possibility of joint operation with NOAA.

The acquisition of the two research vessels in 1974-76 was shortly followed in 1976 by a move of the marine operations group in BPMG from Menlo Park facility to a large building at the Port of Redwood City. This location provided adjacent pier space for dockage of the *R/V SEA SOUNDER*, and the location for the *R/V SAMUEL P. LEE* at a nearby commercial pier. The newly acquired space at the marine facility also provided for shops, staging areas and storage needed to conduct the growing marine scientific operations at BPMG. In 1983, a disastrous flood of the marine facility prompted relocation to a newer building at the Port of Redwood City. Presently about 20 personnel are located at the MARFAC building. It contains large storage areas, well-equipped machine shops and electronics laboratories, and adjacent docking space for large research vessels.

In 1984, USGS initiated the Exclusive Economic Zone (EEZ) mapping program, which is a cooperative program with the Institute of Oceanographic Sciences (U.K.). The first phase of the mapping program was conducted by BPMG off the west coast of the U.S. The vessel used for at-sea work in this program is the *R/V FARNELLA*, which is operated out of MARFAC. This

ship carries special side-scan sonar mapping instrumentation ("GLORIA" system), and requires deep-water docking capabilities. Present plans call for utilization of the GLORIA system through the year 1996 as part of the EEZ mapping cooperative agreement.

In 1974-75, at about the time the *R/V LEE* and *R/V SEA SOUNDER* were acquired, BPMG received significant increases in staff and funding because of its participation in the Outer Continental Shelf Environmental Assessment Program (OCSEAP). The program was designed to investigate the U.S. continental margins of the Pacific region for petroleum and natural gas accumulations, and to evaluate their economic potential. Additionally, OCSEAP provided for an environmental studies component in which the geological processes that might affect the development of the oil and gas accumulations were investigated in specific continental shelf areas off the western U.S. Although the field areas for this large research effort extended to Alaskan shores, the entire operation was managed and executed from the Western Region location of BPMG in the San Francisco Bay area.

In 1978, largely owing to limited space availability in the Hiller Building and annexes, BPMG was relocated to its present site at the Deer Creek Facility in Palo Alto. This site consists of two large two-story buildings that were completed in 1978 and have excellent office and laboratory space to accommodate the scientific and support staff. The marine operational personnel remain at MARFAC. Space at the Deer Creek Facility is rented by the General Services Administration (GSA) from private owners under a long-term lease agreement that is currently being renegotiated. The present plan calls for renewal of the lease for the period 1990-95, and eventual relocation of BPMG to a new site.

Major Programs:

The scientific staff at BPMG conducts marine geological, geophysical, and geochemical studies of seafloor regions, principally in the Pacific and Arctic Basins and their margins under two broad program elements: 1) Offshore Geologic Framework ; and 2) Coastal Geology. The principal objectives of the offshore Geologic Framework program involve the conduct, on a regional basis, of scientific investigations aimed at the systematic understanding and description of the geologic structure, energy and mineral resources, geohazards, and environmental geology of the United States and other areas of interest to the nation.

Major goals of the Offshore Geologic Framework program include: (a) the systematic mapping and synthesis of information on the general geologic framework of the Continental Margins and deep ocean areas within the EEZ; (b) the seaward advancement of geological knowledge, such as continued discovery of offshore basins prospective for petroleum and the continued discovery of valuable mineral deposits; (c) the predictive evaluation of the energy and mineral resource potential of regions, including the probabilistic assessment of the resources contained therein, for national planning purposes; (d) the study of fundamental marine sedimentary processes that shape the continental margins and influence their use; (e) the conduct of special topical studies, such as geochemical and geotechnical analyses; and (f) cooperative programs with coastal states in assessing offshore resources and environmental problems.

The principal objectives of the Coastal Geology program are to provide geological information and knowledge about the nature, extent and causes of coastal erosion, wetlands loss, and polluted sediments as input to decisions pertaining to the prediction and mitigation of these problems by

various federal and state agencies. Additionally, investigations of the location and extent of hard mineral resources in the coastal regions of the U.S., together with the geological controls on the occurrences of these resources, are integral parts of this program.

Resources:

Annual operating budget (FY 1991):	\$20 million
Personnel:	
Permanent FTE	149
Temporary FTE	23

Outlook for the 1990s:

Due to rising space costs in the Palo Alto/Menlo Park area, BPMG has been exploring options for relocation. Discussions were initiated regarding the feasibility of moving a portion of the branch to the Santa Cruz area, in particular to the Long Marine Laboratory site. Initially, discussions involved the potential move of a subgroup of BPMG (30 to 40 personnel), but as the possible mutual benefits to USGS, UCSC, and the larger Monterey Bay ocean science community became clearer, USGS proposed the possibility of relocating the entire branch to the Long Marine Laboratory site. The initial research program emphasis of BPMG personnel in Santa Cruz would be focused on those components of the overall BPMG program that will benefit most from the enhanced collaboration opportunities with non-USGS researchers at UCSC and elsewhere in the Monterey Bay area. Three possible major program themes that would be initially established at Santa Cruz include:

- Monterey Bay Sanctuary and adjoining regions;
- Coastal California Tectonics, Deformation, and Geohazards;
- Pacific Basin Margin Processes.

Scientific personnel for BPMG and UCSC would collaborate to carry out the goals and objectives of each program theme. All three of these themes are examples of ongoing research efforts in BPMG, encompass program goals directly related to the overall BPMG and UCSC mission, and will greatly benefit from collocation with researchers in the Monterey Bay region.

Opportunities for NOAA Cooperation

Of special interest to NOAA is BPMG's interest in developing a corridor study of the Monterey Bay National Marine Sanctuary. BPMG is interested in establishing a research corridor extending from the crest range, through the wetlands and shoreline, across the shelf and slope to the deep ocean. This program would build on the highly successful cooperative BPMG/NOAA study of the Farallones National Marine Sanctuary. The proposed study promises to bring cooperative funding to the region and the Monterey Bay Sanctuary.

Coupled with the joint USGS/NOAA EEZ mapping program, which coordinates USGS sonar mapping with NOAA's bathymetric mapping, and the joint UCSC/MBARI/NOAA/Naval Postgraduate School \$5 million/5-year ONR funded real-time oceanographic data management system, the addition of a facility such as USGS's BPMG at the Long Marine Laboratory would help put the Monterey Bay region on the map as the largest center for marine research on the Pacific coast.

E. Marine Pollution Studies Laboratory (MPSL)
California Department of Fish and Game (DFG)
(Various Locations)

Mission:

The MPSL is the State of California's primary research facility to investigate marine and estuarine waters to provide data concerning the effects of pollution on living marine resources and marine, commercial, and sport fisheries.

History:

Founded in 1973, the California Department of Fish and Game's Marine Pollution Studies Laboratory (MPSL) has been a major research facility for the development and enforcement of state and federal water pollution control laws and regulations for marine and estuarine waters of California. The laboratory is located at four separate sites in the Monterey Bay area: University of Santa Cruz (Toxicology), Long Marine Laboratory (Trace Organic Chemistry), Moss Landing Marine Laboratory (Trace Metal Chemistry), and Granite Canyon, near Big Sur (Toxicity Testing). The latter site on the open coast, south of the Monterey Bay proper, provides a clean seawater system and facilities, equipment, and scientific personnel to conduct toxicity tests and toxicological evaluations of sediments and water.

In cooperation with NOAA, EPA, the State Water Resources Control Board, the University of California, and the California State University System, MPSL is continuing several major research projects to evaluate the fate and effects of potentially toxic compounds, including petroleum hydrocarbons, polycyclic aromatic hydrocarbons, toxic metals, organochlorine compounds, and oil dispersants utilizing California marine species. Laboratory personnel are also involved in international research programs in Mexico (University of Baja, California) and Australia (Deakin University, Victorian Institute of Marine Sciences).

Major Programs:

The Marine Pollution Studies Laboratory operates four major programs at the aforementioned facilities located around Monterey Bay:

- **California State Mussel Watch:** Located at the Moss Landing Marine Laboratories, six researchers analyze and monitor the contaminants in biomonitoring organisms and sediments. Research activities include field collection and sampling, dissection, and analysis of trace metal contaminants through such techniques as flame and furnace atomic absorption analyses. This laboratory participates in the NOAA Status and Trends–National Institute of Standards and Technology (NOAA-NIST) National Inter-calibration Program for Trace Metals.
- **Marine Bioassay and Sediment Toxicity Project:** Located at Granite Canyon, six researchers are investigating the effects of municipal and industrial waste discharge and contaminated sediments on the development and viability of kelp, fish, mollusks, and crustaceans, with the goal of establishing enforcement standards and criteria for state and

federal water regulations. A major investigation of sediment "toxic hot spots" in Californian bays and estuaries has recently been initiated, in cooperation with the State Water Resources Control Board and NOAA's National Status and Trends Program.

- ***Dispersant, Petroleum Hydrocarbon, and Xenobiotic Marine Toxicology:*** Located at the Institute of Marine Sciences (U.C. Santa Cruz), three researchers conduct a cooperative research program to evaluate the biochemical toxicology of marine organisms, including the detoxification and intoxication mechanisms of oil spill dispersants and other pollutants (organochlorine pesticides).
- ***Oil Spill Cleanup Agent Toxicity Project:*** Located at Granite Canyon, four researchers are developing methods and conducting marine toxicity tests of oil dispersants for establishing criteria and standards of licensing of oil spill cleanup products for use in Californian oil spills.
- ***Trace Organics Facility:*** Located at the Long Marine Laboratory (UCSC), eleven researchers are studying organic chemical concentrations in marine biomonitored organisms, sediments and seawater for evaluating potential impacts to marine organisms for both toxicity testing and marine pollution monitoring. Trace synthetic- and petroleum- hydrocarbons are analyzed in tissues, sediment, and water, using gas chromatography and mass spectrometry. PCB bioaccumulation and bioconcentration in marine food webs are being investigated. This laboratory participates in the NOAA Status and Trends- National Intercalibration Program for Trace Organic Compounds.

