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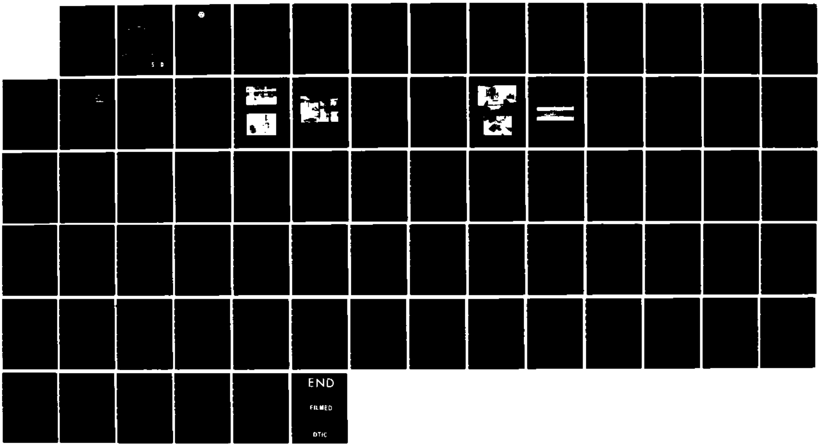

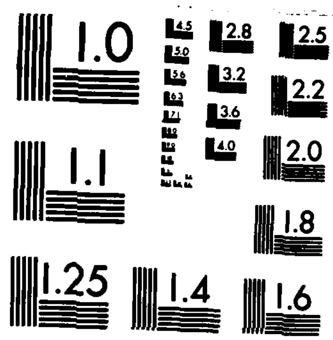

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October 1984
Technical Plan

MARINE ENVIRONMENTAL QUALITY ASSESSMENT PROGRAM

Five-Year Plan (FY 1984-1988)

A. Zirino
R. K. Johnston

Prepared for
Naval Facilities Engineering Command

Naval Ocean Systems Center
San Diego, California 92152-5000

NAVAL OCEAN SYSTEMS CENTER SAN DIEGO, CA 92152

AN ACTIVITY OF THE NAVAL MATERIAL COMMAND

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This document is the second five-year plan (FY84-FY88) of the Marine Environmental Quality Assessment (MEQA) Program. It updates the MEQA Exploratory Development (FY78-FY83) Program Plan and places emphasis on current environmental issues, such as the fate and effects of organotin leachates, real-time monitoring techniques, biochemical analysis and advanced bioassay procedures. Keywords;

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CONTENTS

STRATEGY

In order to adequately serve present and future Navy requirements, the MEQA R&D program must carry out two functions: (1) obtain adequate and timely environmental information and (2) pass on this information, in a useable form, to the cognizant Navy activity. This is accomplished by organizing the work effort into four distinct areas wherein information is collected by the first three and disseminated by the fourth.

These work units are:

1. Development of analytical methods and instrumentation.

2. Development of field survey methodology.

3. Determination of biological effects to Navy pollutants.

4. Transfer of the MEQA information to Navy activities through the Marine Environmental Support Office (MESO).

SUMMARY OF MEQA ACTIVITIES, FY78-FY83

Specific products and capabilities have been developed during the last 5 years (FY78-FY83) and have been utilized in support of marine environmental compliance (see Appendix B: Direct Support to Fleet Activities by MEQA). The program has become a viable and valuable component of the Navy's overall effort in Environmental Protection Technology.

The basic MEQA approach of developing real-time analytical techniques, of studying community effects and of developing whole organism and biochemical bioassays has proven highly successful in providing answers to major Navy questions, such as the fate and effects of organotin leachates from AF paints. MEQA has also provided technology which has benefitted many other programs including those on bioluminescence (ONR-NOSC), <u>in-situ</u> hull cleaning (NAVMAT 08), Cu-based AF paints (NAVSEA), marine chemistry (ONR), and many others. Appendix A contains a complete summary of all significant progress carried out under the MEQA program during FY78-FY83.

TECHNICAL PLANS

Technical development for each of the MEQA work units during FY84-FY88 are summarized below. (A detailed product schedule is included in the main body of the report as Table 1.)

a. Develop analytical methods and instrumentation for organotin analytical methods, multielement analysis techniques, analysis of organic compounds, spectral radiometry techniques, and the subsequent application of these analytical methods to field instrumentation.

b. Improve field survey methodology including the test and evaluation of the Marine Environmental Survey Craft (MESC) and the Portable Environmental Test (PET) platform.

EXECUTIVE SUMMARY

INTRODUCTION

The National Environmental Policy Act (NEPA) of 1969 and Executive Orders 11752 and 12088 were promulgated by OPNAVINST 5090.1, which states Navy environmental policy: "... [to] actively protect and maintain the quality of the environment, through adherence to all applicable regulatory requirements, by initiating actions to conserve natural resources ... and prevent or control pollution caused by Navy facilities" (para. 1201). To meet this requirement, NAVMAT and OPNAV have funded the Naval Ocean Systems Center to develop technology for Marine Environmental Quality Assessment (MEQA).

OBJECTIVE

The objective of the MEQA program is to provide the Navy with the technology capable of defining, measuring and predicting the environmental impact of Naval activities on harbors and coastal areas in which the Navy operates. Within the context of this broad objective, specific subobjectives of this program are to:

1. Develop the technology for ascertaining and predicting marine environmental quality.

2. Maintain the scientific and technical expertise within the Navy to evaluate the Navy's marine ecological and environmental problems.

3. Develop an up-to-date capability to integrate environmental quality assessment technology into operational programs.

NAVY NEED

The Navy must be able to anticipate the environmental effect of its operations and legally defend those operations with scientifically sound data and practical alternatives in order to:

1. Cut the high cost of pollution control.

2. Increase operational effectiveness (in terms of time, manpower and costs).

3. Discriminate sources of pollution.

4. Predict the environmental consequences of its operations and activities.

PROGRAM STRUCTURE

The project focus is to develop a capability to assess the effect of the marine environment on Navy operations, and the effect of the Navy on the marine habitat. The goal is to solve specific and timely questions as well as analyze and develop procedures by which both environmental measurements and decisions will be made.

STRATEGY

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The basic MEQA approach of developing real-time analytical techniques, of studying community effects and of developing whole organism and biochemical bioassays has proven highly successful in providing answers to major Navy questions, such as the fate and effects of organotin leachates from AF paints. MEQA has also provided technology which has benefitted many other programs including those on bioluminescence (ONR-NOSC), in-situ hull cleaning (NAVMAT 08), Cu-based AF paints (NAVSEA), marine chemistry (ONR), and many others. Appendix A contains a complete summary of all significant progress carried out under the MEQA program during FY78-FY83.

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CONTENTS

I. INTRODUCTION

The National Environmental Policy Act (NEPA) of 1969 made environmental protection and pollution abatement a national objective. Subsequent Executive Orders (11752, 12088) called on federal agencies to provide leadership in the nationwide effort to protect and enhance the environment.

Accordingly, it is Navy policy (OPNAVINST 5090.1, para. 1201) to "actively protect and maintain the quality of the environment, through adherence to all applicable regulatory requirements, and by initiating actions to conserve natural resources . . . and prevent or control pollution caused by Navy facilities." Similarly, "all facilities owned by, leased to, or leased from the Navy Department shall be designed, operated, maintained, and monitored to conform to all applicable standards for pollution abatement" (para. 1102).

In April 1971, the Chief of Naval Material delegated primary responsibility to the (now) Naval Ocean Systems Center (NOSC) for conducting research and development towards determining the impact of Navy operations on the inshore and nearshore marine environment. The resulting effort, known as the Marine Environmental Quality Assessment (MEQA) Program, was block funded with Exploratory Development funds (PE 62765N) by the Naval Material Command (NAVMAT) to NOSC, with the Naval Facilities Engineering Command (NAVFAC) maintaining management cognizance over the program. In FY83, funds for Advanced Development were provided under PE 63721N. In FY84, the 6.2 environmental protection program was transferred to PE 62759N.

This document is the second Five-Year Plan (FY84-FY88) of the MEQA Program. It is intended to update the MEQA Exploratory Development (FY78-FY83) Program Plan, with emphasis on current environmental issues, such as studying fate and effects of organotin leachates, developing real-time monitoring techniques, and establishing advanced bioassay procedures. The Exploratory Development Program Plan* and Subproject Program Plan** should be consulted for additional background information on the program.

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* Copies of Marine Environmental Quality Assessment Exploratory Development Program Plan, Oct 1978, may be obtained by request to Code 522, Naval Ocean Systems Center, San Diego, CA 92152.

** Full title of Subproject Program Plan: "Environmental Protection Ashore," subproject number YF59.559, 6 August 1984.

II. OBJECTIVES

The following statement is the objective of the MEQA program:

Develop Technology Necessary to DEFINE / MEASURE / PREDICT Environmental Impact of Naval Activities on Harbors and Coastal Areas in which the Navy Operates.

Within the context of this broad objective, specific subobjectives of this program include the following:

1. Develop the technology for proving and predicting marine environmental quality to:

   - efficiently and economically meet marine environmental compliance requirements,
   - identify sources of pollution, and
   - provide state-of-the-art, scientifically sound, environmental data for legal defense of Navy positions.

2. Maintain in-house personnel qualified and equipped to solve the Navy's marine environmental problems and specifically be able to:

   - organize a quick-response environmental survey, measurement, and advisory capability;
   - advise and represent the Navy when called upon; and
   - evaluate proposed federal, regional, or Navy regulations and recommend appropriate responses.

3. Integrate marine environmental quality assessment technology with other Navy programs in order to:

   - optimize the "cost effectiveness" of new pollution abatement procedures,
   - predict and measure the environmental response to new materials and antifouling coatings, and
   - predict the environmental consequences of new systems, operations, and construction activities.

III. NAVY NEED

Naval operations in bays and harbors must comply with local, state, and federal regulatory requirements. The Navy's environmental problems arise from the necessity of meeting these environmental requirements which are often site specific and which require techniques that are designed specifically to assess Navy pollutants. The advent of a 600-ship Navy and of deeper draft vessels will increase the potential Navy environmental impact and the need for compliance. With increasing knowledge of the effects of man's products and activities on the environment (including man himself), the constraints imposed by regulatory agencies will most likely be extended and made more rigorous. The Navy must be able to anticipate the environmental effects of its operations and legally defend those operations.

Many reasons point to the critical need for this program. Some of these include:

1. Need to cut high cost of pollution control. Between 1968 and 1980 pollution abatement procedures and pollution monitoring for ships and shore installations have been estimated to cost between 1 and 1.5 billion dollars. Fleet operations, maintenance, and construction activities are also subject to real costs stemming from delays due to environmental restrictions and permitting procedures. The MEQA program seeks to develop methods and techniques that would cut the costs of pollution control and provide the capability to assess the Navy's impact on the marine environment in a scientifically sound and legally defensible manner.

2. Need to acquire scientific knowledge. Setting standards for marine environmental quality is difficult and complex. Although PL95-217 stipulates the development of criteria for water quality reflecting scientific knowledge of the effects of pollutants on aquatic life, the existing knowledge is still quite incomplete. In its continuing dialogue with regulatory agencies and environmental groups, the Navy must be fully cognizant of the complexities of environmental situations. This can only be done if the Navy maintains an active environmental capability. With a credible in-house scientific effort, the Navy is also in a better position to validate or suggest realistic alternatives to proposed regulations. These alternatives will benefit the Navy in terms of operational effectiveness, time, manpower, and costs.

3. Need to discriminate sources of pollution. In carrying out its mission, the Navy has not only multiple, but little-understood impacts on the marine environment. When accused of environmental non-compliance, the Navy should be able to distinguish its contribution to water pollution from that of industry, agriculture, or municipalities. The ability to identify sources of pollution in areas of current Naval activities is essential in the legal defense of those activities.

4. Need to predict. The Navy needs a capability to predict (or anticipate) the environmental consequences of its operations and activities in order to avoid future problems with regulatory agencies. Developing this capability will allow the Navy to optimize its pollution abatement efforts, expedite operations, and minimize capital investments.

IV. PROGRAM STRUCTURE

GOAL

Environmental assessment is a dynamic science, dealing with questions which are inherently complex because they are multifaceted, multidisciplinary, and constantly changing as technology and methods of analysis improve. Consequently, the goal of the MEQA program is to solve specific and timely questions as well as analyze and develop the procedures by which both environmental measurements and decisions will be made. This is a key point since both measurements and decisions are subject to ambiguities and are likely to change with time. In order for the Navy to fully protect its own and the public's resources, it must have a clear understanding of the ambiguities involved in the criteria used for both environmental measurements and decision making. MEQA attempts to anticipate the technological needs required by future Navy environmental obligations.

Thus, the task of environmental assessment is essentially one of judgment based on direct information, comparisons with information previously collected, and consultations with "experts" (figure 1). The final value judgment is usually based on biological criteria. These criteria arise from two types of environmental alterations: (1) those which relate directly to the aesthetics, economics, and well-being of the local (human) population and (2) the more subtle environmental changes among biological communities such as those caused by chronic, yet sublethal toxicity. The latter are most often subject to debate or interpretation since these effects are often indistinguishable from those of long-term natural changes.

The National Environmental Policy Act of 1969 places upon the Navy the responsibility to prevent both types of environmental alterations, subject to other mitigating factors. Gross environmental insults are usually prevented by legislation and/or directives. This leads to preventive construction or engineering modifications, such as the installation of sewage-holding tanks on ships. On the other hand, subtler environmental changes, such as those which may be caused by antifouling (AF) paints or the disposal of dredge spoils, are much more difficult to assess, causing delays in remedial actions, and possibly, costly ex post facto fixes. Moreover, by lacking a proper understanding of the environmental subtleties, the Navy, in its eagerness to comply, may buy expensive / d unnecessary corrective measures.

A final -n is the fact that the national perception of environmental impact changes -chnology, information, science, and popular expectations increase. This me_'s a procedure permissible today may not be acceptable tomorrow or the next day. The environmental record contains many outmoded permits and regulations. Recent examples include procedures for handling asbestos, chemical wastes, and agricultural pesticides (DDT, EDB, etc.). Similarly, advances in information science, including the availability of computers, software for advanced statistics, and direct access to data bases have made it possible to explain previously ambiguous cause and effect relationships. An example of this is the medical community's success in relating different types of human cancers to differing nutritional habits and other occupational or environmental exposures.

Milestones for this work area include:

- Installation of organotin analyzer aboard MESC (Sep 84).
- Automated navigational capability on MESC (Jul 85).
- Real-time data analysis capability onboard MESC (Jul 85).
- New generation AASV trace metal analyzer installed on MESC (Jul 86).
- Multielement methodology used onboard MESC (Jul 87).
- Spectral radiometry techniques used for water quality assessment (Jul 88).

[ELD SURVEY METHODOLOGY

\e Marine Environmental Survey Craft Program

The MESC T&E program was begun in FY82 and is now in its second year. ie initial phase was carried out at NSSB King's Bay, Georgia, in conjunction ith OICC, TRIDENT. The program objectives were to (1) determine temporal and patial characteristics of many water quality parameters in King's Bay; (2) etermine the concentrations of heavy metals in King's Bay, Cumberland Sound, id inflowing rivers as a "baseline" prior to extensive construction; and (3) etermine if the extensive dredging program caused heavy metal concentrations o increase in the bay. All of the objectives were met during a 5-week survey eriod for which the MESC was trucked from San Diego, California to Georgia. ithin a few hours of arrival, the complete MESC system was in the water and ollecting data, demonstrating both the portability and easy deployment of the ystem.

The second phase of the T&E, to be carried out in FY84-85, will test the sefulness of the craft as a platform and floating laboratory for monitoring rganotin concentrations in the waters and sediments of bays and harbors ocupied by the Navy. This program will be carried out in conjunction with the aseline survey being conducted by NAVMAT in four selected bays and harbors. he program will also support Naval Ship Research and Development Center NSRDC), Annapolis, personnel in their efforts to obtain data in support of an nvironmental assessment of the Fleet use of organotin paints. Finally, the ESC will be used to monitor the concentration and dispersion of trace metals n effluents from oil-water separators newly installed on two ships in San iego Bay.