Resources:

Annual operating budget:	\$2.6 million
Personnel:	32

Outlook for the 1990s:

Several major pollution events in the 1980's have stressed the need for continued and increased surveillance efforts for our near coastal marine and estuarine waters to evaluate and understand the effects of pollution. Recent legislation by the state has directed state water regulatory authorities to commit over \$5 million in three fiscal years to support of marine sediment toxicity research at the Marine Pollution Studies Laboratory. This is being accomplished with the cooperation and supplemental funding of NOAA's National Status and Trends Program (Seattle). The State Mussel Watch continues to be the "cornerstone" for contaminant data that has been utilized successfully by regulatory authorities to cleanup a number of coastal pollution problems. On January 1, 1991, a new Department of Fish and Game office (Office of Oil Spill Prevention and Response) assumed the operation of the Marine Pollution Studies Laboratory with increased capital, operations, and personnel support. The new Office is headed by the Administrator for Oil Spill Response, who is appointed by the Governor and confirmed by the State Senate. The Administrator is also a Chief Deputy Director of the DFG. The position is given broad powers in responding to, and preventing, oil spills. Among the duties that the Administrator is required to carry out are the following:

- Adopt and implement regulations, guidelines and policies for the programs required by the bill.
- Direct industry and State agency response to oil spills, ensure that all necessary trained persons are at the scene of an oil spill as quickly as possible and eventually determine the cause of a spill.
- Develop, in coordination with the Office of Emergency Services and the California Conservation Corps, an oil spill response training program and conduct periodic drills to test oil spill response.
- Coordinate Federal, State and local planning and preparation for oil spill response. The State Administrator will promote the adoption of Federal regulations to improve the tanker safety equipment and operating procedures.
- Negotiate with Alaska, Oregon, and Washington to develop an interstate compact regarding tanker safety and oil spill response and prevention. The compact will be coordinated with British Columbia and Mexico.
- Implement the State's oil spill contingency plan.
- Establish rescue and rehabilitation stations for wildlife.
- Determine when it is appropriate to use dispersants.
- Encourage development of better oil cleanup technologies.

This program of prevention and clean up is the first of its kind in the nation. Its annual budget of \$15 million is financed by a four cent per barrel tax on crude oil shipped in the State.

In a related matter, pursuant to Reorganization Plan Number One of 1991, Governor Wilson created the California Environmental Protection Agency (CAL-EPA) on July 17, 1991. Consolidating State environmental protection responsibilities into one cabinet-level agency, CAL-EPA includes:

- The Office of the Secretary for Environmental Protection;
- The Air Resources Board;
- The Integrated Waste Management Board;
- The State Water Resources Control Board (including the Regional Water Quality Control Boards);
- The Department of Toxic Substances Control (the Toxic Substances Control program, transferred intact from the Department of Health Services);

- The Department of Pesticide Regulation (the Pesticide Regulation program, transferred intact from the Department of Food and Agriculture); and
- The Office of Environmental Health Hazard Assessment (specified “environmental” functions of the Health Hazard Assessment Division, transferred from the Department of Health Services).

As the new Cal-EPA takes shape, it will need to strengthen interfaces with Cal DFG in connection with the latter’s marine pollution responsibilities . The new Cal-EPA, working with Cal DFG, could provide a more integrated approach to air and water pollution control that could set a standard for the nation in such problem areas as non-point source pollution of the marine environment.

Opportunities for NOAA Cooperation:

Cooperation with NOAA already exists. The Marine Pollution Studies Program, particularly the State Mussel Watch, is closely connected to the National Ocean Service's marine environmental monitoring activities. The Granite Canyon facility, used by the DFG program, is actually a NOAA owned facility. In the near term, the expansion of DFG staff to augment new oil spill prevention and clean up responsibilities will be accommodated at NOAA’s facilities in Monterey.

Looking ahead in the 1990s, several areas for increased collaboration between NOAA and DFG can be anticipated. First, a close working relationship on hazardous materials response between NOAA and DFG is a natural extension of shared responsibilities. Second, NOAA’s new efforts in marine damage assessment and habitat restoration could benefit from DFG’s expertise for actions in California. Third, NOAA’s new responsibilities for regional planning for non-point source pollution of the marine environment (stemming from 1990 amendments to the Coastal Zone Management Act) could benefit from “prototype” partnerships and approaches taken in cooperation with DFG and the new Cal-EPA.

CAL-EPA Secretary James Strock has proposed the creation of seven regional districts in the state to deal with water, air, toxics, pesticides, and hazardous waste. One of the regions would be on the central coast, including Monterey Bay. If the reorganization is approved, the consolidated approach to environmental regulation would provide for a one-stop permit process. It would also allow for coordinated environmental monitoring in the Monterey Bay area. Groundwork for such a program was begun with the Monterey Basin Pilot Monitoring Project created by Governor Reagan in 1971.

F. **Monterey Marine Resources Laboratory— California Department of Fish and Game (Monterey, CA)**

Mission:

The mission of the Monterey Marine Resources Laboratory is to document and manage the living marine resources, and the habitats upon which they depend, for their ecological value and for their use and enjoyment by the public.

This mission includes the following objectives:

- To insure the continued existence of all marine species;
- To recognize the aesthetic, educational scientific, and nonextractive uses of the living marine resources;
- To protect the living marine resources from the effects of pollution and the impacts of human activities;
- To provide for reasonable sport fisheries;
- To provide for local commercial fisheries and marine aquaculture in a manner that is consistent with the other objectives; and
- To manage the marine fisheries on the basis of adequate scientific information.

History

The California Department of Fish and Game (DFG) has conducted marine research and management activities in the Monterey Bay area since at least the early 1930's. Office and laboratory space were located at Hopkins Marine Station until 1970. That year, a Department of Fish and Game Office and Marine Resources Laboratory were established at their present location on Garden Road. Since 1970, the staff of the laboratory has expanded considerably, and now includes elements from the Marine Resources Division, and the Wildlife Protection Division.

A separate laboratory, the Marine Culture Laboratory, was established at Granite Canyon in 1969 to conduct aquaculture oriented research on marine species. This laboratory worked closely with the Garden Road laboratory until 1990, when its functions were changed and it was transferred to the newly-created Office of Oil Spill Response. However, the Environmental Services Division staff still maintains a presence at Granite Canyon.

Major Programs

- ***Central California Marine Sportfish Program.*** This program receives three-fourths of its funding from the Federal Aid in Sport Fish Restoration Act and one-fourth from State sources. The program has three major projects:

Commercial Passenger-Fishing Vessel (CPFV) Sampling: Field technicians at the ports of Morro Bay, Monterey, Santa Cruz, Half Moon Bay, San Francisco, and Bodega Bay collect information while onboard CPFVs. Species composition, catch per angler, total effort, and, when possible, length frequency are subsequently analyzed on a reef-by-reef basis to document the importance of recreational fish stocks in specific fishing areas. Occasional aerial flights are being conducted to determine the fishing location of CPFVs accurately.

Marine Reserve Study: Project staff are determining the feasibility of using marine resource reserves as an alternative strategy for management of nearshore sport fishing resources. Comparisons are being made between fish populations in existing reserves and in fished areas. Potential reserve sites are being investigated with regard to existing spawning populations, larval transport processes, and recruitment of juvenile rockfish to adjacent areas.

Biological Investigations: A comprehensive rockfish bulletin is in preparation which includes life history information on numerous species of central California rockfish. A study is underway to determine the spawning success, timing, and recruitment of California halibut in central California's coastal waters and estuaries.

- **Monterey Resource Assessment Project.** This program monitors and assesses marine sport and commercial fisheries in Monterey and Santa Cruz Counties, makes management recommendations, provides liaison and management for marine aquaculture, reviews and makes recommendations on development projects which could affect living marine resources, conducts management-oriented research, and prepares scientific, technical, and popular reports.
- **Central California Gill and Trammel Net Project.** This program documents the take of target and non-target fish, seabirds, and marine mammals in gill and trammel nets, evaluates effectiveness of regulations to reduce the take of certain non-target species, and makes recommendations to mitigate problems and improve management of these species. Since 1990, the program has supervised NMFS personnel conducting observations aboard the boats. The program analyzes data and prepares scientific and technical reports.
- **Sea Otter Research Project.** This project is headquartered in Morro Bay and monitors sea otter population status and abundance, investigates mortality rates and causes, and cooperates with the U.S. Fish and Wildlife Service in translocation and zonal management of sea otters. Much of the project work occurs in the Monterey Bay area. The project analyzes data and prepares scientific, technical, and popular reports.
- **Environmental Services Project** This project provides information necessary to enforce the pollution control sections of the Fish and Game Code, and provides recommendations to other regulatory agencies on measures needed to protect fish, wildlife, and plant resources and their habitat from the effects of human activities.

The staff conducts environmental reviews of human activities affecting water quality and fish, wildlife, plants, invertebrates and their habitats in the ocean, bay, estuarine, and shoreline areas. Recommendations are developed regarding mitigation for impacts to fish and wildlife and their habitats, including sensitive species. Correction activities are coordinated with other agencies.

Investigations and surveys are also conducted to determine impacts on fish and wildlife and their habitats from pollution. They can include conducting bioassays on fresh and salt water species including collection of necessary samples, identification of pollution sources, and analysis/interpretation of the findings. Recommendations are prepared for clean-up and restoration of impacts, further studies, and monitoring.

Appearing as DFG experts before decision-making bodies to support DFG recommendations is another function of this project. Expert testimony is prepared and provided at water quality enforcement hearings and court trials. Information is provided to other agencies to determine water quality criteria for point and nonpoint source discharges.

Resources

Annual Budget:	\$1.25 million
Personnel:	16 permanent, 9 temporary

Outlook for the 1990's:

The Central California Marine Sportfish Program will continue and perhaps expand as Federal Aid in Sportfish Restoration Act funds are redistributed within the state. The project will utilize the opportunity created by the mandated establishment of new marine ecological reserves along the California coast to help document the contribution of marine resources to the fishing stocks in adjacent or distant areas.

Resource assessment and monitoring activities will continue in the Monterey area. The Gill and Trammel Net Project will likely be phased out in 1993 as the National Marine Fisheries Service assumes full responsibility for the observer program. The sea otter project will continue its present activities.

Environmental Service activities will continue and expand in response to increasing human impacts on the marine environment. The project is expanding its bioassay capabilities by outfitting new laboratory facilities at Granite Canyon.

Opportunities for NOAA Cooperation

The Central California Marine Sport Fish Program has planned research cruises for 1992 and 1993 in cooperation with NOAA to assess the importance of physical processes in transporting early life stages of nearshore rockfish species into Monterey Bay. Research will focus on transport processes prior to and during upwelling events and their relation to species composition, relative abundance, age, and time of extrusion of larval rockfish. This will contribute to our understanding of settlement and recruitment of nearshore rockfish in fished areas of central California.

The Resource Assessment Project hires Federally-funded groundfish and albacore observers and conducts commercial fisheries sampling programs that provide data for the NMFS/Pacific Fisheries Management Council's fisheries management plans. The Resource Assessment Project also interacts with the local NMFS Special Agent by providing information on local commercial fisheries.

The Environmental Services Project works with NOAA, EPA, and the Corp of Engineers in developing recommendations to protect the marine environment.

G. Hopkins Marine Station (Stanford University) (Pacific Grove, CA)

Mission:

The Hopkins Marine Station (HMS) is a teaching and research facility that operates as a branch of the Department of Biological Sciences of Stanford University. The mission of HMS is to conduct advanced research and teaching in marine biology and oceanography. The focus is on the biology of marine organisms, especially the interactions between organisms and their environment. The goal is to use novel and sophisticated techniques to address fundamental questions that were previously unanswerable by conventional approaches, providing new understanding and fresh perspectives of marine biological and oceanographic processes. This fundamental research provides interfaces between such areas as ecology, biomechanics, fluid dynamics, larval recruitment, larval settlement, biochemistry, molecular biology, and cell biology. By employing molecular biological tools, some researchers at HMS are beginning to determine the mechanisms of speciation and the evolutionary significance of genetic variation within species while other researchers are addressing the fundamental cellular mechanisms responsible for pollution resistance by marine organisms.

As a central part of its mission, HMS hosts visiting scientists for both field and laboratory research. HMS is also dedicated to providing state-of-the-art laboratory facilities to visitors through the development of shared resources.

History:

HMS is located in Pacific Grove, California on an eleven-acre site with one mile of Monterey Bay shoreline. It was established in 1891, making it the oldest marine station on the west coast and the second oldest in the nation. The first Stanford class was taught in 1892. HMS is financed in part by endowment income from the Timothy Hopkins Trust and the Harold A. Miller Fund.

The site at HMS is exceptional for studies in marine biology. The Hopkins Marine Life Refuge, sanctioned by the State of California in 1931 and administered by HMS and State Fish & Game, protects the intertidal, subtidal and kelp forest environments surrounding HMS to the 60-foot depth contour and is widely used for ecological studies. Habitats represented include granite reefs and outcroppings, protected channels and tidepools, sandy beaches, and offshore kelp beds.

Over the years, HMS faculty and graduate students have led research relating to neurobiology, microbiology, developmental biology, cellular immunity, endocrinology, circadian rhythms, and marine ecology. At present, there are nine resident research groups.

Major Programs:

Students may work towards the Ph.D. or M.S. degrees, with specialization in behavior, biomechanics, cellular and developmental biology, molecular biology, genetics, systematics, ecology, population biology, immunology, neurobiology, phycology, comparative physiology, and biological oceanography. Courses are provided in marine biology for matriculated and nonmatriculated undergraduates and graduates in biology during the spring and summer. HMS faculty also offer courses on the Palo Alto campus during other times of the year.

In addition to undergraduate teaching, the HMS faculty provides advanced summer courses in Video Microscopy and Image Processing, Biophysics of Ion Channels, Theoretical Ecology, Biomechanics, Physiology and Molecular Biology of Macrophytes, Molecular Probes in Marine Ecology and Oceanography, and Cell Biology of Early Development. In addition, HMS faculty teach upper undergraduate and lower graduate level courses in Oceanography, Intertidal Ecology, Subtidal Ecology, and Problems in Marine Biology.

HMS has a present physical plant of 57,797 square feet. Currently, the majority of the research and teaching is conducted in six buildings: the Blinks Laboratory, the Harold A. Miller Library, the Agassiz Laboratory, the Loeb Laboratory, the Monterey Boat Works Building, and the Fisher Building. Five other buildings provide support facilities.

The Lawrence Blinks Laboratory, originally built in 1963, was renovated in 1988 at a cost of \$500,000 to house the group whose research focuses on the biochemistry and molecular biology of marine organisms. This 4,000 square foot laboratory was equipped with \$750,000 of modern and sophisticated equipment for doing "cutting edge" research in molecular marine biology and biochemistry. This equipment is made available to others at HMS and to appropriate visiting scientists. Since the use of molecular probes to address problems in stock assessment and recruitment studies of marine fishes is an exploding research area, it would be a valuable facility for NOAA fisheries researchers.

The Harold A. Miller Library, completed in 1989, provides an additional 8,900 square feet of space. The Library is an integral part of the HMS, having 27,000 monographs and bound journals, and 450 current journal titles. Interlibrary loan service from Stanford is available within a day, and the library is connected by computer to the Stanford Library Database (five million volumes) and the Research Libraries Information Network/Research Libraries Group.

The Agassiz Laboratory, originally built in 1917 and renovated in 1977, provides approximately 8,000 square feet of research and teaching space. It houses research space for two ecologists and a marine phycologist. There are also several undergraduate and graduate teaching laboratories. This space is allocated for studies in the biology and ecology of marine invertebrates, fishes, and algae. Special facilities within Agassiz include: the shared Satellite Image Analysis Facility, the Marine Phycology Laboratory, common Computer Facilities, a reference collection of marine invertebrates, the Gilbert M. Smith herbarium of marine algae, several seminar rooms, and three major teaching laboratories. These common or shared facilities are extensive. In addition, computer facilities include a series of IBM computers and printers for general use by students and visiting investigators and more powerful computers in individual faculty laboratories that can be used for special projects by arrangement. The Stanford mainframe computers are also available to HMS faculty, students, and visiting scientists via modem and hard wire connections.

The two-story Jacques Loeb Laboratory, built in 1928 and renovated in 1977, provides research space for cell and developmental biology, physiology, immunology, and neurobiology of marine animals, plants, and microorganisms. It houses laboratories for two developmental biologists, two neurobiologists, and two immunologists. It also houses common use facilities including the Digital Image Processing Laboratory, the Electron Microscope Facility, several common Temperature Controlled Rooms, Tissue Culture Facilities, the Autoclave and Sterilization Facilities, and common Glassware Washing Facilities. These common use facilities are extensive and sophisticated. The Digital Image Processing Laboratory, for example, built in 1985, has been in continuous use and is essential to the work of several permanent and visiting investigators at HMS.

The Monterey Boat Works Building houses the major administration offices for the Hopkins Marine Station, a 2,723 square foot 100-seat lecture hall, an 800 square foot conference room, and a 1,495 square foot SCUBA diving facility, including: dive lockers, showers, and a dive safety office.

The Walter K. Fisher Building includes two large teaching laboratories, three small seminar rooms, a research laboratory, and a large multi-user Biomechanics Facility devoted to the study of the hydrology and biomechanics of marine organisms. The teaching laboratories are used for undergraduate and graduate courses in Cell and Developmental Biology as well as advanced courses in Neurobiology.

In addition to the various common facilities in these buildings, there are extensive sea water facilities for culturing and maintaining marine organisms. A high quality sea water system at HMS supplies tanks with either filtered or unfiltered sea water of high quality. There are four areas that are dedicated to holding and culturing marine organisms. These aquarium areas include a variety of tanks for squid and fish and numerous water tables for less active specimens.

HMS has satellite data processing capability for accessing information from the National Oceanic Data Services-JPL, Scripps Institution of Oceanography, and the National Weather Service. The facility is being used to build a continuous data base on current patterns and surface temperatures in the region.

Resources:

Annual operating budget: \$3.5 million

Personnel:

Faculty/Staff	26
Graduate Students	20
Postdoctorates	25

Outlook for the 1990's:

Three new faculty members will be added over the next five years. As the result of a recent gift of an endowed professorship, HMS is launching a search in 1992 for a senior faculty member in the marine sciences. The intention is to bring in researchers who will apply new sophisticated technologies to fundamental problems in marine biology and oceanography; some of this will relate to DNA technologies, others to ecology and the use of imaging and satellite technology. HMS also expects to expand its scientific and educational interactions with the staff of the Monterey Bay Aquarium Research Institute (MBARI) and other marine institutions in the Monterey Bay area.

A new HMS building has been planned that will add another 17,500 square feet of high quality research and teaching space. Two more buildings are anticipated over the next ten years of approximately 30,000 to 40,000 square feet each. In addition, HMS was recently awarded a \$25,000 planning grant to expand its sea water system, including architectural drawings for an additional aquarium building for culturing of marine organisms. The architectural drawings have been completed and a proposal for the construction of the building has been submitted to the National Science Foundation.

Important to the future of HMS is the new Environmental Sciences Initiative at Stanford, an interdepartmental grouping which includes the School of Earth Sciences, the School of Humanities and Sciences, and the School of Engineering. It is intended to be an imaginative and interactive mix of environmental sciences, social sciences, economics, and engineering with linkages between HMS and the program at Stanford.

Opportunities for NOAA Cooperation:

Opportunities for cooperation between the Hopkins Marine Station and NOAA involve both research and teaching. Long-standing cooperation between HMS and NOAA's Pacific Fisheries Environmental Group in Monterey has linked Hopkins' marine larval ecology and biomechanics capabilities to NOAA's marine ecosystem variation studies. Other potential research areas for expanded Hopkins/NOAA collaboration include: the use of molecular-genetic markers for fisheries stock assessment, molecular approaches to population dynamics/genetics studies, mechanisms of pollution resistance, molecular approaches to difficult taxonomic issues, studies of viral and bacterial aquatic born diseases, fish immunology, global warming issues, impacts of ultraviolet radiation on marine organisms, marine natural products chemistry, aquaculture, and marine biotechnology.

Ultimately, the development of the Environmental Sciences Initiative at Stanford, with its opportunity for teaching graduate and undergraduate students at the interface of studies on the ocean, atmosphere and biology could lead to more NOAA opportunities for interdisciplinary interactions with Stanford in the marine environmental sciences area.