Following a successful T&E the MESC system will be updated and specifications for an advanced MESC system will be issued for procurement. Procurement f the advanced MESC will occur by first obtaining a new craft of specified ull design and finally by obtaining new equipment. At that point the MESC ill be transitioned to OPNAV funding. During the T&E period, efforts to nprove MESC capabilities will continue. Paramount is the installation of a avigation system which interfaces with the data acquisition system. Miniangers and Loran C receivers are currently being considered. Also, previous fforts to develop a real-time data analysis capability will continue. The bject is to combine data acquisition and analysis in a single instrument ackage. The present approach is to combine a newly available commercial smart front end," i.e., a data logger, with an IBM-compatible personal comuter. This approach promises low cost, flexibility, and the use of existing tatistical software.

Spectral Radiometry for Water Quality Assessment. Despite the high degree of spatial and temporal variability present in Navy-occupied bays and harbors, environmental measurements are carried out from small craft which sample the environment either by taking bottle (point) samples or making continuous (line) measurements. Thus only a small portion of the environmental volume is sampled at any one time. Extrapolation of these measurements to the unmeasured volume requires a thorough knowledge of the spatial and temporal variability of the parameters measured. This information (essential for realistic environmental assessments) can be obtained economically only with instrumentation capable of measuring large areas at once and which, at the same time possess a high degree of resolution. Spectral radiometry for color and temperature can potentially fulfill these requirements, if the environmental parameters (such as eutrophication and circulation) can be linked to the color or temperature of the water.

Benefit to the Navy would be the capability to carry out environmental assessments over large scales, with a maximum degree of spatial and temporal resolution. Significant cost benefits will result since a maximum degree of coverage and resolution will be obtained with a minimum of sea craft or personnel support, unlike the amount required now for environmental measurements. Additionally, definition of circulation patterns will enable the Navy to dissociate its effluents from those of other sources.

Milestones for this work area include:

- Evaluate use of color and temperature to measure environmental parameters (Feasibility Report, Feb 86).
- Correlate spectral radiometry output with environmental parameters using MESC (Interim Report, Feb 87; Final Report, Feb 88).
- Evaluate use of color to assess environmental parameters (Report, Feb 89).
- Develop algorithms for water quality assessment in terms of spectral radiometry output (Interim Report, Feb 90; Final Report and Transition Plan, Feb 91).

Advanced Field Instrumentation

Field determinations generally require specialized equipment beyond what is available in the laboratory. Sample collection and analysis on a routine basis are best carried out with automated equipment. Such equipment ensures uniformity of procedure as well as ease of operation. The Marine Environmental Survey Craft (MESC, NOSC TD 383, Sept 1980), has been equipped with instrumentation which reflects the technology of the early 1970s. As presently configured, MESC is a prototype built to demonstrate a capability rather than being an operational vessel. Thus, it is anticipated that a future operational MESC will incorporate many improvements designed to make the equipment easily operable by field personnel and to accommodate new or improved equipment. Immediate improvements include developing the capability to perform real-time data analysis as well as acquisition, installing the automated organotin analyzer, upgrading the AASV trace metal analyzer, and procuring an automated navigational system.

Milestones for this work area include:

- Determine feasibility of multielement analysis (Technical Report, Feb 85).
- Initiate development of methodology for multielement analysis of saline water (Interim Report, Feb 86).
- Complete method development of best multielement technique (TR, Feb 87).
- Complete feasibility determination of real-time field multielement analysis of heavy metals (Report, Feb 88).
- Develop analytical methods for real-time field multielement analysis (Interim Report, Feb 89; Final Report, Feb 90).
- Complete intercalibration of multielement analysis with NBS (Feb 89).
- Develop real-time field multielement analyzer and transition to PE 63721N (June 90).

Analysis of Dissolved Organic Compounds in Navy Harbors. While a Navy in-house capability for heavy metal analysis has existed at NOSC for many years, funding and manpower considerations have largely precluded the development of a capability for the detection and measurement of organic compounds in marine samples. The recent Navy interest in the fate and effects of organotin leachates has confirmed the importance and need for this capability. Techniques available for the analysis of organic materials include HPLC (high performance liquid chromatography), fluorescence spectroscopy, and GC/MS (gas chromatography coupled with mass spectrometry). Although these techniques have been available for at least a decade, marine samples require specialized methodology and calibration before the results can be accepted by regulatory agencies. This subunit aims to develop the methodology capable of analyzing selected organic compounds in natural samples (seawater, tissues, and sediments).

Benefits to the Navy would be the capability to perform sensitive, accurate analysis of organic materials in effluents resulting from Naval operations and to properly assess their environmental impact in bays and harbors. This capability will reduce the costs of making environmental assessments.

Milestones for this work area include:

- Develop techniques for speciating and quantifying organotins in seawater, tissues, and sediments (Technical Report, Feb 85).
- Develop methodology for analysis of selected organic compounds in seawater (Interim Report, FY87; Final Report, FY88).
- Complete feasibility determination of real-time field analysis of selected organic compounds (Report, Feb 88).
- Develop analytical methods for real-time analysis of selected organic compounds (Interim Report, FY89; Final Report, FY90).
- Complete intercalibration of methodology for analysis of selected organic compounds with NBS (Feb 89).
- Develop real-time field analyzer for selected organic compounds and transition to PE 63721N (Feb 90).

VI. TECHNICAL PLANS (FY84-FY88)

ANALYTICAL METHODS AND INSTRUMENTATION

Organotin Analytical Methods

The NOSC laboratory now has the expertise to automate and field adapt any analytical technique for which sensors exist. Present major emphasis is on methods for determining and speciating organotin compounds in seawater, sediments, and tissue samples. Following developmental work begun in FY83, a computer-controlled, automated analyzer for organotin compounds is being constructed and will be field tested. The testing program will be carried out in conjunction with NAVMAT's effort to obtain "base-line" values of organotin compounds at selected Navy harbors. Instrument calibration will be performed using GC/MS (gas chromatography/mass spectrometry) techniques.

Near term milestones for this area - include:

- Feasibility of field organotin analyzer: Interim Report (Dec 84).
- Final feasibility report (Feb 85).
- Install analyzer onboard the Marine Environmental Survey Craft (MESC), transition to program element (PE) 63721N (Feb 86).

Advanced Analytical Methods

Discharges from Navy operations, such as oil-water separators, contain heavy metals and organic compounds of environmental significance. The analytical determination of those heavy metals is problematic because of interferences from the seawater matrix and organic compounds. The seawater matrix can also interfere with the determination of organic compounds. The next generation of MEQA instrumentation is aimed at developing the capability to perform rapid, sensitive and accurate analysis of heavy metals and organic compounds in effluents from Naval operations. This capability will allow the Navy to properly assess the environmental fate and effects of effluents and reduce the cost of making environmental assessments.

Multielement Analytical Methods. Recent technological improvements have made it possible to analyze for a large number of elements simultaneously using such techniques as atomic fluorescence, x-ray fluorescence, Zeeman-effect atomic absorption, and Inductively-Coupled-Plasma Atomic Emission Spectroscopy (ICPAES) analysis. Multielement detection generally forms the basis for fingerprinting pollutants. For instance, it is well known that it is possible to identify the source of spilled crude oil by its heavy element content. Multielement analysis is also useful to clarify cause and effect relationships in environmental situations which typically deal with more than one variable. As in the past, new analytical techniques need to be adapted to marine samples and to undergo rigorous calibration procedures before they can be used for environmental quality assessment. The MEQA program plans to update its analytical capability for multielement analysis during the forthcoming planning period by carrying out a vigorous testing program of various techniques to determine their suitability for marine analysis.

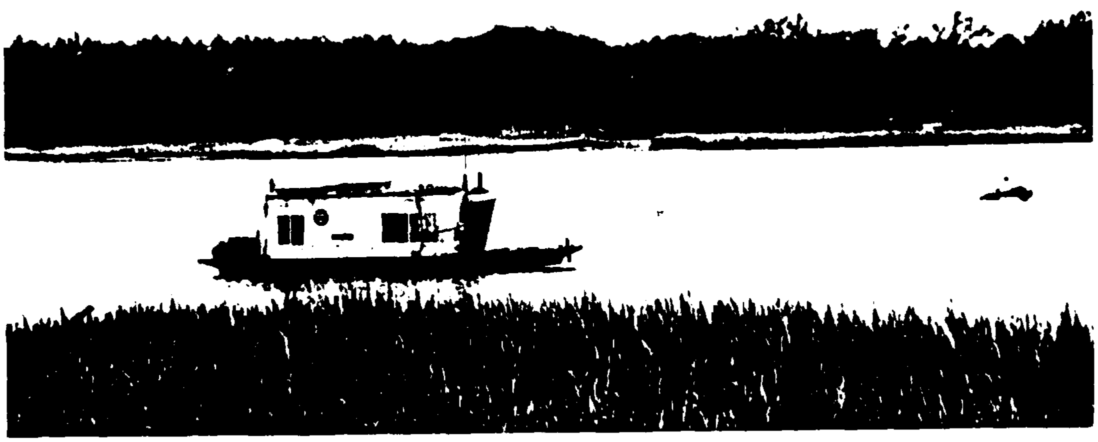

Figure 7. Marine environmental survey craft collecting data in Kings Bay, Georgia.

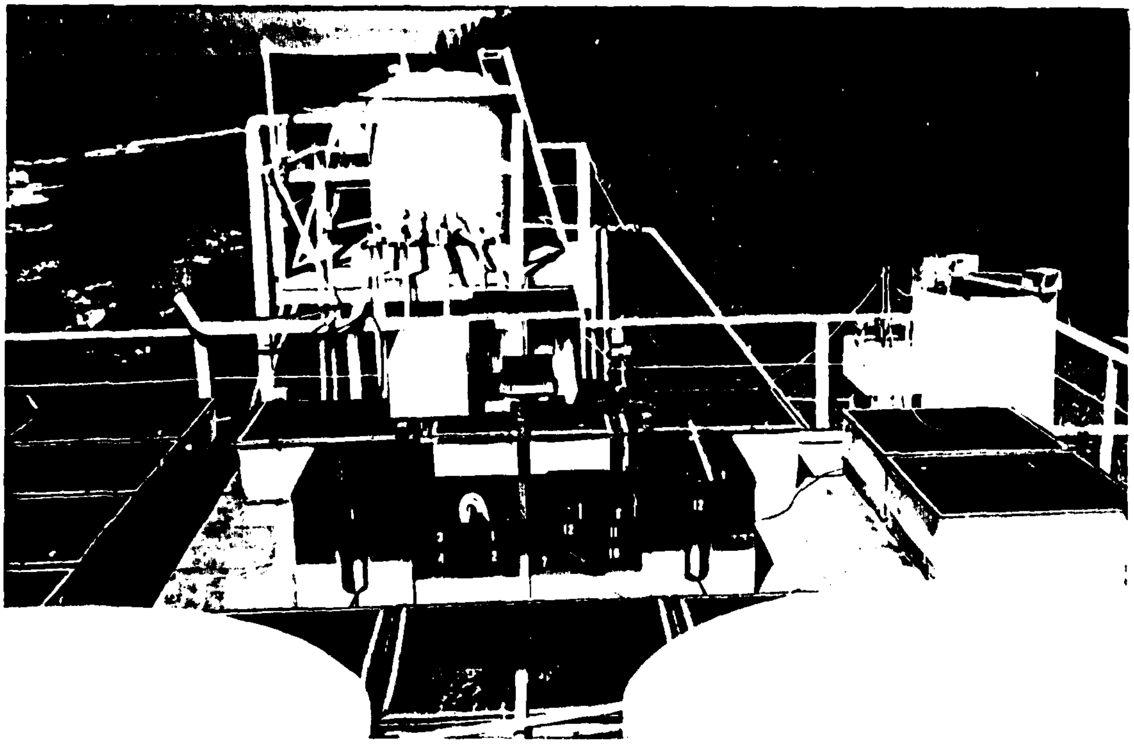

Figure 5. Marine microcosm at NOSC, Kailua, Hawaii.

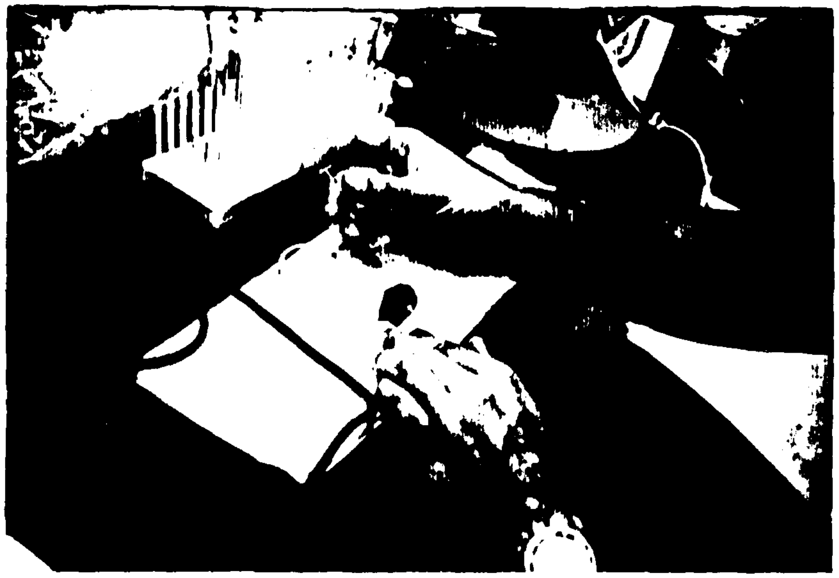

Figure 6 Performing biochemical analysis on mussels

as permitted by funds, over the next 5 years with added strength in the information transfer component.

In the past, the transfer of information between the research community and the users (EFDs, etc.) was done passively. No concerted effort was made to distribute information to the Navy activities and no organized effort was made to solicit information from them. This is seen as an inherent weakness in the program which will be corrected in the coming 5-year period by the establishment of a Marine Environmental Support Office (MESO) to deal specifically with the collection and dissemination of environmental information. MESO will have available to it all of the facilities and experience of the MEQA program and will be the instrument for transferring advanced environmental technology and information to the Fleet and facilities.

The marine microcosm, shown in figure 5 and located at the NOSC facility in Kailua, Hawaii, is a unique flow-through seawater laboratory used for conducting experiments to determine the effects of pollutants on marine communities living in near normal conditions. The facility consists of cubic meter fiberglass tanks with continually flowing seawater drawn from the intertidal zone. Communities of marine organisms from the intertidal zone are recruited into the tanks to serve as miniature ecosystems which can be submitted to controlled environmental stresses. By comparing the metabolism and population structures of stressed microcosms to those of controls, it is possible to determine the responses of complex functional communities to a variety of stresses from pollutants (references 3-10).

Biochemical analyses of body fluids extracted from marine organisms, such as mussels (shown in figure 6), are used to determine biochemical changes due to stress from pollutants, before visible and irreversible symptoms (death) occur. Biochemical analytical techniques now being developed by the MEQA Program will be able to measure stress enzymes and proteins which are present in the organism's bodily fluids as a defensive response to toxic pollutants. Results from these analyses will allow sublethal environmental impact assessments to be made in Navy bays and harbors, to determine if there is an environmental problem before pollutants reach critical levels (references 11 and 12).

The Marine Environmental Survey Craft (MESC), shown in figure 7 collecting environmental data in Kings Bay, GA, is a 38-foot self-contained laboratory capable of sophisticated real-time and near real-time analysis of water quality parameters. The MESC is equipped with an interocean CTD to measure temperature, dissolved oxygen, depth of probe, conductivity, and turbidity. A fathometer is used to measure bottom depth and a pumped flowthrough seawater system supplies seawater to various sensors including ion-specific electrodes (pH and Cu++) (reference 13); an in-house-developed automated trace metal analyzer (references 14, 15, 16, and 17); and Turner Designs' fluorometers. These fluorometers measure the fluorescence of Chlorophyll <u>a</u> (productivity), fluorescence of rhodamin B dye (current studies), ultraviolet fluorescence of dissolved oil in seawater, and the scattering of light (nephelometry and turbidity). The MESC also serves as a platform to carry out other environmental analyses, such as cold vapor determinations of mercury in seawater and the collection of biological samples.