H. Moss Landing Marine Laboratories (MLML) (Moss Landing, CA)

Mission:

MLML is a marine science education and research facility operated by a consortium of six campuses of the California State University: CSU Fresno, CSU Hayward, CSU Sacramento, San Francisco State University, San Jose State University, CSU Stanislaus. San Jose State University serves as the administering institution. Classes at MLML are open to properly qualified upper-division undergraduate and graduate students enrolled through the consortium campuses. The educational goal of MLML is to produce broadly trained environmental scientists with strong backgrounds in marine biology, physical oceanography, biological oceanography, marine chemistry, and geology, with emphasis on field research and investigation. Faculty specialization covers a broad range of disciplines from biology and chemistry to geology and oceanography. The program at MLML provides extensive field and laboratory work for advanced study in the marine sciences.

History:

MLML was established in a converted cannery that was later transformed into a private research facility by the Beaudette Foundation for Biological Research. In 1966, the San Jose State University Foundation, acting with assistance from four other California State College foundations and a National Science Foundation grant, purchased the property and formed a consortium. Approximately 110 students are enrolled each semester, 80 percent at the graduate level and 20 percent upper-division undergraduates .

Over 190 students have completed the requirements for their Master's degrees. Twenty-seven percent of the graduates have gone to Ph.D. programs at other universities; 59 percent are currently employed in marine-related fields, and 14 percent are teaching.

Major Programs:

Scientists at MLML participate in a very active research program. For example, during 1990-91, faculty members had support from 19 private, state, and federal granting agencies. Funds from these grants are used for the purchase of major equipment and supplies, various support staff positions, and graduate student assistantships.

Current faculty research interests cover a wide area, and in many cases, scientists from more than one discipline cooperate on individual projects. In many cases, graduate students work closely with faculty members on these research projects, while in other cases, students perform research under limited supervision.

- **Marine Habitat:** Cooperative studies have concentrated on specific habitats in the Monterey Bay area. An integrated team of faculty, technicians, and students has been involved in a multidisciplinary study of Elkhorn Slough, including oceanography, benthic invertebrates, adult and larval fishes, zooplankton, plants, birds, and sediments providing a broad picture of how this coastal ecosystem functions. Similarly, several studies have centered on the ecology of the Monterey Submarine Canyon.

Other projects have included the observation of various facets of the natural history of the numerous marine vertebrates in the Bay, including censuses, post-mortem studies of beach-cast birds, pinnipeds, sea otters and cetaceans; and investigation of age, growth, and reproduction of elasmobranchs, billfish and sturgeons in relation to increasing fishery demands. Succession in marine benthic invertebrate and algae communities is being investigated, as well as the physical and biological factors which structure intertidal algal associations and giant kelp forests.

- **Marine Geology:** Marine geological research has centered on the processes active in transportation and deposition of sediments along the continental margins and within deep-sea basins. Marine geologists are also involved in studies of the bathymetry, stratigraphy and geophysics of the Monterey Canyon and Fan. Other research includes paleoceanography, deep-sea sedimentation, and tephrochronology.
- **Physical Oceanography:** Research in physical oceanography presently concerns the circulation and mixing of coastal waters using oceanographic instrumentation and digital data acquisition systems. These tools are highly portable and allow oceanographers great flexibility. For example, they may investigate geostrophic currents in the open ocean or internal waves in Monterey Submarine Canyon, map surface temperature, salinity, chlorophyll and turbidity at sea, or examine how the tides affect these parameters in the slough or harbor. Recent work with NASA and NOAA is exploring the use of remote sensing from satellites to aid the understanding of coastal processes.
- **Biology and Chemistry:** Biological and chemical oceanographers are also studying the mechanisms by which organic matter and associated elements, natural series radionuclides, and pollutants are transported from the surface to deeper waters. Particle interceptor traps, designed to collect organic and inorganic detritus as it settles in the water column, have been tested at several localities throughout the eastern Pacific. Large quantities of diatom frustules, organic and inorganic debris have been collected successfully. Actual flux measurements on a host of substances of biological and chemical importance are being obtained. Other projects related to the vertical transport of particulate matter include plankton production studies in the surface water and the ecology and physiology of the deep-living organisms that consume the sinking particles.
- **Marine Pollution:** In conjunction with the studies described above, scientists are also studying the distribution of trace elements in sea water (cadmium, lead, copper, manganese, etc.). Because of contamination problems associated with this research, considerable effort has been put into the development of specialized sampling gear that permits the sampling and analysis of clean ocean water.

Invertebrate zoological research has concentrated on the ecology of the benthic infauna of soft-bottoms at various depths in Monterey Bay, Elkhorn Slough and offshore San Francisco. These studies have concentrated on the life history features of the dominant invertebrates, and the interactions of these invertebrates with various predators, sediments and larval settlement. From these studies, researchers hope to gain a better understanding for food chain relationships among the various components of the soft-bottom communities and of the factors influencing the stability of the system.

In addition, the California Department of Fish and Game's State Mussel Watch Program is located at MLML. This program is funded by the State Water Resources Control Board to monitor toxic substances such as lead, mercury, cadmium, DDT and PCB's in the marine waters off California. Chemists at MLML analyze mussels gathered from hundreds of locations each year for purposes of accessing pollution trends.

A recent cooperative agreement between MLML and the U.S. Geological Survey established a USGS research office at MLML. Students have access to maps, charts, and other USGS resource materials.

Due to the 1989 Loma Prieta Earthquake, MLML has temporarily relocated ten miles inland in Salinas. However, a shore lab facility and marine operations are maintained in Moss Landing. MLML's Marine Operations facilitates oceanographic research by providing shore support, and by housing equipment used for in-port maintenance and parts fabrication, storage and maintenance of scientific equipment, SCUBA air compressor, shore-based radio operations and other support needs.

Specialized facilities include a photographic darkroom, a filtered-air clean laboratory for trace element analyses, a benthic ecology lab, a complete histology preparation facility, light and SEM labs, and algae, and core storage facility. The MLML library houses an expanding collection of specialized materials relating to the marine sciences. The library's holdings include 9,234 bound volumes, 380 serial titles with 103 current subscriptions. In addition, as a member of the Central California's Oceanographic Cooperative (CENCAL), MLML operates the 135-foot *R/V POINT SUR*, built in 1981, and well-equipped for instructional use and research with a trawl winch, two hydrographic winches and three laboratories. Scientific equipment for sampling and oceanographic profiling include Smith-McIntyre grabs, rock dredges, and various types of coring devices. Also available are a variety of nets for bottom and midwater trawls. The Labs also own and operate the 35-foot *R/V ED RICKETTS*. This workboat is used for trawling, water sampling and other work near shore, and serves as a diving platform. A complete inventory of SCUBA diving equipment is also available for use by qualified individuals.

The Elkhorn Slough National Estuarine Research Reserve is minutes away from MLML and offers research and educational opportunities for students and the community at large. MLML is working to develop a research program on the Reserve and to broaden understanding of important coastal wetlands.

Many scientists use diving as a tool in the performance of their research. Currently, 45 students are certified to dive to depths of 30 to 130 feet. In order to assure safety, diving activities are supervised and approved by MLML's diving officer with the assistance of a diving control board of seven experienced student divers. Certification by MLML is required for any diving activities conducted under the auspices of the Laboratories.

Resources:

Annual operating budget		\$3.0 million
Personnel:	Faculty/Staff	40
	Students	110

Outlook for the 1990s:

Once the new facilities for MLML are constructed to replace the earthquake damaged buildings, MLML will have a modern base for its research and educational activities. Several developments promise opportunities for MLML. As MBARI increases its activities at Moss Landing, collaborative work with MLML will provide teaching and research capabilities in the marine sciences to a technological level of sophistication that could be matched at few other institutions. As the California Department of Fish and Game (DFG) expands its marine pollution activities, teaching and research opportunities with DFG at MLML will increase. As a natural extension of MLML's activities at the Elkhorn Slough National Estuarine Research Reserve, the Monterey Bay National Marine Sanctuary will create a new educational and research challenge for MLML. Building upon a cooperative relationship with the Marine Geology Branch of the U.S. Geological Survey in Menlo Park, MLML would benefit greatly from the tentative plans of USGS to relocate to the Monterey Bay area which would create a marine geology capability in the region virtually unequalled anywhere else.

Opportunities for NOAA Cooperation:

Several obvious opportunities present themselves for increased NOAA cooperation with MLML. The Elkhorn Slough Reserve and Monterey Bay National Marine Sanctuary have already been mentioned. In NOAA's growing role in the conservation of marine habitat, NOAA will need to undertake additional research to support such responsibilities as hazardous materials response, damage assessment and restoration of contaminated sites. MLML's capabilities in both research and education could greatly assist NOAA. In fact, MLML could become an increasingly important source of highly trained professionals to enter the NOAA workforce. Special MLML programs such as the diving program could also provide an opportunity for NOAA.

I. Institute of Marine Sciences (IMS) (UCSC) (Santa Cruz, CA)

Mission:

The overall mission of the Institute of Marine Sciences of the University of California, Santa Cruz is to encourage, facilitate and strengthen marine research and instruction conducted by the University faculty, researchers, students, and staff. This mission is accomplished through 1) the identification and support of programmatic Centers of Excellence, 2) the development and maintenance of facilities to promote and enhance marine research and instruction, and 3) the provision of technical and administrative support.

History:

IMS is an interdisciplinary Organized Research Unit within the University of California, Santa Cruz. Marine sciences was identified an area of special strength for the Santa Cruz campus in the initial 1964 academic plan approved by the Regents of the University. The initial objective of developing an active marine sciences educational and research program was achieved with the

approval of the Organized Research Unit in 1976. Long Marine Laboratory was dedicated in 1978 as an oceanfront research facility of the institute.

Major Programs:

The marine sciences area is currently recognized as a special campus strength with support and involvement of 23 academic faculty members from five departments (Biology, Chemistry, Physics, Earth Sciences, and Marine Sciences), as well as 15–20 researchers in the area of Oceanography, Marine Mammal Biology, Marine Ecology, Marine Geology and Geophysics, and Environmental Toxicology.

The Santa Cruz campus continues to develop strength in a number of areas of marine science research which have been targeted as Centers of Excellence:

- Marine Vertebrate Biology
- Continental Margin Tectonics
- Ocean Processes and Paleoceanography
- Nearshore Ecology
- Coastal Processes and Hazards
- Environmental Toxicology
- Ocean Acoustics
- Marine Biotechnology

The programs in Environmental Toxicology, Ocean Acoustics, and Marine Biotechnology are areas where program development is at an early stage but where future growth is being anticipated and encouraged. An M.S. degree in Marine Sciences, with specialties in biological, chemical, geological, and physical oceanography, is offered by an interdisciplinary graduate group in Marine Sciences. A Ph.D. degree for students who work on marine problems is available in the disciplines of Biology, Chemistry, Earth Sciences, and Physics.