The MESC system has been used to monitor estuarine waters of various Naval harbors, including (1) San Diego Bay, to determine <u>in-situ</u> leach rates of antifoulant paints; (2) Charleston, SC, to collect data for a DEIS on the effect of <u>in-situ</u> hull cleaning; and (3) Kings Bay, GA, to determine if continued dredging and dredge spoil run-off was significantly affecting the water quality of Kings Bay and Cumberland Sound (reference 18).

The basic MEQA approach of developing real-time analytical techniques, of studying community effects, and of developing whole organism and biochemical bioassays has proven highly successful in providing answers to major Navy questions, such as the fate and effects of organotin leachates from AF paints. MEQA has also provided technology which has benefitted many other programs including those on bioluminescence (ONR-NOSC), <u>in-situ</u> hull cleaning (NAVMAT 08), Cu-based AF paints (NAVSEA), marine chemistry (ONR), and many others. Since the over-all approach has been a successful one, it will be continued,

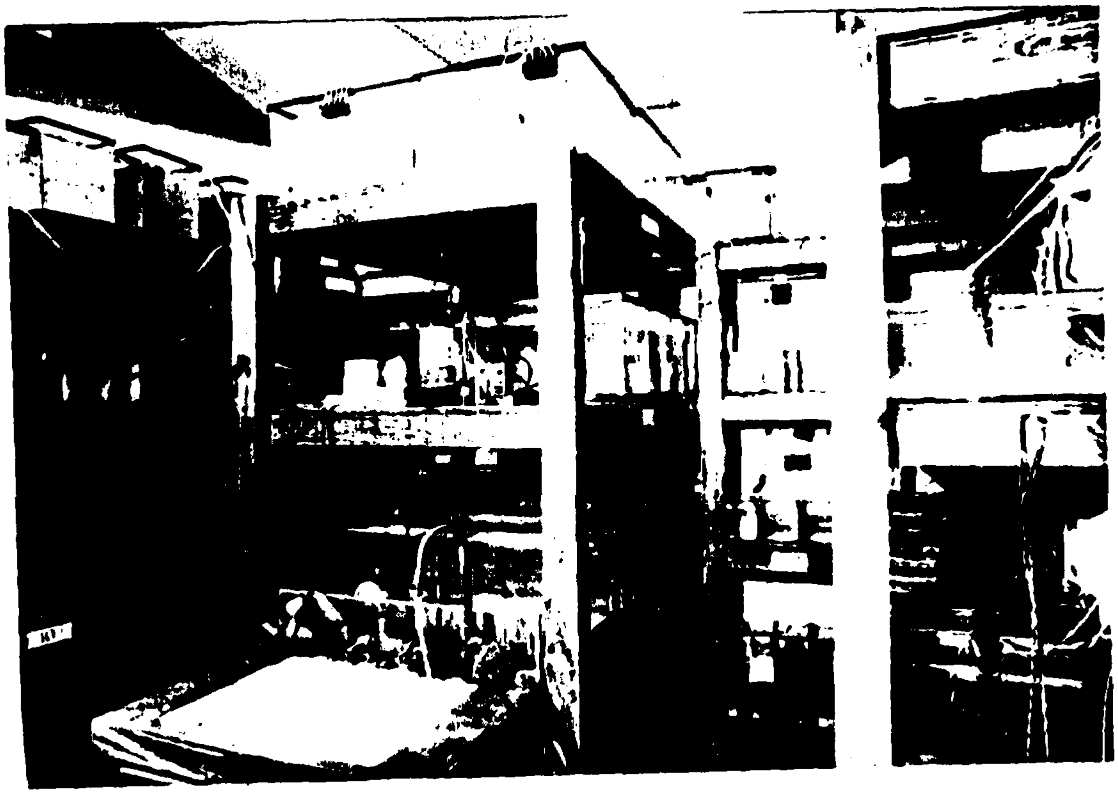

Figure 4. Bioassay laboratory.

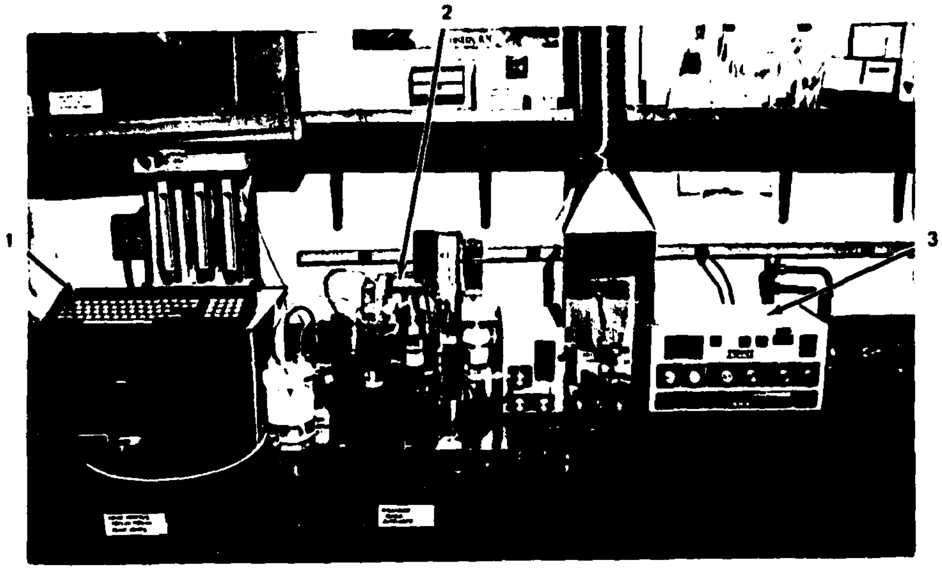

Figure 3a. Automated organotin hydride system (AOTHS) showing three modules: (1) control computer, (2) chemical analysis package, and (3) detector module.

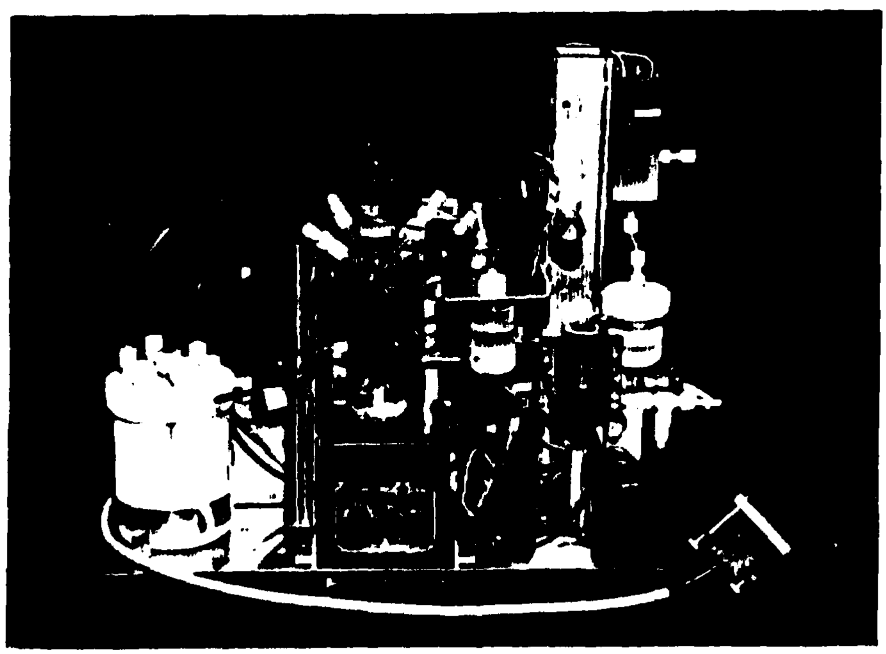

Figure 3b. Close up of chemical analysis package of the AOTHS.

V. SUMMARY OF MEQA ACTIVITIES, FY78-FY79

Appendix A presents all significant progress carried out under the MEQA program during FY78-FY83. The program has become a viable and valuable component of the Navy's over-all effort in Environmental Protection Technology. MEQA efforts, as dictated by Navy needs, have ranged from the filling of specific gaps in technology, such as the development of methods for the determination of organotin in marine samples, to broader scientific questions such as the biochemical quantification of stress, to actively supporting the Fleet and facilities by performing specific tests and offering consultation services. Throughout the period, MEQA R&D has attempted to anticipate trends in environmental awareness while, simultaneously, remaining responsive to specific Fleet and facilities requests for assistance (Appendix B).

Specific products and capabilities have been developed during the last 5 years (FY78-FY83) and have been used in support of marine environmental compliance. These products and capabilities include the Bioassay Laboratory, the Marine Microcosm, the Marine Environmental Survey Craft, various analytical methodologies, and the scientific and technical staff. Through these efforts, the MEQA program has become an in-house resource for assisting the Navy in environmental efforts.

One emphasis of the program has been to develop automated instrumentation capable of performing analysis of Navy pollutants in near real time. The automated organotin hydride system (AOTHS) (shown in figure 3a) was developed to perform routine analysis of organotin (tri-, di-, and monobutyl tin) compounds in seawater.

The instrument system consists of three modules: (1) control computer and associated electronics; (2) the chemical analysis package (hydride generator) (figure 3b); and (3) the detector module (atomic absorption spectrophotometer) and will measure parts per trillion quantities of organotin species in marine waters. This instrument system provides a timely capability to determine organotin concentrations in Navy bays and harbors for the assessment of environmental effects and to provide a baseline survey and monitoring capability. The system also can be optimized to measure other trace pollutants in the marine environment such as mercury, arsenic, selenium, organo-leads, etc.

Various techniques and methodologies also have been developed by the MEQA Program to assess the toxicity of Navy pollutants to marine organisms. These include bioassay procedures, microcosm experiments, and biochemical analysis of body fluids from marine organisms.

The bioassay laboratory shown in figure 4 can be used to perform static or flow-through bioassays for various indicator organisms such as mysids, bivalves, and worms (reference 1). The emphasis is on developing bioassay techniques which can be combined with other laboratory and field studies to obtain a more accurate assessment of toxicity than is obtained by standard bioassay procedures alone. This work is being coordinated with the EPA and ACOE and is aimed at expediting the process of obtaining Navy Dredging Permits (reference 2).

b. Maintaining a dialogue with Federal regulatory agencies (Environmental Protection Agency (EPA), the U.S. Army Corps of Engineers (COE)) and local agencies (Water Quality Control Board and Department of Fish and Game) to incorporate Navy requirements into permitting and environmental regulations.

c. Providing information and advice to Navy activities (EFDs, OICCs) on permitting procedures, testing protocols, and environmental effects.

To support the Fleet's marine technology needs, a trial Marine Environmental Support Office (MESO) will be developed to facilitate implementation of MEQA technology and provide liaison with Fleet Activities and Commands. MESO will help apply capabilities developed by the MEQA Program to Fleet marine environmental problems. Because of the continuing requests for technical assistance and the anticipated future need, an official MESO is needed as an integral component of the Navy Environmental Protection Support System (NEPSS), to consolidate and centralize the marine environmental compliance effort. MESO will provide a system which can deploy instrumentation, specialized equipment, and qualified personnel to provide cost-effective compliance, maintain a positive public image of the Navy's environmental awareness, and educate Navy personnel on pollution abatement procedures. Through MESO, the MEQA Program will be able to provide scientifically sound and legally defensible data to support the Fleet's marine technology needs and minimize the environmental impact on the Navy's primary mission.

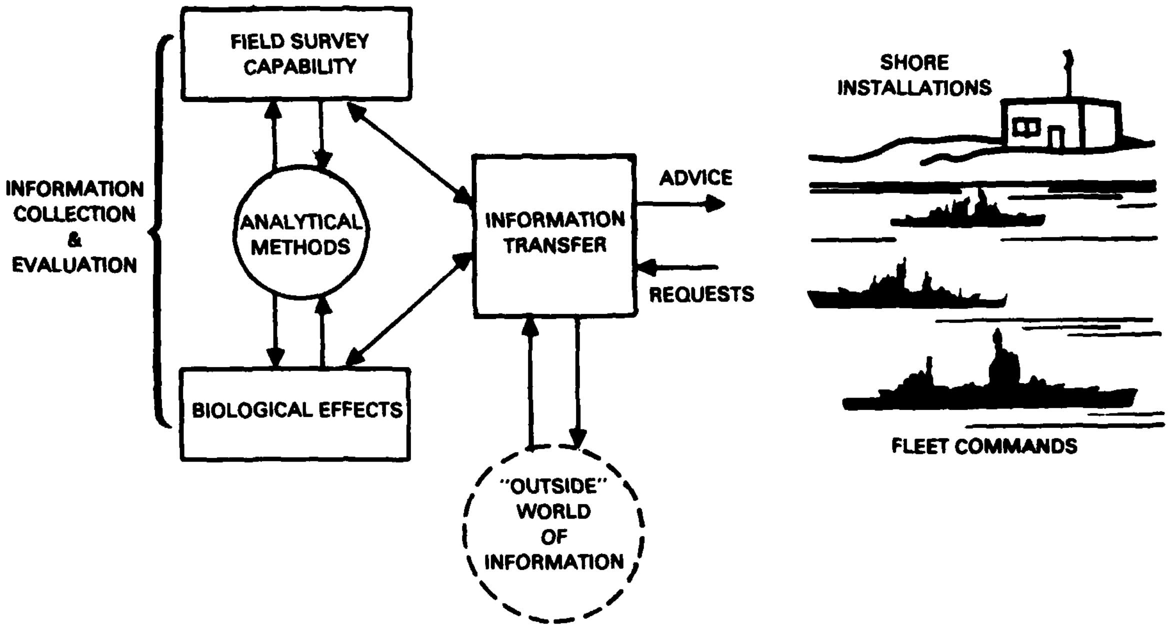

Figure 2. The Marine Environment Quality Assessment Program.

2. Field survey methodology. The constraints imposed by making measurements in dynamic environments of very high spatial and temporal variability in addition to the inherent Navy need to act in a timely manner, call for unique technologies for environmental assessments. The emphasis of this work unit has been on the development of protocols for rapid biological surveys and for real-time chemical and physical measurements.

3. Biological effects. This work unit provides facilities and methodology for biological testing. Its research is directed towards developing less ambiguous, standardized testing procedures for the possible environmental effects of antifouling paints and dredge spoils. A significant effort is also being directed towards identifying biochemical or molecular products in marine organisms subjected to chronic, but sublethal, environmental stress.

4. Information and technology transfer by establishing the Marine Environmental Support Office (MESO). This work unit collects environmental information and makes it available to the Fleet and facilities. MESO will function as the in-house consultant on marine environmental matters for Navy activities in their dealings with regulatory agencies. This support function will be carried out by the following tasks:

a. Publishing environmental methodology in the open literature and intercalibrating methods and instrumentation with other laboratories (NBS, EPA, etc.) to gain acceptance of new technologies by federal, state, and local regulatory agencies.