The Institute of Marine Sciences has developed facilities both on- and off-campus to support the instructional and research needs of its affiliated faculty, students, and researchers.

The program office of the Marine Sciences Academic Program and that of IMS are located on campus in the Applied Sciences Building. Each faculty member has a well-equipped research laboratory. In addition, the sciences are supported by a centralized, general-access Electron Microscope Facility, Electronic Shop, Student and Main Machine Shop, Glass Shop, and Computer Center. IMS has developed diverse facilities to support marine research and instruction. On campus there are the Marine Analytical Laboratories, Isotope Geochemistry Laboratory Facility, Marine Algal and Invertebrate Culture Rooms, Computing Room, and a Cruise-staging Facility. An 83,000 ASF (assignable square-foot) state-of-the-art Earth and Marine Sciences building is under construction and is scheduled for completion in September 1993. IMS will move to new facilities in this building at that time.

On the open Pacific coast, the Institute has the Joseph M. Long Marine Laboratory with diverse large and small tanks to support dolphin, seal, sea lion, sea otter, and seabird research; a Trace Organics Facility; a Marine Physiology Laboratory; a room for Histology and Electrophoresis; a Bioacoustics Laboratory; a plankton room; and a larval culture room, in addition to diverse

research laboratories with running seawater. The Institute has scientific control over nearby Año Nuevo Island for marine mammal and seabird research. Access to nearshore waters is provided by a variety of small boats. Use of larger vessels for open ocean research is available through the UNOLS fleet program.

The Institute of Marine Sciences has a cooperative agreement with the U.S. Fish and Wildlife Service which maintains a research office on campus and a small field station on San Nicolas Island. IMS has also developed a cooperative agreement with the California Department of Fish and Game focused on aquatic toxicology with a research program centered at Long Marine Laboratory. A state-of-the-art laboratory at Long Marine Lab for analysis of trace organics is the focal point of this cooperative program.

Resources:

Annual operating budget (State funds):	\$0.5 million
Annual contracts and grants:	\$5.0 million
Personnel:	
Faculty/Staff	40
Students	90

Outlook for the 1990s:

The Institute of Marine Sciences anticipates growth and development in several areas in the decade ahead. The Branch of Pacific Marine Geology of the United States Geological Survey is in the final stages of considering a relocation of their entire branch to Long Marine Laboratory. This would considerably strengthen the Monterey Bay area research capabilities as well as cooperative programs with UCSC/IMS researchers in marine geology and geophysics from the shoreline to the deep-sea. The U.S. Geological Survey has recently proposed a cooperative agreement with the University focused on a research corridor from the coast to the deep-sea floor across the Monterey Bay National Marine Sanctuary.

The California Department of Fish and Game is in the final design and planning stages of a \$3.5 million Oil Spill Rescue and Rehabilitation Facility for construction at Long Marine Laboratory. This facility is mandated by State legislation and is planned in the event of a major oil spill in California waters as a means to rescue and rehabilitate marine mammals and birds, with specific attention on sea otters.

Faculty are being hired for a new graduate research program in Environmental Toxicology which has been initiated by the University and, in combination with the ongoing cooperative agreement with California Department of Fish and Game, will be an area of significant growth and new research effort.

Ocean acoustics is another area in which growth and development is anticipated. The proposed Heard Island experiment, combined with the new ONR interest in marine mammal acoustics, promises to bring funding to Long Marine Laboratory in support of the study of acoustical behavior of marine mammals as well as the effects of experiments such as Heard Island on these animals.

Opportunities for NOAA Cooperation:

IMS at Santa Cruz offers broad spectrum research and educational capabilities of potential benefit to NOAA. In particular, NOAA's interest in research involving the Monterey Bay National Marine Sanctuary, and more generally, support of NOAA's marine habitat conservation efforts could be pursued with the talent at IMS Santa Cruz. This is especially the case with the sophisticated marine mammal and seabird research capabilities at the Long Marine Laboratory.

Additionally, the proposed USGS/UCSC cooperative program, focusing on a research corridor across the Sanctuary, would combine the earth and marine sciences research strengths of UCSC and the Branch of Pacific Marine Geology to provide an additional focus and potential source of research funding for the Monterey Bay Sanctuary.

J. Monterey Bay Aquarium Research Institute (MBARI) (Pacific Grove, CA)

Mission

The Monterey Bay Aquarium Research Institute (MBARI) is dedicated to basic research relevant to all the ocean sciences, and the development of equipment, instrumentation, systems and methods which will have wide-spread applicability within the science community. The oceanic knowledge gained from its studies is expected to be of great use in global and local environmental modeling and decision-making—an activity in harmony with the interpretive mission of its sister institution, the Monterey Bay Aquarium.

Given MBARI's broad research mandate, scientists and engineers are free to set their own research directions with excellence and innovation as principal requirements. As an independent, non-profit institution for research and education, MBARI attracts exceptional individuals and fosters a creative team concept by offering:

- An environment where technology and science collaborate to create a vigorous approach to oceanographic research;
- Independent funding through the David and Lucile Packard Foundation which frees scientists and engineers from extensive administrative and classroom responsibilities;
- Daily access to the 4,000-meter depths of the Monterey Canyon and its vast range of oceanographic phenomena; and
- Substantial oceanographic resources including ships, remotely operated vehicles, and instrumented moorings.

History

MBARI was founded by David Packard in 1987. The original planning for the Monterey Bay Aquarium, which opened in 1984, always anticipated that research would be an integral part of the Aquarium program. In the summer of 1985 an independent group of researchers carried out

pilot studies in Monterey Canyon with a manned submersible. This early effort attracted the attention of Aquarium leaders. As the idea of a strong research institute progressed, it appeared that MBARI would benefit from being operationally separate from the Aquarium, yet maintaining a close intellectual relationship. Thus, MBARI was established as a separate corporate entity with a separate governing board.

After the initial experience with a manned submersible, it was decided that remotely operated vehicles (ROVs) offered more opportunities and challenges and a safer environment for technical innovation and development in support of deep ocean research. This early interest in ROVs has led to the creation of exceptional deep ocean observing and experimental capabilities, and rapid advances in control theory, telemetry and systems development for the ocean sciences. This technology has been used for research, exploration, education and as a platform for technical advancement.

MBARI houses its primary research facility at 160 Central Avenue, Pacific Grove, California. In 1989, a MBARI marine facility was constructed at the fishing village of Moss Landing 22 miles to the north. The seven-acre site is home to a modern dock and a 23,000 square foot operations building housing a sophisticated machine shop and field experimental support facilities. The marine operations installation at Moss Landing is linked to Pacific Grove for high speed data transmission, and both are linked to its research vessel via a dedicated microwave link atop nearby 3,500-foot Mt. Toro.

MBARI maintains strong ties with the marine science and technology institutions that ring Monterey Bay: The Monterey Bay Aquarium, Hopkins Marine Station of Stanford University, the Naval Postgraduate School, Moss Landing Marine Laboratories, the University of California at Santa Cruz, and the Federal laboratories of NOAA and the Fleet Numerical Oceanography Center.

Major Programs

The deep water laboratory afforded by the Monterey Canyon offers access to water depths of 4,000 meters and a great range of oceanic phenomena within easy reach. MBARI maintains programs in acoustics, ocean instrument research and development, information management and modeling, and ocean physics, chemistry, geology and biology. With a commitment to public and pre- and post-doctoral education, MBARI is strengthening its institutional base.

Research

Operationally, MBARI researchers are members of the Science or Engineering departments, each charged with continual and beneficial interaction. MBARI scientists at the Assistant, Associate or Senior level propose and execute innovative studies, either experimental or theoretical, in the ocean sciences. Engineering research and development are encouraged, as is interaction with local academic and governmental laboratories.

The *RV POINT LOBOS*, and ROV *VENTANA* operate nearly every weekday from Moss Landing. This unique combination offers the chance for ocean scientists to return with data, samples or specimens on a schedule not available to researchers at the very largest institutions, who often are dependent upon uncertain granting systems and who must routinely wait for a year or more for access to the deep ocean.

The ROV is able to operate to 1,000 m at this time; advanced capability to 4,000 m depth is anticipated in 1994. MBARI also maintains two deep ocean moorings as experimental platforms for the emplacement of novel sensors, transmitters and receivers, and the rapid telemetry of their data.

Education

While not formally chartered as an educational institute, MBARI is deeply committed to training and education. Live video broadcasts are transmitted to the Monterey Bay Aquarium several times each week. There, in an award-winning program, educators provide interpretation of research activities for Aquarium visitors. In addition, the Aquarium is developing new exhibits in concert with MBARI that will showcase deep-sea and open-ocean habitats. MBARI has established post-doctoral fellowship programs in science and engineering which provide wider access to its advanced training and research facilities.

Key MBARI activities

- Advances in buoy technology through development of controllers and sensors which deliver real-time data sets on oceanic, biological, chemical, and physical variables;
- Strong programs in undersea robotics including tethered and autonomous vehicles. The tethered vehicle initiative permits safe surface acquisition of data and samples from depths to 4 km. The autonomous vehicle program is making advances in object recognition, track, and capture.
- Developments in chemical micro sensor technology for long term acquisition of both natural and pollutant chemical signals in remote regions, relevant to NOAA's GOOS program.
- Participation in the global acoustic thermometry, Heard Island experiment, of which NOAA was the lead agency. MBARI scientists, with colleagues from NPS, deployed and successfully recovered the only vertical array in the large field experiment.
- Initiation of advanced scientific information management programs, relevant to NODC, through cooperation with UC Santa Cruz in a five-year multimillion dollar environmental data assimilation technology program.

Resources

Annual operating budget	\$ 8.5 million
1992 capital expenditures (planned)	13.0 million
Personnel	75

Outlook for the 1990s

In Pacific Grove, plans for new laboratory buildings are underway, both on the Hopkins Marine Station ocean front site (a tangible expression of MBARI's close relationship to Stanford University) and at a second MBARI site nearby. The result will be a research triangle of MBARI-Aquarium-Hopkins laboratories that will form a highly efficient center of excellence in ocean science technology and education.