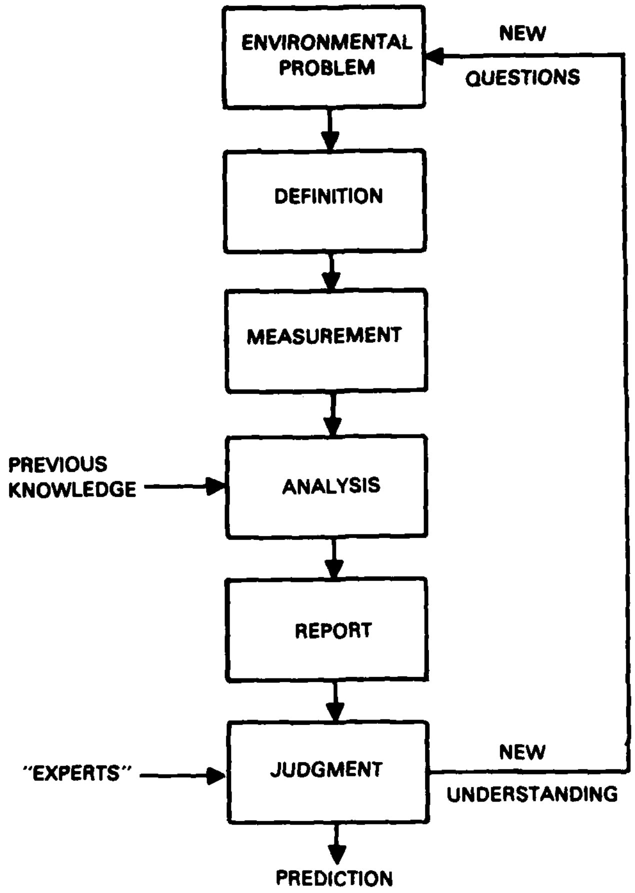

Figure 1. Marine environmental quality assessment process.

STRATEGY

In order to adequately serve present Navy needs and future Navy requirements, the MEQA R&D program must carry out two functions: (1) obtain adequate and timely environmental information and (2) pass on this information, in a usable form, to the cognizant Navy activity. Meeting Navy requirements is accomplished by organizing the work effort into four distinct areas wherein information is collected by the first three and disseminated by the fourth: Figure 2 represents the relationship between the MEQA program effort and the Fleet requirements. The four work units are detailed below:

1. Development of analytical methods and instrumentation. This work unit is tasked with developing cost-effective technology for measuring, defining, and predicting marine environmental quality when technology from the civilian sector is not available or not adequate or applicable.

Milestones for the MESC program include:

- King's Bay survey report and cost/benefit analysis (Aug 84).
- Over-all MESC cost benefit analysis, Final Report, including modularization specifications (Jul 85).
- Specifications for procurement of advanced MESC (Final Report, Jul 86).
- Advanced MESC System, ILS Report (Jul 87).
- User Data Package and transition plans (Jul 88).

Portable Environmental Test (PET) Platforms

The Navy's requirement for environmental assessment has already been acknowledged. What is not yet clear, however, is the degree of dependence of the assessment on local conditions. Recent research indicates that, under sublethal stress, individual environments become conditioned over time and react uniquely to ship effluents, dredging activities and toxins from AF coatings. Thus criteria which apply to San Diego Bay, for instance, do not necessarily apply to Norfolk or to Charleston. While the MEQA program has developed state-of-the-art assessment methodology in the past, much of the work with flow-through aquaria has of necessity been site dependent.

The PET program will design and construct a scaled-down, portable version of NOSC's unique Hawaii microcosm facilities. The intent is to develop a capability to accomplish cronic and short-term community level tests for pollutant effects at specific harbor and shoreline locales of interest to the Navy. The PET units are to be readily portable, either self-propelled as a van, camper, or truck or towed as a trailer. They should fit into a standard military air transport. They will also have the capability to pump ambient seawater to flow-through acquaria and to monitor and record biota and chemical effects. Initial goals are to construct a prototype PET system at Pearl Harbor and to use organotin leachates to compare the PET results against the Ulupau (unimpacted) microcosm. This will be followed by constructing a field unit and deploying the unit for T&E at several Navy impacted areas. Final plans call for the construction of two units and for their transition to use by the EFDs and OICCs as needed.

Milestones for PET platforms include:

- Initial feasibility report on prototype PET and initial test (Feb 84).
- Final feasibility report on PET facility (Feb 85).
- Report on T&E of PET at impacted areas (Dec 86).
- ILS plan on advanced PET units (Dec 87), User Data Package and Final Report (Dec 88).

BIOLOGICAL EFFECTS

Biochemical Detection of Environmental Stress From Navy Pollutants on Marine Organisms

Laws, regulations, and executive orders require the Navy to anticipate and prevent detrimental environmental effects from occurring as a result of

Naval operations. The Navy is often required to test the toxicity of materials before they are adopted for Fleet use or before their disposal after use. True assessments of toxicity require knowledge of long term, sublethal effects of pollutants. These measurements are difficult to obtain from standard toxicity tests based on organism mortality, or from chemical data, or physical observations alone, because many potential pollutants exert cumulative effects over longer periods of time than generally employed in standard assays.

The Navy benefit from this research is to develop the capability to determine environmental stress at sublethal levels, in a timely manner so that appropriate corrective action can be implemented before acute damage occurs. Direct knowledge of toxicity (or lack of toxicity) or environmental impact of Navy specific pollutants will enable the Navy to prepare realistic environmental assessments and propose efficient and effective mitigating procedures.

This project develops rapid, sensitive, and quantifiable methods of assessing the health status of impacted marine organisms at sites of Naval relevance. By choosing an approach based on state-of-the art biochemical technology, information on the "health" of the environment is obtained in real time. Biochemical assays will ultimately indicate an animal's general condition, survival potential, response to a suspected pollutant or toxicant, and finally, whether the pollutant is organic (e.g., a petroleum hydrocarbon) or a heavy metal.

The approach is three pronged: (1) Specific, "indicator" proteins are isolated from organisms stressed in the laboratory with known toxicants, such as Cu ion or tributyltin oxide. (2) Antibodies to these proteins are grown in rabbits. (3) The antibodies are then used in an Enzyme-Linked Immunosorbent Assay (ELISA) to quantify the stress-induced proteins in collected field samples. Because ELISA techniques are very sensitive and very specific, the tests can be conducted in the field or in the laboratory without laborious concentration and isolation steps.

Three types of stress proteins are being considered as indicators of stress: (1) hydrolytic enzymes such as lysozyme, which have been studied by the MEQA program recently; (2) metallothioneins which act to bind and thus detoxify heavy metals; and (3) components of the mixed function oxygenase (MFO) system which detoxify organic pollutants by making the invading toxic organic molecule more susceptible to cleavage and final breakdown by conventional enzyme systems. The first type of response is termed "passive" because it does not constitute a defense by the organism but rather is a sign of internal damage. The other two responses are termed "active" because they represent actual defense mechanisms which (when active) allow the organism to pursue its normal functions despite exposure to toxins.

The program intends to show that marine animals exposed to organotin compounds from antifouling paints, e.g., TBTO, can metabolize the material when exposed at sublethal levels. At present, it seems likely that marine animals have this capability which has already been demonstrated in mammals. If this is the case, tin ions resulting from the cleavage of TBTO will most likely be sequestered by metal binding proteins. Present and future efforts of the program will be directed towards developing ELISA techniques for lysozyme, metal binding proteins, and cytochrome P-450, a component of the MFO system.

Milestones for this work area include:

- Complete toxicity study of AFFF (Sept 84).
- Complete microcosm study of o-tin leachates (Sep 84).
- Determine biochemical responses of bivalves to Cu and Sn (Interim Report Feb 85, Final Report Feb 86).
- Complete chronic low level toxicity field study (Interim Reports Feb 86, Feb 87, Feb 88; Final Report Feb 89).
- Complete biochemical baseline field test and evaluation for Kings Bay, Georgia, and San Diego Bay, California, (Interim Report Feb 85, Final Report Feb 87).

Biochemical Field Investigation of Toxicity (BIOFIX)

The Navy impact to bays and harbors is often subtle and long-termed, requiring specialized methodology to assess the effects on marine organisms. In areas where potential pollution problems exist, methodology is needed that will allow field assessments of marine organism (pre-mortality) health to be made, using the most sophisticated and sensitive techniques currently available. This would allow the Navy to obtain information on the impact of Naval operations on marine organisms in a timely manner, before adverse effects (organism death) occur.

The benefit to the Navy would be the technical ability to deploy highly sophisticated biochemical methodologies rapidly to any area requiring investigation. Rapid response and on-site data acquisition permit "go/no-go" type decision making within a highly compacted time frame. On-site data collection further permits test and survey modification decisions to be made as necessary, depending on analytical results just obtained.

This program will develop portable instrumentation for field biochemical and cytological evaluation of the health status of marine animal populations. Some of these instruments include: a portable Enzyme-Linked Immunosorbent Assay (ELISA) spectrometer; a portable hand-held centrifuge; a field microscope for cell counting; and a battery-powered electrophoresis unit. Appropriate state-of-the-art chemistries will be developed and/or adapated for selected tests to be performed using field instruments, such as immunochemical methods for field analysis using antibodies. Methodologies for field implementation of appropriate tests will be developed and calibrated against laboratory methods by conducting field analytical operations and simultaneously obtaining samples for laboratory analysis. Finally, rapid data logging, calibration, and analysis will be implemented using portable microcomputer and/or modem connection to a larger (data-base) computer system.

Milestones for BIOFIX include:

- Develop field instrumentation package for BIOFIX (Interim Report, Feb 88; Final Report, Feb 89).
- Develop biochemical methodologies for BIOFIX (Interim Report, Feb 88; Final Report, Feb 89).

- Field test and implement BIOFIX including near real-time data logging and analysis (Interim Report, Feb 89; Final Report, Feb 90).
- Transition to PE 63721N (Feb 91).

Expediting Navy Dredging

The Navy must have free and unrestricted access to and from the sea and to the berths of its ships. This access requires dredging to attain and maintain adequate depths which, in turn, requires that the environmental impact of the dredging and spoil disposal be determined. Existing bioassays required by COE/EPA permitting procedures are often cumbersome, expensive, and may lead to serious delays and excessive costs for Navy dredging projects. This work will combine standard bioassays and newly developed techniques with additional laboratory and field studies to develop procedural modifications to streamline the dredge permitting process. The work will be closely coordinated with the COE and EPA offices to assure full acceptance of the streamlined methodology. Navy procedures will be thoroughly documented to allow performance by either in-house or contractor personnel.

In addition to developing new tests and bioassay procedures, an effort will be made to formulate new guidelines on permitting procedures with the COE and to incorporate Navy requirements into COE planning. Additionally, a cooperative experiment on bioaccumulation will be carried out with the COE. Annual training symposia on permitting procedures will be conducted for EFD personnel. A complete NAVFAC dredging permit manual will be prepared to provide instructions on procedures for obtaining permits. It will be made available to EFDs, OICCs and major claimants.

Milestones for this work area include:

- TR on new test procedures (Sept 84).
- Report on guidelines and memorandum of understanding with COE (Mar 84).
- Annual summary reports on training symposia (Dec 84; Dec 85).
- Report on joint NOSC-COE bioaccumulation experiment (Dec 85).
- Procedures manual on dredge permitting procedures (Dec 85).

INFORMATION TRANSFER - MARINE ENVIRONMENT SUPPORT OFFICE (MESO)

The full value of each of the work areas described in this document can only be realized if the information is transferred expeditiously to the potential user. Similarly, the value of each unit is enhanced if the information is received with an understanding of the content of the overall program. On the other hand, the MEQA R&D program and any other Navy environmental R&D program can be responsive to the Navy's needs only if it has an ear to the Navy's problems. For this reason the MEQA program will sponsor the development of a Marine Environmental Support Office (MESO).

MESO will be organized as an in-house consultant on environmental matters, supporting the NAVFAC EFDs, planning codes, and OICCs in their transactions with local, state, and federal regulatory agencies. Via a telecommunications network, MESO will also be the interface between the Navy's major claimants and the body of environmental information available in the private, academic, and military sectors. MESO will be the Navy's center of excellence on the technical aspects of marine environmental quality and the regulatory aspects of environment compliance. MESO will perform quality assurance of marine environmental information and act as a liaison between regulatory agencies and the Navy. Figure 8 shows how MESO interfaces between the users and suppliers of environmental information.

As can be seen from Appendix B, the Environmental Sciences Division of NOSC is already called upon frequently to provide support on environmental matters. This support ranges from answering queries to performing special surveys, bioassays, and other functions. These requests come informally, primarily from local EFDs. The level of importance and the frequency of unsolicited requests for a nonadvertised service strongly suggests that many more requests will be forthcoming if MESO is instituted and made known to all potential Navy users. Also, the formation of a MESO established at the same level as the other Naval Environmental Protection Support Service (NEPSS) offices (AESO, SESO, and OESO) will consolidate and centralize the Navy's environmental assessment efforts.

As presently conceived, MESO will

a. Provide for access to environmental data bases via an Information Support Function (ISF).
b. Provide users with updated environmental information.
c. Provide consultation services as required.
d. Provide environmental measurements including chemical and biological surveys, bioassays, modeling, etc., on a cost reimbursable basis via a Field Support Function (FSF).
e. Provide inputs into the Navy's Environmental Protection R&D programs.

Initially, MESO will be supported with MEQA PE 63721N funds for a trial period not to exceed 3 years.

Milestones for this work area include:

- Issue Information Brochure and Multiyear Plan for MEQA/MESO (Oct 84).
- Issue Information Brochure of capabilities available (Jul 85).
- Establish telecommunication link to EFDs and data bases via MESO Information Network (Jul 85).
- Progress Report on Information Support Function and cost/benefit analysis (Jul 84, Jul 85, Jul 86).
- Progress Report on Field Support Function and cost/benefit analysis (Jul 85, Jul 86).
- Transition Plan (Jul 86).
- MESO office fully staffed and operational (Oct 86).

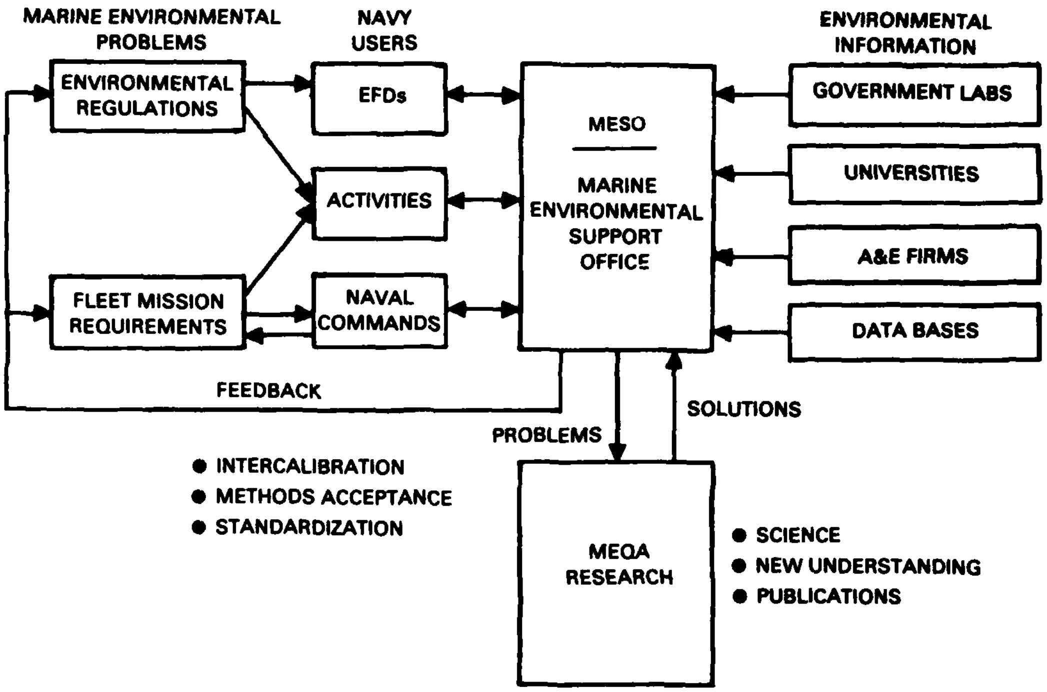

Figure 8. Quality assurance relationship between the Marine Environment Support Office and other environmental activities.

SUMMARY OF MEQA 5-YEAR PROGRAM AND PRODUCT SCHEDULE

Table 1 presents the time lines and prospective products to be produced by the MEQA program areas.

Table 1. MEQA 5-year program and product list.