In Moss Landing, MBARI is making plans to expand its research and engineering capabilities with new laboratories and the development of a technologically advanced deep-diving submersible. A new SWATH (Small Waterplane Area Twin Hull) designed research vessel, 114 feet long and 53 feet wide, is scheduled for completion in 1994, providing berths and laboratories for a ship's complement of 22, and offering unique handling and sea-keeping capabilities. It will allow equipment deployment ranging from MBARI's planned 4,000-meter-capable ROV to advanced mooring devices, making the SWATH a principal observatory for the institute and enabling MBARI to expand beyond Monterey Bay.

Opportunities for Cooperation with NOAA

The high technology focus of MBARI on undersea robotics and its intensive observations of the Monterey Bay marine environment combine to provide unprecedented opportunities for NOAA through cooperation with MBARI.

Besides those cited above, obvious areas of shared interests include (1) research in the Monterey Bay National Marine Sanctuary, (2) advanced sensing and observation technologies development with NOAA's Wave Propagation Laboratory, and (3) introduction of a major new robotics thrust within the NOAA Undersea Research Program. In the area of development of real-time data assimilation techniques and predictive modeling, MBARI could greatly assist NOAA as it seeks a more data-rich predictive basis for operational forecasting in fish stock assessment, marine environmental quality, and warning of hazardous ocean conditions.

K. Research Division of the Monterey Bay Aquarium (Monterey, CA)

Mission:

The mission of the Research Division of the aquarium is to contribute to the knowledge of the biology and husbandry of Monterey Bay's organisms through a program of basic and applied research which: focuses on organisms relevant to the aquarium's exhibit program; takes advantage of the aquarium's facilities; nurtures interactions with neighboring academic and scientific institutions; provides research opportunities for visiting investigators; contributes to the aquarium's mission of interpretation of ocean science for the public; and is dedicated to the highest standards of quality.

History:

The Research Division was established in 1983 to carry out the aquarium's scientific research mission. The division has grown from an original staff of two people to 12 staff scientists and research assistants. In the early years the division primarily supported visiting investigators and their research projects, but over time the emphasis has shifted toward long-term funding and permanent scientific staff appointments. The primary research initiatives from 1985 through 1990 have been the biology and social organization of the California sea otter, the biology and ecology of forests of giant kelp, and studies of the development of the kelp forest in the Kelp

Forest Exhibit compared to kelp forests in the wild. In 1991 the Division embarked upon a new research initiative focusing on the biology of deep-sea and open ocean organisms, in connection with a major exhibit expansion (The New Exhibit Wing) that will focus on deep-sea/open ocean habitats of Monterey Bay.

Major Programs:

The primary program is basic research, with three major research projects. One project examines the role of physical and biological disturbance in structuring forests of giant kelp *Macrocystis pyrifera*. The major elements of this program include a long-term field sampling program of populations of dominant kelp forest species and monitoring of selected physical parameters (wave height, light, and temperature). This program has also supported studies of the export and fate of macroalgal detritus produced by kelp forests, and mechanisms of recruitment in shallow and deep-water echinoids.

The second program focuses on the physiological ecology of two dominant kelp species, *M. pyrifera* and *Pterygophora californica*. This program examines the response of these plants to variation in physical parameters and how these responses influence kelp forest community structure. The approach involves correlating plant growth rates with monitored physical parameters and experimental manipulations of the plants' light and nutrient regimes.

The third program examines the biology and social organization of the California sea otter *Enhydra lutris*. Through an intensive program of tagging individual sea otters with visual and radio tags and long-term observations of these animals, the sea otter research team is addressing such questions as patterns and costs associated with mate selection, variation in success in raising pups, individual variation in foraging patterns, and the transmission of these patterns from mother pup. The research team also worked closely with state and federal wildlife officials in their conservation and research efforts, and with the Husbandry Division in the Sea Otter Rescue and Care Program.

The Research Division also supports husbandry research, especially in connection with development of exhibits for the New Exhibit Wing (NEW). Over 100 species of deep-sea and open ocean organisms will be exhibited in NEW, and most of these have never been held in captivity. The Division is devoting significant resources to assisting the Husbandry Division learn how to maintain and, if possible, culture these species for long-term exhibition (and research) purposes.

The Research Division supports visiting investigators through the Research Intern Program, and through formal and informal arrangements with students and scientists from neighboring academic institutions. The aquarium's extensive holding facilities for organisms of a wide variety of types and sizes, the Research Division's wet and dry laboratory facilities, and the husbandry staffs' expertise in raising and culturing many marine species offer opportunities for organismal research that are available at few other institutions.

Finally, Research Division staff are committed to assisting other aquarium personnel in their research projects and problems. For example, Research Division staff are playing an important role in an aquarium-wide project to study the feasibility and application of ozone to control microbial populations in multi-species exhibits.

Resources:

Annual operating budget:		\$0.6 million
Personnel:	Staff Scientists:	3
	Administrative/technical support:	9

Outlook for the 1990s:

Since nearly all the work is funded internally, growth potential is set by attendance patterns and major aquarium program initiatives. The growth potential will be somewhat limited over the next five years by the NEW expansion program. The kelp forest research programs will wind down in 1991 as interests expand in the direction of deep-sea and open ocean organismal biology. The sea otter research program will continue approximately at its present level. The Division is planning to remodel and expand the wet lab, analytical lab, and office facilities in order to facilitate research of the present staff and make room available for an expanded visiting investigator program.

Opportunities for NOAA Cooperation:

The two NOAA programs with which the aquarium's research program can most productively interact are the National Marine Sanctuary Program and the NOAA Undersea Research Program (NURP). Although the specific research goals of the Sanctuary are not clear at this time, the Sanctuary's mission is closely aligned with that of the aquarium in general and of the Research Division in particular. With the Division's long-term data sets on important nearshore community members, it could contribute to the development of research programs within the Marine Sanctuary. With funding from NURP, the Research Division has visited the floor of the Monterey and Carmel Submarine Canyons to examine the ecological importance of drift macrophytes to deep-sea communities. NURP funding will be an important part of the Division's new research efforts on deep-sea/open ocean organisms, and will play an increasingly important role in the research programs in Monterey Bay in general. Cooperation with NURP in the development of proposals and initiatives would be extremely valuable.

L. Joint Mechanisms

Several organizations have been created or planned to institutionalize cooperation in the Monterey Bay marine and atmospheric sciences with varying degrees of formality. They include:

Central California Oceanographic Cooperative (CENCAL)

Created in 1985 under the auspices of the University National Oceanographic Laboratories System (UNOLS), CENCAL is administered by the Moss Landing Marine Laboratories to promote shared interests between MLML, U.C. Santa Cruz, U.C. Santa Barbara, U.S. Geological Survey, and the University of Southern California, CENCAL coordinates use of the 135-foot UNOLS *R/V POINT SUR*, and provides a pool of equipment and technical support for member organizations.

Cooperative Institute for Research in the Integrated Ocean Sciences (CIRIOS)

Created in 1991 by agreement between NOAA, the Naval Postgraduate School, and the Naval Postgraduate School Foundation, Inc., CIRIOS is a cooperative research institute designed to provide sponsoring organizations:

- A means to increase the effectiveness of research and teaching in ocean related science and engineering through close collaboration;
- A center for interdisciplinary collaboration among ocean researchers from Monterey Bay and Central California on projects ranging from local to global oceanic scales; and
- A means to educate personnel for research in ocean science and engineering.

CIRIOS represents a close research and educational link between NOAA and the Department of Oceanography at NPS. Participation in CIRIOS is open to other interested NOAA organizations, other NPS academic departments, other Navy facilities, including the Fleet Numerical Oceanography Center and the Naval Research Laboratory, and other national and international marine science institutions. Research in CIRIOS may be supported by private and other public organizations.

Research in CIRIOS will be initially concentrated in broad disciplinary areas including local to global ocean and climate variability. These areas are:

- Data assimilation, modeling, and prediction;
- Data collection and dissemination; and
- Coastal ocean processes, with emphasis on Monterey Bay, the Gulf of the Farallones, and the adjacent California Current System.

The staff of CIRIOS consist of:

- **Fellows** who are scientists and engineers of established national or international standing.
- **Visiting Fellows** who are scientists of outstanding promise. They are selected by the Director and Fellows under the Visiting Scientist Program. The selection is based on scholarly criteria.
- **Scientific support personnel** are employees of NPSFI, with qualifications specified by NPSFI.

NOAA's Activities in the Monterey Bay

Monterey Bay Oceanography Coordinating Committee

At the personal initiative of California Assembly member Sam Farr, this informal Coordinating Committee was established to promote coordination and communication among institution directors active in the Monterey Bay area. Meeting approximately quarterly, the Committee shifts venue to each of the participating organizations. Participants include directors from the Hopkins Marine Station, Fleet Numerical Oceanography Center, Naval Research Laboratory, Monterey Bay Aquarium Research Institute, NOAA Center for Ocean Analysis and Prediction, Naval Postgraduate School, NMFS Pacific Fisheries Environmental Group, the Moss Landing Marine Laboratories and the Institute of Marine Sciences (UCSC).

The Committee supports the following activities in the Monterey Bay area:

1. Environmental Group (PREG)

The Environmental Group in the National Marine Fisheries Service (NMFS) supports the development of marine assessment and understanding of the environmental effects of human activities on the group of marine living resources.

The Environmental Group is a result of a cooperative agreement between the Institute of Marine Sciences (UCSC) and the Fleet Numerical Oceanography Center (FNOC) of the Navy's Fleet Numerical Oceanography Center (FNOC). The group is focused on understanding the effects of natural environmental variability on marine living resources. The group includes PREG and FNOC as well as other organizations. The group is currently monitoring program to monitor natural variability in the Monterey Bay area. The group is currently monitoring program to monitor natural variability in the Monterey Bay area.

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III. NOAA's Activities in the Monterey Bay area:

Present and Future

NOAA has been active in the Monterey Bay area for decades. Nautical charts of the region have long served safe navigation. Bathymetric charts were prepared in the 1980s which document the dramatic structure of the seafloor associated with submarine canyons. Fisheries surveys are routinely conducted by the National Marine Fisheries Service for numerous commercial and recreational fish stocks. Daily weather forecasts and storm warnings have been provided by the National Weather Service office in Redwood City. Undersea research by the Monterey Bay Aquarium Research Institute has been supported by the NOAA National Undersea Research Program.

Present:

NOAA conducts the following activities in the Monterey Bay area:

Pacific Fisheries Environmental Group (PFEG)
(Monterey, CA)

Mission:

PFEG is the single laboratory in the National Marine Fisheries Service (NMFS) system that focuses on comprehensive assessment and understanding of the fundamental effects of natural environmental variability of marine living resources.

History:

PFEG began in 1967 as a result of a cooperative agreement established to exchange bathythermographic data from the then Bureau of Commercial Fisheries' surveys for real-time meteorological data from the Navy's Fleet Numerical Oceanography Center (FNOC). PFEG was interested in understanding the effects of natural environmental variability on fishery resources. The relationship between PFEG and FNOC was augmented to include exchange of data for the bathythermographic monitoring program in waters between California and Hawaii. After becoming part of the Southwest Center of NMFS in 1976, PFEG continued its focus on fundamental research on natural variability.

Major Programs:

PFEG is collocated with FNOC. FNOC is primarily concerned with describing and predicting marine weather and ocean conditions. The Navy's global environmental data network has its major terminus at FNOC, and provides real-time products and archived historical data for use in fishery/environmental research.

PFEG concentrates on understanding how natural variability interacts with human actions in controlling the population dynamics of fishery resource populations. Research activities are divided into three areas: mathematical modeling and data analysis; fishery environmental linkages, including fishery database management; and physical oceanography to develop effective methodologies for incorporating information on natural environmental and biological variability into fishery management activities.

Principal research areas include the development of environmental index time series, diagnostic studies of marine environmental anomalies such as El Niño, identification of environmental/biological causal linkages, interregional comparative studies, and development of environment-dependent fishery modeling methodology. An example is a recently funded proposal, under NOAA's Climate and Global Change/Marine Ecosystems Response Program, for an international collaborative study to address potential effects of global climate change on living resource populations of the highly productive marine ecosystems of upwelling regions.

Center for Ocean Analysis and Prediction (COAP) (Monterey, CA)

Mission:

COAP was established as a NOAA national center for the development, exchange, integration and dissemination of oceanographic products and services in support of NOAA's high priority programs involving the marine environment. A further objective is to serve as a focal point for coordination and collaboration between NOAA and external organizations working in these priority ocean program areas.

History:

In the mid-1980's, NOAA's National Ocean Service established the Ocean Applications Group (OAG) in close association with FNOC in Monterey. In September 1991, OAG was renamed the Ocean Applications Branch (OAB) of the NOS Office of Ocean and Earth Sciences. OAB's primary mission was to provide on-line routine access to FNOC's ocean data sets and products for NOAA and external users in the civilian community.

In 1988, NOAA created the Center for Ocean Analysis and Prediction (COAP) in Monterey to seek a more focused and productive way for NOAA to work with the Navy to develop and improve the ocean data and model output products that would be jointly produced by NOAA and the Navy in the future. Since FY 1989, OAG/OAB has operated as an element of COAP.

Major Programs:

As a NOAA element formed to advance marine capabilities agency-wide, COAP has become a primary interface for collaboration between the Navy and NOAA line organizations to develop new data bases, models, and techniques in support of marine requirements in the civilian sector.

COAP's programs are organized in three areas: ocean data management, ocean modeling, and ocean-related research.

COAP's highest priority has been directed to the most compelling need—the development of a system for providing direct access to marine data by a wide variety of users.

NOAA's mission requires that it collect, manage, analyze, and disseminate a broad range of oceanographic data and products. Besides NOAA Offices, potential users include federal, state, and local governmental agencies, the research and education communities, and the private sector. Historically, three factors have restricted NOAA's ability to meet these responsibilities: (1) different offices have responsibility for different data types, requiring the user needing multiple data types to seek them in multiple offices; (2) each office manages and disseminates data in different formats, requiring the user to reformat in order to integrate; (3) windows of non-availability while data are being archived may cause delays of up to 90 days.

COAP/OAB is working to implement a modern relational database management system (RDBMS) which uses standard formats and is capable of handling all types of observational data, gridded data from computer models, and images. The heart of the integrated data management system consists of software developed by the Naval Research Laboratory-Monterey as part of their Navy Environmental Operational Nowcasting System (NEONS) project and provided to COAP/OAB under the Navy's Technology Transfer Program.

Access to the database is provided through (1) a network of dedicated circuits, linking major NOAA centers around the country called the NOAA Ocean Communications Network (NOCN); (2) INTERNET, which links universities; and (3) a dial-in system. The system will also support LAN connections for local users. For the dial-in access system, COAP has obtained from the Navy the necessary software at no cost to NOAA. FNOC provided the latest update to their Navy Oceanographic Data Distribution System (NODDS). This software can be installed on a simple PC and a modem. With this system, a user can access the COAP database and download and display the data.

Data and products that will be integrated into the RDBMS will come from many sources—FNOC, the NOAA Ocean Products Center, NRL-Monterey, and NODC, NCDC, and NMC are examples. The system, as installed at COAP/OAB will focus on near real-time data and products and provide access to the most recent 30 days of ocean observations, numerical ocean model output and historical data sets, bathymetry and geographical data sets.

COAP is making the RDBMS software available to other NOAA offices to develop a distributed database network. So far, it has been installed at the National Climatic Data Center (NCDC), in Asheville, North Carolina, and at the ERL Climate Research Division in Boulder, Colorado where it will support the Global Climate Perspectives System. During FY 1993, NOAA plans to incorporate COAP into the new National Institute for Marine Prediction (see page 49).

Elkhorn Slough National Estuarine Research Reserve and Elkhorn Slough Foundation (Watsonville, CA)

Mission

The goal of the National Estuarine Research Reserve Program is to provide information and models on how best to manage the nation's estuaries. Establishment of such Reserves protects vital habitats for wetland-dependent life, and ensures that scientists and the general public can learn about coastal and estuarine ecology in a natural setting.

The 1,400-acre Elkhorn Slough Estuarine Research Reserve is located along the southeast shore of Elkhorn Slough in the central Monterey Bay area. The Reserve is managed by the California Department of Fish and Game (DFG) under an agreement with the Sanctuaries and Reserves Division of NOAA. Programs on the Reserve and around the Slough are also supported by the Elkhorn Slough Foundation, a nonprofit membership-supported organization dedicated to the conservation and wise use of Elkhorn Slough and other coastal wetlands in the Monterey Bay area. The Foundation assists DFG with financial and programmatic support for research and education on the Reserve and has administered federal research grants in the Slough.

History

The National Estuarine Research Reserve Program was established by the Coastal Zone Management Act of 1972. The Act functions to provide financial assistance to coastal states to acquire, develop, and operate valuable and unique estuarine and wetland areas as natural field laboratories for long-term scientific research and for educational programs.

Elkhorn Slough was nominated California's first Estuarine Reserve in 1978 and is now one of 19 estuarine reserves established nationwide. The Reserve helps protect and manage one of the few relatively undisturbed coastal wetlands remaining in California. The main channel of the Slough winds inland nearly seven miles and encompasses several thousand acres of marsh and tidelands. This is the largest tract of salt marsh in the state outside of San Francisco Bay. The Slough supports a tremendous diversity of plants, fish, and other wildlife. Over 400 species of invertebrates, 80 species of fish and 267 species of birds have been identified from Elkhorn Slough. The channels and tidal creeks of the Slough are nursery grounds for the young of many species of fish, some of which are important commercially. In addition, the Slough is on a migratory flyway, and provides an important feeding and resting ground for many kinds of waterfowl and migratory shorebirds. At least six rare, threatened or endangered species use the Slough and environs.

Major Programs

Since its designation in 1979, the Reserve has contributed to the scientific understanding of Elkhorn Slough and to the overall management of the Slough's resources. NOAA funding for research has been a critical component of this aspect of the Reserve's work.

There are many players and jurisdictions in the Elkhorn Slough watershed. The National Estuarine Research Reserve has helped to encourage communication among these jurisdictions and to begin coordination of activities. The Reserve maintains strong ties with local researchers and provides research opportunities for students and interns from a number of institutions.

In addition, the Elkhorn Slough Interpretive Guides Association is a group of volunteers working under the aegis of DFG and the Elkhorn Slough Foundation. There are over 100 volunteers that work on a variety of projects including leading guided walks on the Reserve and throughout the Slough, assisting scientists with Slough research, maintaining a water quality monitoring program, staffing the Reserve Visitor Center, developing curricula for Reserve education programs, leading teacher workshops and generally providing support and energy for Slough programs. Annual visitation at the Reserve is approximately 45,000 people. The school program serves over 7,000 students per year.

Facilities on the Reserve include the 2,500 square-foot Visitor Center with exhibits, offices and a bookstore, a garage and shop, a small laboratory/classroom space, boat dock and small boats and motors, several habitat restoration sites including both wetland and upland. There is an automated weather station on the Reserve that feeds into the ALERT network.

The Elkhorn Slough Foundation is currently piloting a habitat restoration project in the upper Slough watershed and recently completed development of a new public access with the Nature Conservancy. The development of partnerships between the private, local, state and federal agencies and organizations has been an important ingredient to the success of Elkhorn Slough conservation programs.

The reserve is managed by the California Department of Fish and Game in cooperation with NOAA and with the input of a Reserve Advisory Committee. The Committee includes members representing research, education, agriculture, industry, residential property owners, fishermen, Sea Grant, Elkhorn Slough Interpretive Guides, Monterey County, DFG and NOAA.

Future:

NOAA has planned investments in three additional areas during FY 1993–1994:

Monterey Bay National Marine Sanctuary Office (Monterey, CA)

Mission:

In 1972, Congress passed the Marine Protection, Research and Sanctuaries Act. Title III of the Act authorizes the Secretary of Commerce, with Presidential approval, to designate discrete aquatic areas as National Marine Sanctuaries for the purpose of preserving or restoring their special ecological, historical, recreational and esthetic resources. 1984 amendments to the Act made it clear that one of the purposes of the Sanctuary Program was to provide authority for comprehensive and coordinated conservation and management of marine areas that would complement existing regulatory authority.

History:

Ten National Marine Sanctuaries have been designated since the Program's inception. They include nearshore coral reefs, as well as, open ocean water, and range in size from less than one to 2,600 square nautical miles. In addition, NOAA's Sanctuaries and Reserves Division is in the process of studying or preparing designation documents for seven additional Sanctuaries. One of these sites, the Monterey Bay National Marine Sanctuary (MBNMS), covering over 4,000 square nautical miles of central California coastal waters, is scheduled for formal designation in late 1992.