PROJECTS/PRODUCTS	FY 84				FY 85				FY 86				FY 87				FY 88			
Quarters:	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
A. ANALYTICAL METHODS AND INSTRUMENTATION																				
1. Organotin Analytical Methods (6.2)	—	—	—	—	—	—	—	—	—	#										
a. Organotin analytical methods developed	*																			
b. Feasibility of o-tin analyzer determined				*																
c. Automated o-tin analyzer developed										H										
2. Advanced Analytical Methods (6.2)																				
a. Multielement analysis					S	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
(1) Methods for multielement analysis of O/W separator effluents										*				*						
(2) Feasibility of real-time multi-element analysis determined																		*		
b. Analysis of Organic Compounds									S	—	—	—	—	—	—	—	—	—	—	—
(1) Methods for analysis of dissolved organic compounds in seawater														*						
(2) Feasibility of real-time analysis of organic compounds determined																		*		
c. Spectral Radiometry for Water Quality									S	—	—	—	—	—	—	—	—	—	—	—
(1) Use of color and temp. to measure environmental parameters established														*						
(2) Radiometry output correlated with data from MESC																		*		
3. Advanced Field Instrumentation (6.3)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
a. Automated navigational system onboard MESC							*													
b. Real-time data analysis capability onboard MESC							*													
c. O-tin analyzer installed onboard MESC										*										
d. New generation AASV trace metal analyzer installed onboard MESC												*								
e. Multielement methodology used onboard MESC																*				
f. Spectral radiometry techniques used for water quality assessment																				*
B. FIELD SURVEY METHODOLOGY (6.3)																				
1. Marine Environmental Survey Craft	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	$
a. Kings Bay survey (1982) report				*																
b. Test & evaluation of MESC completed							*													
c. Specifications for procurement of advanced MESC completed											*									
d. Advanced MESC system logistics support plan developed																*				
e. User data package and transition plans prepared																				$

Notes:

S New Start

* Reports (TN, TR, TD and open literature publications)

H Hardware available

$ Transition to OM&B Funding

Program complete

Table 1. Continued.

PROJECTS/PRODUCTS	FY 84				FY 85				FY 86				FY 87				FY 88			
Quarters:	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
B. FIELD SURVEY METHODOLOGY (6.3) (Continued)																				
2. Portable Enviromental Test Platform (6.3)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—$
a. Initial feasibility study and prototype PET completed:				*																
b. Final report on feasibility and development of PET facility:								*												
c. Test and evaluation of PET at impacted Navy site:											*									
d. Logistics support plan for advanced PET unit:																*				
e. User data package and transition plans:																				$
C. BIOLOGICAL EFFECTS (6.2 & 6.3)																				
1. Biochemical Environmental Assessment (6.2)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—#				
a. Complete toxicity study of AFFF:				*																
b. Microcosm study of o-tin leachates completed:				*																
c. Biochemical responses of bivalves to Cu and Sn determined:										*										
d. Low level toxicity field and laboratory study completed:										*										
e. Biochemical baseline field test and evaluation for Kings Bay and San Diego Bay completed:															*					
2. Biochemical Field Investigation of Toxicity (BIOFIX) (6.2)													S—	—	—	—	—	—	—	—
a. Interim report on instrumentation for BIOFIX:																			*	
b. Interim report on methodologies for BIOFIX:																			*	
3. Expediting Navy Dredging (6.3)	—	—	—	—	—	—	—	—	—	—	—	—#								
a. Report on new test procedures completed:						*														
b. Report on guidelines and MOU with ACoE completed:								*												
c. Report on joint NOSC-ACoE bioaccumulation experiment:										*										
d. Summary reports on training symposia:								*				*								
e. Manual on dredge permitting procedures published:												*								
D. INFORMATION TRANSFER (6.3)																				
1. Establish Marine Environmental Support Office (MESO) at NOSC	S—	—	—	—	—	—	—	—	—	—	—	—$								
a. Multi-year plan for MEQA/MESO published:				*																
b. Communications link with EFDs, etc. established with MESO Information Network:								*												
c. Progress reports on information support function (ISF) and field support function (FSF):								*				*								
d. Transition plan completed:												$								

Notes:

S New Start

* Reports (TN, TR, TD and open literature publications)

H Hardware available

$ Transition to OM&B Funding

Program complete

VII. MANAGEMENT PLAN

ORGANIZATION

Program direction flows from the NAVMAT Environmental Protection Administrator and from CNO (OP-45) through the NAVFAC Environmental Protection Program Manager to the Program Manager, Marine Environment Quality Assessment Program, NOSC.

The Naval Ocean Systems Center and other Naval laboratories and contractors will perform specific tasks. Responsibility for their completion is retained by the MEQA Program Manager.

MANAGEMENT CONTROL STRUCTURE

The NAVFAC Program Manager (PM) has full responsibility and authority for program accomplishment as set forth in the milestone schedule (Section VI, "Summary of MEQA 5-Year Program"). He is responsible for control of program information, initiative of corrective actions, and plan revisions. He will review periodic project reports and technical publications of the project for decision-making information. Review of documentation will be supplemented by direct inspection of work in progress and personal conferences with the MEQA Program Manager.

The MEQA Program Manager will have direct responsibility over technical projects. He will allocate resources within overall budget constraints and accomplish milestones on schedule. He will recommend changes to the plan based on technical progress and changing needs and will insure that all work is timely and adequately documented. Figure 9 shows the program management structure.

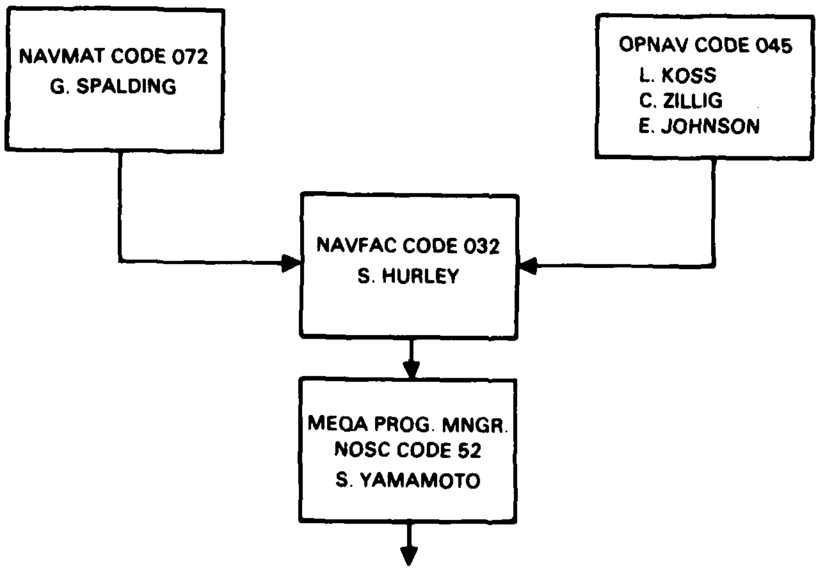

Figure 9. MEQA program management structure.

VIII. FUNDING

Table 2 reflects funding for the MEQA 5-year program.

Table 2. MEQA 5-year program funding ($K).

PROJECTS	FY 84	FY 85	FY 86	FY 87	FY 88
A. ANALYTICAL METHODS AND INSTRUMENTATION (6.2 & 6.3)					
1. Organotin analytical methods (6.2)	102	120	—	—	—
2. Advanced analytical methods (6.2)					
a. Multielement analytical methods	—	45	90	80	95
b. Organic analytical methods	35	45	75	65	90
c. Spectral radiometry for water quality	—	—	30	75	70
3. Advanced field instrumentation (6.3)	—	40	50	100	200
B. FIELD SURVEY METHODOLOGY (6.3)					
1. Marine environmental survey craft	200	235	320	450	400
2. Portable enviromental test platform	100	80	100	160	250
C. BIOLOGICAL EFFECTS (6.2 & 6.3)					
1. Biochemical environmental assessment (6.2)	150	150	155	70	—
2. Biochemical field investigation of toxicity (BIOFIX) (6.2)	—	—	—	80	150
3. Expediting Navy dredging (6.3)	134	105	30	—	—
D. INFORMATION TRANSFER (6.3)					
1. Marine Environmental Support Office (MESO)	88	120	200	—	—
TOTAL (6.2)	287	360	350	370	405
(6.3)	522	580	700	710	850

IX. REFERENCES

1. Meador, J. P., S. C. U'Ren, M. H. Salazar, 1984. A Flow-through Bioassay System for the Evaluation of Organotin AF Compounds. Water Research 18:5, pp 647-650.

2. Salazar, M. H., S. C. U'Ren, S. A. Steinert. "Sediment Bioassays for NAVSTA San Diego Dredging Project." NOSC TR 570, April 1980.

3. Henderson, R. S., S. V. Smith, E. C. Evans. "Flow-through Microcosm for Simulation of Marine Ecosystems: Development and Intercomparison of Open Coast and Bay Facilities." Naval Undersea Center, TP 519, October 1976.

4. Evans, E. C., 1976. "Microcosm Responses to Environmental Perturbants." In Proceedings of the 6th International Helgoland Symposium.

5. Grovhoug, J. G. "A Preliminary Evaluation of Environmental Indicator Systems in Hawaii." Naval Undersea Center, TN 1689, January 1976.*

6. Evans, E. C., R. S. Henderson, 1977. "Elutriator/microcosm System: Pilot Model and Test." EPA-600/3-77-093. Environ. Prot. Ag. NTIS Pub.

7. Henderson, R. S., S. V. Smith. "Flow-through Microcosms for Simulation of Marine Ecosystems: Changes in Biota and Oxygen Production of Semitropical Benthic Communities in Response to Nutrient Enrichment." NOSC TR 310, 16 October 1978.

8. Henderson, R. S. and S. V. Smith, 1980. "Semitropical Marine Microcosms: Facility Design and an Elevated Nutrient Effects Experiment." In Micro9 cosms in Ecological Research, J. P. Giesy, Jr. Ed., U.S. Dept. of Energy Symposium, Series 52 (CONF-781101), pp. 869-910.

9. Henderson, R. S., 1981. "In-situ and Microcosm Studies of Diel Metabolism of Reef Flat Communities." In Proceedings of the 4th International Coral Reef Symposium, Manila, Vol. 2, pp. 697-686.

10. Henderson, R. S., 1983. Benthic Metabolism as an Environmental Quality Indicator. Manuscript submitted to Bulletin of Environmental Pollution.

11. Steinert, S. A., G. V. Pickwell, 1984. Quantitative Determination of Lysozyme in the Hemolymph of Mytilus Edulis by Enzyme-Linked Immunosorbent Assay (ELISA). Mar. Envir. Res. 14 (1984), pp 229-243.

12. Pickwell, G. V., S. A. Steinert, 1984. Serum Biochemical and Cellular Responses to Experimental Cupric Ion Challenge in Mussels. Mar. Envir. Res. 14 (1984), pp 245-265.

* TNs (technical notes) are NOSC in-house working documents. As such, they are not distributed outside NOSC.

13. Zirino, A. and P. F. Seligman. "MESC: The MESC Program for Marine Environmental Quality Assessment," NOSC TD 383, September 1980.

14. Clavell, C. and A. Zirino, "Computer-Controlled Anodic Stripping Voltammetry for the Measurement of Trace Metals in Seawater." In Press in "Mapping Strategies in Chemical Oceanography," Zirino, A. (ed), Advances in Chemistry, Series #209, American Chem Society, Washington, D.C. 1985.

15. Clavell, C., "Microcomputer-Assisted Flow-Through Anodic Stripping Voltammetry System." NOSC TR 532 (September 1979).

16. Zirino, A., S. H. Lieberman, and C. Clavell, 1978. Measurement of Cu and Zn in San Diego Bay. Envir. Sci. & Tech., 12, pp 73-79.

17. Kenis, P., A. Zirino, and C. Clavell, "Automated Anodic Stripping Voltammetry for the Analysis of Cu, Zn, Pb, and Cd for Environmental Monitoring." NOSC TR 243. June 1978.

18. Bower, D. R., "Environmental Survey, Kings Bay, GA, October 1982," CSC Final Report, Contract #N66001-83-D-0043, Delivery Order 044, August 1984.

APPENDIX A

MEQA PROGRESS FY78-FY83

ACCOMPLISHMENTS (FY78-FY83)

The following section presents all significant progress carried out under the MEQA Program during 1978-1983. The summary is organized under each of the four work units. Numbers in parentheses refer to MEQA publications for this period listed in Appendix C, "Publications." Details of work carried out prior to FY78 are given in MEQA Exploratory Development Plan of May 1978.

Analytical Methods and Instrumentation

Trace Metals. The computer-controlled field trace metal analyzer, dubbed the AASV (for Automated Anodic Stripping Voltammetry, the electrochemical principle of its operation) analyzer, originally designed and constructed prior to 1978 was field tested and minor modifications were made to the controller. The instrument worked well for the routine detection of Zn, Cd, Cu, and Pb in estuarine waters and was placed on the Marine Environmental Survey Craft (MESC) under development at that time. Under co-sponsorship with ONR, open ocean field tests were also conducted (1). It was found that the instrument was not sufficiently sensitive to detect Cu in the surface waters of the open ocean. However, good signals were obtained for Zn, Pb, and Cd which are electrochemically better suited to the analysis. A report was issued describing the construction and operation of the instrument (2).

Field tests with the AASV and other electrochemical detectors placed directly in seawater streams showed that a grounding problem could occur, depending on the sensor and measuring circuitry. A device was invented which electrically insulated the flowing stream of seawater from the ocean while still maintaining all of the characteristics of the stream. A patent for a spinning disc electrical isolator was issued to C. Clavell in June 1978 (3). This was the third NOSC-MEQA patent dealing with underway electrochemical detectors. Four reports showing results obtained with underway sensors and with the general concept of real-time, underway sampling in environmental assessment were issued (4,5,6,7).

Data Acquisition. The development of underway monitoring technology led to a requirement for adequate underway data acquisition and for an in-house data analysis capability. Thus, during the late 1970s, efforts were devoted to the establishment of a data acquisition and handling system. Since commercial data acquisition systems of the time were deemed inadequate, a data logger based on the Motorola 6800 microchip was designed and constructed. The data logger also contained a specially built "front end" which isolated and amplified incoming signals as necessary. This development was critical because several of the sensors under development produced only weak DC signals. The data logger, dubbed MEDAS (for Marine Environmental Data Acquisition System) was fully field tested aboard the MESC and on larger ships operating in the open ocean. A manual on the MEDAS was issued in July 1982 (8).

Organics by Fluorescence. An effort was made to develop instrumentation for the underway measurement of algal species, dissolved organic matter, and diesel fuels in seawater by making use of their unique fluorescent signatures. The research was carried out jointly with NOSC in-house funding. The work was discussed at two international meetings and preliminary reports were issued (6,9). Although this work was pre-empted by other tasks, the investigations using the fluorescence approach are still being continued in our laboratory (10). We have recently asked ONR for additional funding to develop real-time analysis for Zn in seawater by fluorescence spectroscopy.

Recently, a fluorometric analysis for diesel fuels in seawater was field tested in San Diego Bay aboard the MESC. The tests indicated that the technique was a suitable complement to the suite of onboard techniques developed for the MESC.

Electrochemical Speciation of Heavy Metals in Seawater. Diagnostic techniques and criteria for determining the speciation (chemical form) of trace metals in seawater using voltammetric analysis were developed and published as a series of papers culminating in an 81-page review article (11, 12, 13, 14). The work, which received additional support from ONR and NOSC IR/IED funds, provided valuable in-house experience in dealing with a crucial problem in marine chemistry. This experience is directly applicable to the problem of the speciation of organotin compounds in seawater.

Specific Ion Electrodes. The requirements of continuous, real-time analysis demanded that sensors with this capability be developed. Efforts were directed towards applying two commercially available ion selective electrodes (ISE) to underway environmental assessment. Operating protocols were developed for the ORION Cu(II) ISE (15) and the Corning semimicro pH electrode. Experience gained with the Cu ISE was applied directly in two other Navy programs. The ISE was used to measure the in-situ leach rate of Cu-based antifouling (AF) paints and to measure the possible environmental impact of in-situ hull cleaning.