On June 18, 1992, President Bush announced his intention to designate the Monterey Bay National Marine Sanctuary with the largest boundary alternative and a ban on oil and gas drilling. Paralleling some 350 nautical miles of shoreline along six central coast counties, MBNMS will be the nation's largest marine sanctuary.

Major Programs:

NOAA released the Final Environmental Impact Statement/Management Plan (FEIS/MP) for the MBNMS in June 1992. On August 12, 1992, the California Coastal Commission found the Sanctuary Plan to be consistent with the California Coastal Management Program. The FEIS/MP includes eight categories of activities that will be regulated: oil and gas; disposal within the Sanctuary; disposal impacts from outside the Sanctuary; historical resource protection; dredging, dumping and development, and wildlife protection; low-flying aircraft; and motorized personal water craft. The FEIS/MP also lists two additional categories of activities which are potentially subject to regulation; vessel traffic; and aquaculture/kelp harvesting.

The MBNMS will provide an integrated program of resource protection, research, and education to assist in the long-term management and protection of its resources. Research will include baseline studies, monitoring, and analysis and prediction projects to provide information needed in resolving management issues. An education program will be directed to improving public awareness of the Sanctuary's resources and the need to use them wisely to ensure their viability. Resources protection efforts will involve cooperation with other federal, state, and local agencies in formulating resources protection policies and procedures.

NWS Weather Forecast Office (WFO)
(San Francisco, CA)

Mission:

As a part of the modernization and associated restructuring of the National Weather Service (NWS), the new regional forecast office for the Central California Coast will provide the full spectrum of public weather and flood warning and forecast services covering an area defined by a circle of approximately 150 mile radius centered on Monterey Bay. It will also serve the maritime area seaward to the edge of the Exclusive Economic Zone off Central California.

History:

For the last several decades, the regional Weather Service Forecast Office (WSFO) for San Francisco operated out of Redwood City. During the 1990s, the modernization and restructuring of the NWS field structure will result in more than doubling of the full service forecast offices from 47 to 115 in the continental United States. In FY1994, the new WFO will begin initial operations from a location adjacent to FNOC with the Next Generation Doppler Radar (NEXRAD). By late 1990s, the full suite of new technologies will be installed, and the Monterey WFO will operate in the new configuration.

Major Programs:

The future operations at Monterey will allow forecasters to address the air-sea environment in their assigned area comprehensively. The observation and analysis of current and expected weather conditions can be quickly and reliably completed, critical decisions made, and translated into immediate warnings and forecasts. This is contrasted to current operations in which a number of meteorologists and technicians are required to evaluate individually a limited database and separately derive the required variety of warnings and forecasts.

The concept of the local database is central to future operations. The high volume of data from the local NEXRAD and geostationary meteorological satellites combined with the high frequency observations from automated surface observing sensors (ASOS) will flow directly to the Weather Forecast Office. The most complete data sets will only be available to the local WFO. However, summarized data from all NEXRADs and ASOSs in the nation will be made available to all field offices.

The new observing systems are designed to provide data sets which can be immediately integrated into three dimensional depictions of the rapidly changing state of the environment. Each system will contribute a critical part, combining with and complementing data from all other systems to form a complete set of information about the space from the earth's surface to the upper atmosphere over the WFO's area of responsibility. The Advanced Weather Interactive Processing System (AWIPS) work stations will allow the forecaster to quickly update, quality-control, and analyze current processes and events detailed within the area of concern. New dedicated supercomputer capabilities and high resolution models running at the National Centers will provide a stream of detailed, frequently updated guidance to forecasters, assisting in the prediction of future conditions. This represents a new, highly integrated mode of operation which greatly increases the productivity of personnel, and also holds the promise of increased accuracy and greater timeliness of forecast services for the nation.

The basic tool for more accurate and timely warnings and forecast from the WFO is AWIPS. It will assemble, process and display the observational data and guidance from the National Centers. AWIPS will help meteorologists with the warning and forecast decision process through an interactive work station. It will preformat warning and forecast products and disseminate these products to the users in a timely manner.

The Monterey WFO will provide weather and hydrologic services in four major areas:

- Watches and warnings for the general public for severe local storms, floods, flash floods and winter storms. Local and zone public forecasts, and fire weather forecasts;

- Local aviation watches and warnings, terminal forecasts, and domestic aviation enroute forecasts;
- Marine warnings and forecasts for coastal areas; and
- Hydrologic services which identify flash flood-prone areas and the development of community support surveillance systems.

National Institute for Marine Prediction

(Monterey, CA)

Mission:

Establishment of the National Institute for Marine Prediction (NIMP) is being considered as a science-based service organization which originates and issues operational marine atmospheric boundary layer and ocean surface analyses and forecasts of relevant variables, and warnings of hazardous conditions, over ocean basins. Guidance products for the offshore and coastal areas adjacent to the U.S. coast will be generated for use by other forecasters with primary responsibility for these areas.

History:

NIMP will be established in FY 1993 as an evolutionary step building upon the NOAA Center for Ocean Analysis and Prediction (COAP) which has operated in Monterey since 1988. Incorporating operational marine forecast activities from the National Meteorological Center in Camp Springs, MD, NIMP will work in tandem with the Navy's Numerical Oceanography Center.

Major Programs:

The NIMP's products are to be distributed to field offices of the National Weather Service (NWS) and other NOAA Line Offices, and will be made available to marine users through the U.S. Coast Guard via radio broadcast, INMARSAT group broadcasts, as well as by automated access to NIMP by telephone. To provide these services, NIMP will develop specialized techniques for high seas, offshore and coastal marine applications, based on numerical model output fields. NIMP will coordinate closely with the modeling community with respect to requirements for developing these applications.

The NIMP product suite is evolutionary. It will initially consist of ocean surface and marine atmospheric boundary layer products which are currently being issued. Drawing upon the intellectual resources available in NOAA, NASA, the U.S. Navy, and the academic community, the NIMP product suite will expand over time to include upper ocean products in support fisheries management and other marine industries. The expansion will occur first in the Pacific, where the data base will first be sufficient to support the generation of useful products, and will expand to the Atlantic and Gulf of Mexico as advances in observations permit. The intent of the NIMP is

to issue an initial suite of products based on the current state of science, to be alert for opportunities to transfer advances in the science to operations, and to stay in close touch with the needs and requirements of the users.

The NIMP is to be one of six Service Institutes of the National Institutes for Environmental Prediction (NIEP), and will be supported within NIEP by the National Institute for Environmental Modeling (NIEM) and by NIEP Central Operations. As noted above, however, it will also draw upon the intellectual resources of a much larger community. Its location in Monterey, California will particularly facilitate interactions with the Navy's Fleet Numerical Oceanography Center, Naval Research Laboratory–Monterey, and the Naval Postgraduate School, other NOAA units including the Central California Weather Forecast Office of NWS and the Tiburon Laboratory of the National Marine Fisheries Service (NMFS); and several important state and local marine agencies.

DEQ - Department of Fish and Game, California

DoD - Department of Defense

EPA - Environmental Protection Agency

ERL - Environmental Research Laboratory

FNOC - Fleet Numerical Oceanography Center

HMN - Hopkins Marine Station

IOOE - IOOE Institute of Marine Science

NSA - National Security Agency

NSA/DIR - National Security Agency Research Institute

NSA/CSS - National Security Agency Central Security Service

NSA/CSS/DIR - National Security Agency Central Security Service, Directorate

NSA/CSS/IS - National Security Agency Central Security Service, Information Systems

NSA/CSS/IT - National Security Agency Central Security Service, Information Technology

NSA/CSS/ISS - National Security Agency Central Security Service, Information Systems Security

NSA/CSS/IS&A - National Security Agency Central Security Service, Information Systems Security and Analysis

NSA/CSS/IS&A/DIR - National Security Agency Central Security Service, Information Systems Security and Analysis, Directorate

NSA/CSS/IS&A/DIR/ISS - National Security Agency Central Security Service, Information Systems Security and Analysis, Directorate, Information Systems Security

NSA/CSS/IS&A/DIR/ISS/IS - National Security Agency Central Security Service, Information Systems Security and Analysis, Directorate, Information Systems Security, Information Systems

NSA/CSS/IS&A/DIR/ISS/IS/IS - National Security Agency Central Security Service, Information Systems Security and Analysis, Directorate, Information Systems Security, Information Systems, Information Systems

NOAHL - Naval Oceanographic and Atmospheric Research Laboratory

NOAA - National Oceanic and Atmospheric Administration

ACRONYMS

Organizations and Facilities

AFGWC - Air Force Global Weather Central

BPMG - USGS Branch of Pacific Marine Geology

CIRIOS - Cooperative Institute for Research in the Integrated Ocean Sciences

CENCAL - Central California Oceanographic Cooperative

COAP - Center for Ocean Analysis and Prediction

DFG - Department of Fish and Game (California)

DoD - Department of Defense

EPA - Environmental Protection Agency

ERL - Environmental Research Laboratory

FNOC - Fleet Numerical Oceanography Center

HMS - Hopkins Marine Station

IMS - UCSC Institute of Marine Science

MBA - Monterey Bay Aquarium

MBARI - Monterey Bay Aquarium Research Institute

MLML - Moss Landing Marine Laboratory

MRD - DFG Marine Resources Division

MPSL - Marine Pollution Studies Laboratory

NCDC - National Climatic Data Center

NEPRF - Naval Environmental Prediction Research Facility

NERR - National Estuarine Research Reserve (Elkhorn Slough)

NESDIS - National Environmental Satellite and Data Information System

NIST - National Institute of Standards and Technology

NMFS - National Marine Fisheries Service

NMC - National Meteorological Center

NOARL - Naval Oceanographic and Atmospheric Research Laboratory

NOAA - National Oceanic and Atmospheric Administration

NODC - National Oceanographic Data Center

NOS - National Ocean Service

NPS - Naval Postgraduate School

NRL - Naval Research Laboratory

NWS - National Weather Service

OAB - NOS Ocean Applications Branch

ONR - Office of Naval Research

PFEG - NMFS Pacific Fisheries Environmental Group

PMEL - Pacific Marine Environmental Laboratory

UCSC - University of California at Santa Cruz

USGS - United States Geological Survey

WFO - Weather Forecast Office