The pH electrode was used to determine the surface pH of San Diego Bay and of NSSB, King's Bay, Georgia. It was determined that pH changes correlated closely with biological and chemical events occurring in those environments. For instance, pH was used to trace the path of dredge spoil effluent in King's Bay. Also, pH-temperature relationships were found to contain much information about biological processes in the ocean. With additional ONR and IR/IED funding, the technique, obtained via MEQA funding, was applied to the open ocean, to the Gulf of California, to the Peruvian Upwelling System, and to the Norwegian Sea. Several papers were published in the open literature describing these findings (16, 17, 18).

Organotins. The Navy's intention to shift from Cu-based AF to organotin-based paints called for new techniques for the measurement of organotin compounds in natural samples such as seawater, sediments, and the tissues of marine animals. The work effort focused on three separate techniques:

(1) extraction with an organic solvent followed by analysis by atomic absorption spectrophotometry (AAS) using the graphite furnace;

(2) electrochemical analysis by anodic stripping voltammetry; and

Key West. NOSC developed a pilot study for using a containment boom to alleviate the problem and demonstrated a workable solution for all ships in the area.

45. Optimization Studies of In-Water Hull Cleaning, 1981-1983

Copper leach rate measurements before, during, and after in-water hull cleaning were used to predict the flux of copper into the marine environment. Additionally, measurements of antifoulant coating thickness and panel studies were conducted over time and suggestions were made for optimum cleaning schedules to increase efficiency and minimize environmental impacts.

46. FBM Submarine Support Facility, Atlantic, 1982-present

Baseline surveys using real-time chemical measurement techniques were conducted before and during construction dredging at the new Trident Submarine Base in King's Bay, Georgia. The surveys to investigate dredging impacts were used as a T&E of the Marine Environmental Survey Craft. Biochemical monitoring of oysters using state-of-the-art techniques developed at NOSC was also performed.

47. Environmental Assessment, Tomahawk Launcher Shock Tests, 1983

An environmental assessment was prepared for the shock testing of a Tomahawk Cruise Missile Launch System with underwater explosions in the waters off San Clemente Island. Environmental impact liaison was provided with regulatory agencies before, during, and after the tests. Environmental surveys were also conducted as part of the mitigating action.

48. Anaheim Bay Bridge Removal, NWS Seal Beach, 1983

After preparing additional, more comprehensive documentation of environmental impacts last year, and securing the necessary permits for demolition, the project was delayed. NOSC was again asked to secure the necessary permits for demolition and act as liaison with appropriate regulatory agencies. The permits were finally obtained and the project was completed. (See items 10, 42.)

49. Sediment Bioassays, Med-Moor Dredging, NAVSTA San Diego, 1983

NOSC conducted sediment bioassays for maintenance and construction dredging in support of a Med-Moor installation between Pier 8 and the Mole Pier at NAVSTA San Diego. After the scope of the project had changed, NOSC conducted a second set of bioassays and prepared a draft report in 45 days. NAVSTA San Diego and WESDIV were assisted in negotiating changes in environmental assessments for the project after the scope had changed.

50. Environmental Assessment Addendum, Med-Moor, NAVSTA San Diego, 1983

After an environmental assessment had been prepared by private contractor and the scope of the project expanded, NOSC conducted grain size analyses and prepared a modified assessment to include the expanded Med-Moor area and the Mole Pier as part of the project. A permit was obtained shortly thereafter that included the expanded Med-Moor area and the Mole Pier.

36. Heavy Metal Contamination, Naval Torpedo Station, Keyport, 1981

Environmental personnel at Naval Torpedo Station, Keyport, were advised on regulatory limits for heavy metals in animal tissues and suggestions were made on required environmental documentation. NOSC also consulted with regulatory agencies to help establish reasonable limits for the proposed project.

37. Dredging, Wilson Cove Pier, San Clemente Island, 1981

NOSC conducted chemical analyses of sediments for WESDIV and assisted in preparing the environmental documentation for dredging at the Wilson Cove Pier.

38. Explosive Testing, San Clemente Island, 1981

Environmental documentation was prepared and a permit was obtained from the Fish and Game Commission to conduct explosive testing at San Clemente Island. NOSC documented the impact of the explosives and determined that there were no significant adverse impacts.

39. Sediment Bioassays, Maintenance Dredging, NAVSTA Long Beach, 1981

Sediment bioassays were conducted to obtain a permit for maintenance dredging between Piers 7 and 9 at NAVSTA Long Beach.

40. Floating Drydock, Construction Dredging, NAVSTA San Diego, 1982

Sediment bioassays for construction dredging in support of a floating drydock at NAVSTA San Diego were conducted. NOSC implemented changes in bioassay procedures and provided liaison with regulatory agencies for supplemental biological surveys and appropriate mitigating action.

41. Anaheim Bay Bridge Removal, NWS Seal Beach, 1982

Since several years had lapsed after the preliminary work, NOSC was asked to prepare additional, more comprehensive, documentation of environmental impacts and secure the necessary permits for demolition. (See items 10, 48.)

42. Dredging, Naval Amphibious Base, Little Creek, 1982

NOSC assisted NAVFAC LANTDIV in defining a realistic scope of work for an upcoming dredging project at the Naval Amphibious Base, Little Creek. As a direct consequence of this guidance, sizable savings were realized in environmental assessment costs.

43. Antifouling Coatings, NAVSTA Key West, Florida, 1982-1983

After learning that existing antifoulant coatings in use on the aluminum-hulled PHM-hydrofoils were not optimum, NOSC initiated a switch to tin-based paints. COMPHMRON-TWO is now part of the Navy's organotin test program.

44. Seagrass Control, NAVSTA Key West, Florida, 1982-1983

Drifting seagrass, driven by wind and currents, was building up near berthing areas and clogging ship (PHM-hydrofoils) seawater intakes at NAVSTA

30. **Construction at NAVSTA, Long Beach, 1979**

The impact of proposed construction on least terns (an endangered species) was assessed. NOSC organized meetings with representatives from state and federal regulatory agencies and the Navy to draw up acceptable mitigating actions.

31. **Strontium-90 Radioisotope Thermoelectric Generators (RTG), 1980-1981**

The Navy uses RTGs to power certain undersea systems. Recovery of the generators after use is costly. Consultation services were provided to the Naval Nuclear Power Unit. Environmental impact documentation was prepared for a permit to leave the RTGs in place.

32. **POL Pipeline, San Diego, 1981**

A year after completing the project, regulatory agencies informed the Corps of Engineers (COE) that the Navy's contractor did not abide by the conditions of the dredging permit. The COE suggested that the Navy would have to fill in the trench and plant eelgrass. NOSC biologists met with the agencies involved and suggested a cooperative underwater survey. During that survey, several clumps of live eelgrass were observed. The regulatory agencies agreed the eelgrass beds would re-establish themselves more rapidly if the area was left undisturbed. (See item 13.)

33. **Oil Spill, Sasebo, Japan, 1981**

The Navy inadvertently spilled diesel fuel at Sasebo, Japan. A portion of the spill drifted into a cove where mariculturists raise fishes, shellfish, and seaweed under natural conditions. Claims for losses due to tainted shellfish and seaweed and killed fishes were made by the mariculturists against the Navy. NOSC scientists were called in 3 months after the spill to assess the condition of the cove. This effort helped to identify the extent of the damage.

34. **Organotin Antifoulants, Environmental Assessment, 1981-present**

A number of laboratory and field studies on organotin AF leachates and biological toxicity studies have been conducted as part of the environmental documentation required prior to the Navy implementing organotin antifoulants. NOSC prepared environmental documentation and reviewed the Draft Environmental Assessment for Fleetwide Use of Organotin Antifouling Paints.

35. **Great Blue Herons, Submarine Support Facility, San Diego, 1980.**

The environmental impact of a Steam Generating Plant (MILCON P-042) was assessed. After questions were raised by regulatory agencies, NOSC advised WESDIV to alter the access road to preserve a great blue heron colony and study nesting success to document the effects of construction. The plant was constructed, the road altered, and the heron colony preserved.

were performed to quantify the movement of these radionuclides from the rock and their degree of penetration through the underlying soil to the ground water. The leaching of these radionuclides from the crushed rock upon exposure to the equivalent of several hundred years of rainfall was measured. This study was conducted for the Naval Nuclear Power Unit and a permit was obtained for disposal. (See item 8.)

24. Environmental Assessment of Finger Bay, Adak, 1978

The State of Alaska and the Alaskan fishing industry wanted to process crab at Adak Island. This would permit the Alaskan fishing industry to better exploit the fisheries in the Aleutians and compete more efficiently with foreign fishermen. The Navy was concerned about the impact of such activities on Naval Air Station, Adak, as well as on the environment. WESDIV NAVFAC and Naval Air Station, Adak, requested NOSC to document the environmental impact of the proposed fish processing operation. Crab processing was not allowed to continue.

25. Selection of Trident II Missile Test Site, 1978

Five potential sites for Trident II missile launch tests were proposed. NOSC was asked to assist in the site selection by providing environmental consultation services.

26. Laser-Guided Projectile Test at San Clemente Island, 1978

NOSC prepared a preliminary Environmental Impact Assessment for the proposed test.

27. Effect of Dredging Operations on Lobster Migration in San Diego Bay, 1979

NOSC biologists studied the migration and movement of lobsters in San Diego Bay during March-June 1977 as part of a study on the environmental impact of pier construction. A dredging permit was contingent upon monitoring lobster migration during dredging. NOSC was tasked to conduct this study. Baseline data from this study provided a basis for predicting the impact of dredging operations on lobster movements.

28. Mitigation Beach, NAS North Island, 1979

As part of the mitigation for a variety of Navy dredging and shoreline construction projects, NOSC initiated the conversion of a seawall habitat to a sandy beach eelgrass habitat. NOSC coordinated a cooperative eelgrass transplant with a number of regulatory agencies including National Marine Fisheries Service, U.S. Fish and Wildlife Service, and the California Department of Fish and Game.

29. Re-Homeporting Ships at NAVSTA, Long Beach, 1979

NOSC reviewed and commented on the Environmental Impact Statement and met with contractors and representatives from OP-45 and WESDIV, NAVFAC to discuss the impact statement.

17. Bioassay Testing of Sediments for Ocean Disposal, 1977-present

In 1977 EPA and the Corps of Engineers (COE) implemented new regulations to demonstrate that dredged material qualified for ocean dumping before a dredging permit could be obtained. This placed an additional burden on all Navy dredging permits that had not been approved. NOSC developed the capability to conduct the necessary bioassays under an R&D program funded by NAVFAC. This capability was made available to Navy activities in a timely manner. The first dredging project to be affected by the new regulation was Pier 2 (see item 14). Subsequently, 30 additional bioassays have been conducted to support dredging projects at NAVSTA, San Diego; Subase, San Diego; Naval Supply Center, San Diego; Naval Air Station, North Island; and NAVSTA, Long Beach. Sediment bioassays for various Navy dredging projects have been conducted on a continuing basis.

18. Baseline Biological Survey Navy Sailing Club, Naval Amphibious Base, Coronado, California, 1977-1978

NOSC conducted a biological survey at the Naval Amphibious Base to provide data for "master planning" and an impact assessment for the proposed project.

19. Environmental Assessment Survey, Piti Power Plant, Guam, 1977-1978

NOSC provided field and laboratory services to PACDIV NAVFAC for an assessment of potential impact at the Piti Power Plant, Guam. This power plant intake assessment was necessary to meet federal requirements imposed by the EPA. A final report was submitted to PACDIV in 1978.

20. Environmental Assessment of NAS Moffett Field Special Project MI-78, 1977-1978

An environmental impact assessment was prepared for the proposed special project. The assessment was completed, submitted, and approved by CINCPACFLT in 1978.

21. Vieques Island, Puerto Rico, 1978

The use of the range of Vieques Island was contested in court by the Commonwealth of Puerto Rico. NOSC assisted NAVFAC by providing environmental consultation and coordinating the collection of baseline data.

22. Environmental Assessment of Navy Power Plants in Pearl Harbor, 1978-1979

The impact of Navy power plant intake structures and effluent discharges into Pearl Harbor on resident marine communities was studied for PACDIV NAVFAC.

23. Removal of Radioactivity from Contaminated Rocks from McMurdo, Antarctica, 1978-1979

Rocks, slightly contaminated with Cs-137 and Sr-90 from the PM-3A nuclear reactor, were in temporary storage at CBC, Port Hueneme. To obtain approval from the Nuclear Regulatory Commission for their permanent disposal, analyses

11. NAS, North Island Dredging, 1977

Due to an unexpected buildup of sediment, a carrier could not enter its berth for predeployment servicing at NAS, North Island, San Diego. Emergency dredging was required. NOSC collected essential data and prepared an Environmental Impact Assessment for the project within weeks and a dredging permit was obtained.

12. New London Dredging, 1977

Dredging was required to accommodate the SSN 688 class submarines in New London. Environmental questions about the disposal of dredge material resulted in a court-ordered dredging termination. A plan to monitor the movement of dredge material at the New London disposal site was prepared at the request of NORTHDIV NAVFAC. Consultation services were provided to Navy representatives at meetings of the Interagency Scientific Advisory Subcommittee on Ocean Dredging and Spoiling (ISASODS). Due to these efforts, dredging was allowed to continue.

13. Construction of POL Pipeline, San Diego Bay, 1977-1980

A POL (Petroleum, Oil, Lubricants) pipeline was to be constructed across the entrance channel to San Diego Bay (project P-005). NOSC provided consultation services, sediment quality analyses, and an assessment of the impact on eelgrass beds. As part of the mitigation, eelgrass beds were surveyed and mapped before and after dredging. (See item 32.)

14. Ammunition Pier Project, San Diego Bay, 1977

After obtaining a dredging permit, additional consultation services were provided regarding specific biological habitats, location of eelgrass, and beach restoration for pier construction. (See items 5, 27.)

15. CEIS for "*In-situ* Removal of Marine Fouling Organisms from Navy Ships," 1977-1980

NAVMAT requested NOSC to prepare a Candidate Environmental Impact Statement (CEIS) to aid in the timely implementation of an in-water hull cleaning program at eight impacted Navy harbors. Biological and chemical surveys were conducted in San Diego Bay in January 1978 during cleaning of the USS HULL. Based on these surveys, a preliminary CEIS was written. Sufficient information was not available to write an adequate final CEIS. Therefore, additional surveys were made during other cleaning operations in San Diego Bay, Charleston Harbor, and Pearl Harbor. As a result, an EIS was written.

16. Response to Public Comments Pertaining to the DEIS for "Proposed New Berthing Pier #2, NAVSTA, San Diego," 1977

Significant public comments concerning the Pier 2 DEIS required that a biological survey be conducted prior to approval of the document. NOSC was requested by WESDIV NAVFAC to conduct the survey and to respond to the comments. Completion of the survey and the subsequent report allowed continuation of Pier 2 planning.

less than 5.5% of the entire bed. Further, rip-rap associated with the new pier would provide habitat that would more than compensate for lost eelgrass. On the basis of these findings and a pilot eelgrass transplant, objections were withdrawn and a dredging permit was obtained. (See items 14, 27.)

6. Eelgrass Beds, Delta Beach, NAVAMPHIBASE, Coronado, 1975-1976

The Navy planned to restore a seriously eroded training beach at the NAVAMPHIBASE, Coronado with fill from a Corps of Engineers dredging project in San Diego Bay. This action was opposed by regulatory agencies because some eelgrass would be destroyed. A NOSC survey of this and other beds in San Diego Bay showed that eelgrass had actually reseeded on filled areas in the bay within 4 to 6 years. State and federal agencies agreed to beach restoration, providing the Navy would encourage and stimulate growth by transplanting eelgrass plugs. This was successfully accomplished.

7. FBM Submarine Support Facility, Atlantic, 1976-1978

Services were provided to the Installation and Planning Division of NAVFAC in the selection of a site for an FBMSSF, Atlantic. These services included review of Environmental Impact Statements, survey plan and procedures, and consultation during contract negotiations.

8. Radioactively Contaminated Rocks from PM-3A Nuclear Reactor Site, McMurdo, Antarctica, 1976

The Navy planned to remove 6500 cubic yards of radioactively contaminated rocks from McMurdo, Antarctica. Selection of a disposal site depended upon the degree of radioactivity mobilization. Radioactivity consisted primarily of Cs-137 and Sr-90 at a total of 0.27 and 0.003 Ci, respectively. Studies showed that both radionuclides were held tenaciously by the rocks when exposed to distilled water. These studies were completed and a final report was submitted to the Naval Nuclear Power Unit (NNPU) within 5 months of the initial request. On the basis of the report, NNPU was able to obtain a permit from the Nuclear Regulatory Commission to temporarily store the rocks at Pt. Hueneme, California.

9. Ready Missile Test Facility, Pacific Missile Test Center, Pt. Mugu, California, 1976

A ready missile test facility was to be constructed at the Pacific Missile Test Center, Pt. Mugu, California. Since the facility would impact Mugu Lagoon, a wetland area valuable to fish and wildlife, objections were raised by regulatory agencies. NOSC was asked to prepare a Draft Environmental Impact Statement. In addition to preparation of a DEIS, mitigating actions satisfactory to the Navy and the state were recommended, and the project was completed.

10. Seal Beach Bridge, Naval Weapons Station, Seal Beach, California, 1976-1978

The Navy was required to remove the remains of a bridge in Anaheim Bay. NOSC was asked to prepare environmental documentation. A preliminary assessment was prepared but the project was postponed. (See items 41, 48.)

APPENDIX B

DIRECT SUPPORT TO FLEET COMMANDS AND INSTALLATIONS BY MEQA

The following is a partial list of studies conducted by NOSC personnel of the Environmental Sciences Division, Code 52. They are examples using capabilities developed and maintained as part of a marine environmental quality assessment program. This R&D program has been funded by NAVFAC to support Fleet activities in the area of environmental compliance.

1. La Maddelena Bay, Italy, 1972

A site survey of a proposed NATO site for home porting U.S. submarines was conducted. The survey was completed and a final report filed with OP-45 within 1.5 months from the time the study was requested. On the basis of the survey, it was concluded that presence of U.S. submarines and support vessels would not seriously threaten the local environment and that the proposed pipeline to conduct sewage away from the vessels was an adequate and cost-effective interim solution.

2. FBM Submarine Support Facility, Pacific, 1973-present

To date, thirteen environmental baseline surveys and two annual monitoring surveys have been completed at the FBMSSF, Naval Submarine Base Bangor, Bremerton, Washington. Results of the initial surveys were included in the Environmental Impact Statement for the proposed facility and more recent surveys have provided comprehensive baseline data. These data are being used by resource management planners.

3. Mercury Contamination of Drinking Water, NAS Bermuda, 1973-1978

Mercury from paints used to coat a catchment basin for drinking water at NAS Bermuda was monitored after identifying a potential contamination problem in the drinking water. A technique was developed for measuring mercury and titanium in paint using neutron activation analysis. Paint samples were collected periodically and analyzed for mercury and titanium. Changes in the ratio of mercury to titanium as a function of time indicates mercury leach rates.

4. Dredge Disposal Site LA-5, San Diego, 1974-1976

Construction of Pier 7 at the Naval Station, San Diego, required dredging and disposal of the dredged material at LA-5. Objections by certain federal and state agencies threatened to delay pier construction. NOSC developed a plan for monitoring the disposal site which was satisfactory and objections were withdrawn. NOSC later surveyed the disposal site before, during, and after dumping.

5. Eelgrass Beds, North Island, San Diego, 1975-1976

Plans for construction of an ammunition pier at North Island were halted due to the presence of eelgrass beds at the proposed site. Regulatory agencies objected to removal of the eelgrass and delayed issuance of a dredging permit. A NOSC survey of the beds showed that the affected area constituted

INFORMATION TRANSFER

Prior to FY84, the results of MEQA R&D were disseminated as reports to sponsors, as publications in the open literature, and at professional meetings. Other transfers of information occurred when MEQA investigators carried out projects funded by other Navy activities which used MEQA-funded technologies. An example of this is the use of the Cu(II) electrode to determine the environmental effects of in-situ hull cleaning and for measuring the in-situ leach rates of copper-based AF paints (funded by NAVMAT OBE). The Cu(II) electrode was also used to study trace metal variability in the open ocean (ONR). While this approach was useful for establishing the professional credentials of the program to the Navy and the outside environmental community, it was not a mechanism for making environmental information available to the principal Navy users, i.e., NAVFAC planning codes, EFDs and OICCs. Contact with these activities occurred primarily through unsolicited, informal requests to the Environmental Sciences Division at NOSC. Over the past 5 years such requests have resulted in 63 separate efforts in support of Fleet activities (see Appendix B).

measured in the field, without extensive laboratory concentration and purification steps. The above work was presented at a national meeting in April 1983 and the two papers presented were published (36,37).

Recent work has concentrated on expanding the analytical approach discussed above to pollutants other than Cu, such as organotin compounds and petroleum hydrocarbons. Collaborative work is being carried out with Dr. R. Lee of the Skidaway Institute of Oceanography (University of Georgia) in an effort to understand detoxification mechanisms in common, estuarine marine animals. Finally, beginning in December 1982, a long term, seasonal monitoring program was begun at NSSB, King's Bay, Georgia, to detect possible seasonal fluctuations in the heavy-metal burdens and associated biochemical factors in oysters.

Bioassay Laboratory. The Bioassay Laboratory (BL) was established at NOSC in 1974 to carry out marine environmental research for directed Navy projects. Unlike the Ulupau microcosms which are designed to study community effects, the thrust of the BL is to quantify stress by monitoring individual species of animals. This approach is extremely useful for solving immediate environmental problems because it relates directly to criteria specified by the Environmental Protection Agency (EPA) and the U.S. Army Corps of Engineers (COE).

The BL situated on Pt. Loma, San Diego, has direct access to ocean water and, at any time, can utilize 125 flow-through tanks, 40 static tanks, and over 200 test beakers — any number of which can be dedicated to a given experiment. A major advantage of the facility is that the pollutant mixing chambers use no pumps or valves to deliver toxicants, resulting in troublefree maintenance. Similarly, because the tanks are of polycarbonate, absorption effects are minimized. Two types of work are carried out at the laboratory: (1) Navy activities are assisted in securing regulatory permits by performing standard and accepted bioassays, and (2) new bioassay procedures are developed in concert with regulatory agencies.

The MEQA program (along with other Navy activities) has supported the laboratory for a number of years. In 1977 the facility was modified with MEQA funding to provide bioassays for dredged materials. Since that time, 17 bioassays have been conducted for the Naval Station, San Diego, and the Naval Station, Long Beach. In 1982 MEQA provided funding to provide a flow-through capability to 125 test tanks. Recent work, supported with MEQA 6.3 funds, has concentrated on a program to expedite Navy dredging by facilitating the dredge-permitting process. To this end, the BL has undertaken a cooperative effort with the COE aimed at standardizing and improving bioassays for dredged materials. Similarly, the laboratory maintains an active dialogue with the COE aimed at acquainting the Navy with COE requirements during the planning stages of major projects.

Since 1978 BL facilities and expertise have been instrumental in determining the environmental impact of in-water hull cleaning (NAVMAT OB), in studying the fate and chemical effects of organotin compounds released in seawater (NAVMAT OB), in developing a biochemical indicator of stress (MEQA, NOSC IR/IED), and in determining the toxicity of drag-reducing polymers and fire-fighting foams to marine organisms. Six reports, including several open literature publications, have resulted from this work (38-43).

c. Effects of Cu and Organotin AF Leachates on Bottom Communities. A comparison study of a currently used Cu-based AF paint (F121) and an organotin-based paint (SPC-4) targeted for possible future use by the Navy was performed using painted panels immersed in microcosms containing soft-bottom harbor-type communities. After 3 months of exposure, the effects of the organotin paint were several times more severe than that of the Cu-based paint. Several species of biota were found to be particularly sensitive to organotin.

d. Effects of OMP-253 Antifouling Leachates on Bottom Communities. The leaching rate of OMP-253 paint (and the concomitant deleterious effect on bottom fauna) was found to be several times higher than those of the SPC-4 paint. However, overall effects on marine flora were less than those caused by the SPC-4 leachate. Highest amounts of the breakdown products of organotins were measured in microcosms enriched with particulate organic material. Also, the highest rates of removal of organotins from the dissolved state were observed in those microcosms which contained large quantities of inorganic particulates. These results suggest that organotin leachates in shallow coastal waters (which contain an abundance of both types of particles) may be rapidly sequestered by sediments and metabolically altered by bacteria.

The analytical determinations used in the above and other studies relied heavily upon technology developed under the "Analytical Methods and Instrumentation" portion of the MEQA program. Since 1977, research at the Ulupau facilities has resulted in eight reports, published either in-house or in the open literature (28-35).

Biochemical Environmental Assessment. It is important to assess the environment before damage occurs. Present technology for environmental assessment depends primarily on estimating numbers of surviving organisms. While this technique is useful for determining whether damage has occurred, it is far less useful for predicting incipient damage. For this reason, the MEQA program has carried out research on biochemical methods for determining stress in marine organisms subjected to toxic but sublethal concentrations of pollutants. (It should also be emphasized that, for many organisms, stress may not be implied by simple tissue burdens since most animals have the ability to cope with pollutants. For instance, at nonlethal concentrations, mussels may sequester toxic metals with metal-binding proteins and render them harmless.)

Initial work is aimed at establishing a relationship between the concentration of lysozyme (a common enzyme associated with damaged cells and tissues) in the hemolymph ("blood") of bay mussels and ambient Cu concentrations. Laboratory tests showed that while the stressed mussels showed no obvious morphological changes or "outward" sign of disease, they were nevertheless stressed as determined by their high concentration of lysozyme (36). In the field, such stress would be the forerunner of changes in community structure since stressed organisms would not compete for food or reproduce as well as healthy ones. A significant advance in the program was made in 1982 when antibodies to purified mussel lysozyme were grown in rabbits. This development made possible a highly sensitive and specific immunochemical assay for lysozyme. In this type of determination, lysozyme antibodies are reacted with lysozyme in extracted hemolymph in a medium which produces a color in proportion to the quantity of lysozyme. This approach, termed ELISA for Enzyme-Linked Immunosorbent Assay, is so sensitive and specific that trace quantities of lysozyme (and other biochemical agents which cause immunoresponses) may be used to digitize the survey area into a coordinate system, upon which the navigational data can be entered to generate plots of the MESC's cruise track.

Current efforts are aimed at upgrading MEDBS by replacing the HP1000 system with a MASSCOMP 530 UNIX based computer system networked with the NOSC Computer Center, to provide access to larger storage capability, statistical software, other environmental data bases (NRDB), as well as the DoD's communications network, MILNET. Also underway is the development of the real-time acquisition and processing system (RTAPS), utilizing a MicroMac 5000 "smart front end" data logger and a Compaq Plus, IBM-compatible, portable computer. This system will be capable of performing data calibration and analysis during data acquisition.

Biological Effects

The Ulupau Marine Microcosm Facility. The Ulupau facility is a unique flow-through seawater laboratory used for marine environmental research. While numerous agencies have contributed to its activities, the MEQA program has provided continuing support for maintenance and for particular studies as needed. The facility consists of twelve outdoor 130-gallon fiberglass tanks with continually-flowing seawater which contain tidepool-like communities of marine organisms, termed microcosms. Maintained under nearly identical conditions, the replicate microcosms serve as miniature ecosystems which can be subjected to controlled environmental stresses. By comparing the metabolism and population structures of stressed microcosms to those of controls, it is possible to determine the responses of complex functional communities to a variety of stresses.

A major advantage of microcosm research over traditional experiments utilizing single species of organisms in restricted abnormal settings is that the long-term effects of low level pollutants can be examined on communities living in near-normal conditions. A large portion of data from such experiments is directly applicable to prediction of long term effects and may indicate potential areas of concern for follow-on studies. Over the last 5 years, experimentation at the microcosm facility has focused on questions relating to potential pollutants in Navy-used harbors. Some of these studies are summarized below:

a. Effects of Elevated Copper. Major alterations in plant and animal populations occurred after 6 months of treatment even at the low levels of 10 and 100 parts/billion Cu. Several species of marine life that were sensitive to Cu poisoning were identified and a Cu tolerance hierarchy was established among them. After termination of treatment, the communities returned to near control character following 6 months of recovery.

b. Effects of In-Water Hull Cleaning Wastes on Bottom Communities. The effects of Cu-rich hull-cleaning wastes on silt dwelling communities were found to be minimal. However, upon exposure, these organisms were found to take up Cu in tissue at high rates. These results and the high Cu content of sediments treated with hull-cleaning debris indicated that future monitoring programs should properly sample both sediments and infauna.

question was whether the mobilization of heavy metals during dredging resulted in unduly high concentrations in the water. As a T&E of MESC capabilities, the craft was trucked to King's Bay with a full complement of sensors which were operational within a few hours of arrival. Transects of the bay in the next few weeks showed that although the bay was relatively well mixed, the plume of dredge spoil run-off could nevertheless be clearly detected by its high pH and chlorophyll values. Using the in-house-developed trace metal detection capability it was determined that the concentrations of Cu, Zn, Pb, and Cd were not significantly higher in the plume and that the activity of free Cu ion (the Cu component toxic to algae) was lower. A full report is in publication (24).

While the MESC represents a significant, state-of-the-art capability, not all of its functions are required for all tasks. Thus it was decided to investigate the possibility of modularizing the instrumentation and shipping it in discrete units to the field as required. A feasibility study conducted in 1982 showed that individual components of the MESC instrumentation could be packaged in commercially available, weather-resistant containers and shipped to virtually any destination. In the field, they could be used aboard any vessel of opportunity given an adequate power supply. Nevertheless, environmental assessments generally require a significant number of sensors which can determine the dynamics of the body of water as well as the particular pollutant in question. Additionally, a positioning capability is also required. Thus, it was concluded that for most environmental operations the MESC would function more effectively as a complete system.

Marine Environmental Data Base System (MEDBS). Data collection in the field calls for data reduction, analysis, and display. A real-time data acquisition capability has little meaning if the results of the analysis and pertinent conclusions cannot be presented to the requesting EFD or OICC in a reasonable amount of time. For this reason the MEQA program has continually supported the concept of "real-time data analysis" as well as acquisition. Inhouse data handling and analysis capability has been established at the NOSC Marine Sciences Laboratory.

The mission of the data base system is to develop software to analyze, display, and archive environmental data collected during real-time environmental surveys. During real-time environmental surveys, data are collected on the MESC and stored by the MEDAS system. Environmental parameters such as salinity, temperature, pH, etc., are assigned a unique time consisting of Julian date, clock hour, minute, second, and millisecond which corresponds to the actual sampling time. Also, during underway acquisition, a detailed navigational log is kept aboard the MESC. The MESC position is plotted on a navigational chart, using range and bearing fixes from known landmarks. Each fix, and locations between fixes are also assigned times corresponding to "dead reckoning" positions of the MESC.

To date, efforts have used an existing Hewlett-Packard (HP) 1000 minicomputer system with nine-track and cassette tape storage capability to process, display, and archive data. Typically, raw data are read into the system where they are calibrated and stored in a specialized data base designed to store real-time data (25). The data can then be accessed to generate time series as well as other plots of the parameters of interest (26). Draw8 (27), a program for entering and displaying navigational data, is

(3) analysis by AAS with a hydrogen flame following reduction of the organotin compound with sodium borohydride.

The electrochemical technique, while by far the simplest, was also found to be insufficiently sensitive to measure the tributyltinoxide (TBTO) concentrations in seawater expected from the fleet-wide use of organotin AF paints. Thus, the results were reported (19) and the technique was abandoned. Extraction followed by AAS was found to be the most versatile and interference-free method, despite the fact that it was not sensitive enough to measure the expected concentrations in seawater. This method was used extensively to measure organotin compounds in sediments and tissue samples. A report was written describing the technique (20). The uptake and absorption of organotin compounds in the marine environment were also studied using the extraction technique and a report was issued describing those findings (21).

Finally, the hydride reduction method was judged most suitable for the analysis of organotins in seawater because of its greater sensitivity and because it could speciate among the various forms of butyltin. The technique was optimized for routine analysis and it was decided to automate it with the intent of increasing sample throughput, increasing precision, and developing a system suitable for routine, quasi-real-time analysis for the MESC. A special furnace was designed and a computer-controlled instrument is under construction. A patent application has been filed for this device.

Field Survey Methodology

Biological Sampling. A protocol for the rapid assessment of biological communities in bays and harbors was developed based on several years experience estimating environmental impact. A "Guide to Environmental Survey Techniques" was prepared in October 1980 and is currently awaiting revision and updating. Since 1973 a series of monitoring surveys has been conducted at SUBBASE BANGOR, Hood Canal, Washington. The surveys have been conducted to obtain data on the environmental impact of the construction and operation of the Fleet Ballistic Missile Submarine Support Facility (TRIDENT) at the Bangor Annex, Washington (22).

The Marine Environmental Survey Craft (MESC) Program. The MESC program was initiated in 1978 in order to provide a real-time field environmental assessment capability and to properly sample a dynamic environment (7,9). A 38-foot houseboat was obtained and converted into a self-powered laboratory capable of sophisticated analyses (23). The vessel contains a "clean" water sampling system, a regulated power supply, an instrumentation package containing nearly twenty real-time or near real-time environmental sensors and sophisticated data-recording capabilities. A capability for making biological collections or on-board experiments also exists. The MESC is transportable (by truck) and has been used extensively for monitoring estuarine waters on both the east and west coasts. The MESC was used in San Diego Bay and in Charleston, South Carolina, to collect data for a DEIS on the effects of in-situ hull cleaning. Similarly, it was used in San Diego Bay to obtain data on in-situ leach rates of AF paints.

Recently the MESC was used to make an environmental survey of NSSB, King's Bay, Georgia, in order to determine if continued dredging and dredge spoil run-off was significantly affecting water quality in the bay. The basic

51. Environmental Assessment, Chollas Creek, NAVSTA San Diego, 1983

An environmental assessment was prepared for maintenance dredging at Chollas Creek, NAVSTA San Diego. Grain size analyses were conducted to justify adding this area to the Med-Moor dredging project without additional bioassays. This was rejected and a bioassay was later conducted.

52. Sediment Bioassays, Supply Pier, NAVSUPCEN San Diego, 1983

NOSC conducted sediment bioassays to obtain a maintenance dredging permit for the Pier 11 Supply Pier, Naval Supply Center, San Diego.

53. Sediment Bioassay, Chollas Creek, NAVSTA San Diego, 1984

EPA and the COE rejected the NAVY proposal to include Chollas Creek in a permit for Med-Moor dredging. NOSC successfully completed a bioassay and draft report within 45 days and negotiated with EPA and the COE to obtain a permit within 1 week of receiving the report. Although the dredging contractor was 1 month ahead of schedule, NOSC expedited environmental documentation to keep up with the dredging contractor. The project was completed ahead of schedule at no additional cost to the Navy.

54. Sediment Bioassay, Pier Extension, SUBASE, San Diego, 1984

A sediment bioassay was performed to obtain a permit for construction dredging to accommodate a floating drydock at Naval Submarine Base, San Diego.

55. Sediment Bioassay, Seawall Construction, SUBASE, San Diego, 1984

NOSC conducted a sediment bioassay for a maintenance and construction dredging permit for MILCON Project P-062 at Naval Submarine Base, San Diego.

56. Sediment Bioassay, Deperming Pier, NAVSTA San Diego, 1984

A sediment bioassay was conducted to obtain a permit for maintenance and construction dredging at the Deperming Pier, Naval Station, San Diego, MILCON Project P-004.

57. Sediment Bioassay, Commercial Basin, San Diego Bay, 1984

NOSC successfully completed a bioassay on sediments from commercial basins, to determine if sediments containing organotins can qualify for ocean disposal after dredging. Sediment contaminated with organotins is not as toxic as originally presumed. This information was used in the Environmental Assessment for Fleet Implementation of organotin antifoulant coatings.

58. Southern California Acoustic Range, San Clemente Island, 1984

The environmental documentation for construction and implementation of an Underwater Acoustic Range at San Clemente Island was prepared. NOSC assisted WESDIV in liaison with regulatory agencies for this NAVAIR project.

59. Emergency Dredging, NAS North Island, 1984

NOSC represented Naval Air Station at meetings with the COE on emergency dredging of the carrier berths. WESDIV was assisted by preparing an Environmental Assessment Addendum and analyzing sediment samples for contaminants. The documentation was prepared in 1 day and the analyses conducted in 1 week to expedite processing the permit application. A permit was obtained 1 week after NOSC submitted the chemical data.

60. Environmental Assessment, Amphibious Loadout Facility, NAVSTA San Diego, 1984

A Preliminary Environmental Assessment (PEA) and Coastal Consistency Determination (CCD) were prepared for an amphibious loadout facility at NAVSTA San Diego.

61. Sediment Bioassay, Fuel Pier, NAVSUPCEN, San Diego, 1984

A bioassay was conducted on sediment from the vicinity of the Fuel Pier, NAVSUPCEN, San Diego Bay. Results from this bioassay will be used to obtain a maintenance dredging permit.

62. Sediment Bioassay, Main Channel, San Diego Bay, 1984

A sediment bioassay was successfully conducted to obtain a permit for maintenance and construction dredging in the main channel, San Diego Bay (MILCON Project P-283). Dredging is to include the area south of the Coronado Bridge to the north side of Pier 8, NAVSTA, San Diego. In addition, the approaches to Piers 2, 7, and 8 are also to be dredged. An Environmental Assessment and a Coastal Consistency Determination were also prepared for the project.

63. Environmental Assessment, Degaussing Facility, NAVSTA, San Diego, 1984

A Preliminary Environmental Assessment (PEA) and Coastal Consistency Determination (CCD) were prepared for the Degaussing Facility, NAVSTA San Diego.

APPENDIX C

PUBLICATIONS

1. Clavell, C. and A. Zirino, "Computer-Controlled Anodic Stripping Voltammetry for the Measurement of Trace Metals in Seawater." In Press in "Mapping Strategies in Chemical Oceanography," Zirino, A. (ed), Advances in Chemistry, Series #209, American Chem Society, Washington, D.C. 1985.

2. Clavell, C., "Microcomputer-Assisted Flow-Through Anodic Stripping Voltammetry System." NOSC TR 532 (September 1979).

3. Clavell, C., "Spinning Disc Electrical Isolator." U.S. Patent #4097680, 22 June 1978.

4. Zirino, A., S. H. Lieberman, and C. Clavell, 1978. Measurement of Cu and Zn in San Diego Bay. Envir. Sci. & Tech., 12, 73-79.

5. Kenis, P., A. Zirino, and C. Clavell, "Automated Anodic Stripping Voltammetry for the Analysis of Cu, Zn, Pb, and Cd for Environmental Monitoring." NOSC TR 243. June 1978.

6. Zirino, A., P. F. Seligman, C. Clavell, and S. P. Kounaves, "Measurements in the Upper 100m" in Proceeding of the "Marine Chemistry into the Eighties" Symposium, Victoria, B.C., 31 May 1979, (1981).

7. Zirino, A., C. Clavell, and P. F. Seligman, Real-Time Measurements in Chemical Oceanography. Naval Research Reviews, June 1978.

8. Clavell, C., J. Salwitz, "Marine Environmental Data Acquisition System," NOSC TM 458.

9. Zirino, A., J. D. Hightower, "Real-Time Marine Environmental Survey Techniques" in Proceedings of the 11th Meeting U.S.-Japan Marine Facilities Panel, Tokyo, Japan, May 1983 (1983).

10. Lieberman, S. H., G. D. Gilbert, P. F. Seligman, and A. W. Dibelka, Relationship Between Chlorophyll a Fluorescence and Underwater Light Transmission in Coastal Waters off Southern California, Deep Sea Research, 31:2 pp 171-180.

11. Zirino, A., S. P. Kounaves, 1977. Anodic Stripping Peak Currents — Electrolysis Potential Relationships for Reversible Systems. Anal. Chem., 49, 56-59.

12. Kounaves, S. P., A. Zirino, 1979. Studies of Cd-Ethylene-diamine Complexation in Seawater by Computer Assisted Stripping Polarography. Anal. Chim. Acta, 109, 322-339.

13. Zirino, A., S. P. Kounaves, 1980. Stripping Polarography and the Reduction of Cu(II) in Seawater at the Hanging Mercury Electrode. Anal. Chim. Acta 113, 79-80.

14. Zirino, A., 1981. "The Voltammetry of Natural Seawater" in Marine Electrochemistry, M. Whitfield and D. Jagner, Eds. Wiley-Interscience, New York, 1981, 81 pp.

15. Zirino, A., P. F. Seligman, 1981. Polarographic Behavior of the Cu Ion Selective Electrode. Marine Chemistry 10, 249-255.

16. Simpson, J. J., A. Zirino, 1980. Biological Control of pH in the Peruvian Upwelling System." Deep Sea Research, 27, 733-744.

17. Zirino, A., C. Clavell, P. F. Seligman, R. T. Barber, 1983. Cu and pH in the Surface Waters of the Eastern Tropical Pacific Ocean and the Peruvian Upwelling System. Marine Chemistry, 12, 25-42.

18. Zirino, A., S. H. Lieberman, 1984. pH Temperature Relationships in the Gulf of California. Advances in Chemistry (In Press).

19. Kenis, P., A. Zirino, 1983. Quantitative Measurement of Tributyltinoxide in Seawater by Differential Pulse Anodic Stripping Voltammetry. Analytica Chimica Acta, 149, 157-166.

20. Homer, V., C. Dooley,. "Quantification of Tin and Organotin in Seawater, Sediments and Biological Materials by Graphite Furnace Atomic Absorbtion Spectroscopy," NOSC TR 918, September 1983.

21. Dooley, C., V. Homer, 1983. "Organotin Compounds in the Marine Environment: Uptake and Sorption Bahavior," NOSC TR 917, September 1983.

22. Grovhoug, J. G., "Trident Biological Surveys: Naval Submarine Base Bangor, Washington (1979, 1980, & 1981) Summary Report (Supplement 3 to NUC TP 510)," NOSC TR 837, 15 September 1982.

23. Zirino, A. and P. F. Seligman. "MESC: The MESC Program for Marine Environmental Quality Assessment," NOSC TD 383, September 1980.

24. Bower, D. R., "Environmental Survey, Kings Bay, GA. October 1982," CSC Final Report, Contract #N66001-83-D-0043, Delivery Order 044, August 1984.

25. Bower, D. R., "Marine Environmental Data Base (MEDB): Description and Implementation of New Structure and Management," CSC Final Report, Contract # N66001-83-D-0043, Delivery Order 005, April 84.

26. Bower, D. R., "MEDBM (Marine Environmental Data Base and Management) Installation and Operations Manual," CSC Final Report, Contract #N66001-83-D-0043, Delivery Order 028, June 1984.

27. Johnston, R. K.,. "Program DRAW8 User's Manual: A Program for Entering and Displaying Navigational Data for the Marine Environmental Data Base System." NOSC TD 559, January 1983.

28. Henderson, R. S., S. V. Smith, E. C. Evans,. "Flow-through Microcosm for Simulation of Marine Ecosystems: Development and Intercomparison of Open Coast and Bay Facilities." Naval Undersea Center, TP 519, October 1976.

29. Evans, E. C., 1976. "Microcosm Responses to Environmental Perturbants." In Proceedings of the 6th International Helgoland Symposium.

30. Grovhoug, J. G. "A Preliminary Evaluation of Environmental Indicator Systems in Hawaii." Naval Undersea Center, TN 1689, January 1976.*

31. Evans, E. C., R. S. Henderson, 1977. "Elutriator/microcosm System: Pilot Model and Test." EPA-600/3-77-093. Environ. Prot. Ag. NTIS Pub.

32. Henderson, R. S., S. V. Smith. "Flow-through Microcosms for Simulation of Marine Ecosystems: Changes in Biota and Oxygen Production of Semitropical Benthic Communities in Response to Nutrient Enrichment." NOSC TR 310, 16 October 1978.

33. Henderson, R. S. and S. V. Smith, 1980. "Semitropical Marine Microcosms: Facility Design and an Elevated Nutrient Effects Experiment." In Microcosms in Ecological Research, J. P. Giesy, Jr. Ed., U.S. Dept. of Energy Symposium, Series 52 (CONF-781101), pp. 869-910.

34. Henderson, R. S., 1981. "In-situ and Microcosm Studies of Diel Metabolism of Reef Flat Communities." In Proceedings of the 4th International Coral Reef Symposium, Manila, Vol. 2, pp. 697-686.

35. Henderson, R. S., 1983. Benthic Metabolism as an Environmental Quality Indicator. Manuscript submitted to Bulletin of Environmental Pollution.

36. Steinert, S. A., G. V. Pickwell, 1984. Quantitative Determination of Lysozyme in the Hemolymph of Mytilus Edulis by Enzyme-Linked Immunosorbent Assay (ELISA). Mar. Envir. Res. 14(1984), pp 229-243.

37. Pickwell, G. V., S. A. Sterinert, 1984. Serum Biochemical and Cellular Responses to Experimental Cupric Ion Challenge in Mussels. Mar. Envir. Res. 14(1984), pp 245-265.

38. Goforth, H. W. Jr.. "The Impact of the Trans-Bay Fuel Pipeline Installation Upon The Eelgrass (Zostera marina) Beds Along Naval Air Station, North Island, California." NOSC TN 903, 15 September 1980.*

39. Goforth, H. W., Jr., S. C. U'Ren. "A Survey of the Spiny Lobster (Panulirus interruptus) Population in San Diego Bay, California — An Impact Study of Pier Construction Activities." NOSC TR 542, April 1980.

40. Meador, J. P., S. C. U'Ren, M. H. Salazar, 1984. A Flow-through Bioassay System for the Evaluation of Organotin AF Compounds. Water Research 18:5, pp 647-650.

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41. Salazar, M. H., S. C. U'Ren, S. A. Steinert. "Sediment Bioassays for NAVSTA San Diego Dredging Project." NOSC TR 570, April 1980.

42. U'Ren, S. C., 1983. Acute Toxicity of Bis(tributyltin) Oxide to a Marine Copepod. Mar. Poll. Bull. 14(8), 303-306.

43. Salazar, S. M., "Toxicity of Aqueous Filmforming Foams to Marine Organisms: Literature Review and Biological Assessment," NOSC TR (in preparation).

APPENDIX D

GLOSSARY

AAS	Atomic Absorption Spectrophotometry
AASV	Automated Anodic Stripping Voltammetry
ACoE	Army Corps of Engineers
AESO	Air Environmental Support Office
AF	Antifouling
AFFF	Aqueous Film Forming Foams
BIOFIX	Biochemical Field Investigation of Toxicity
BL	Bioassay Laboratory
Cd	Cadmium
CEIS	Candidate Environmental Impact Statement
COE	Corps of Engineers
Cu	Copper
DEIS	Draft Environmental Impact Statement
EFD	Engineering Field Division (NAVFAC)
EIS	Environmental Impact Statement
EPA	Environmental Protection Agency
ELISA	Enzyme-linked Immunosorbent Assay
FBM	Fleet Ballistic Missile (TRIDENT Base)
FSF	Field Support Function
GC/MS	Gas Chromatogrophy/Mass Spectrometry
HPLC	High Performance Liquid Chromatography
IDR	Initial Decision Report
ILS	Integrated Logistics Support
IR/IED	Independent Research/Independent Exploratory Development

ISASODS	Interagency Scientific Advisory Subcommittee on Ocean Dredging and Spoiling
ISE	Ion Selective Electrodes
ISF	Information Support Function
MEDAS	Marine Environmental Data Acquisition System
MEDBS	Marine Environmental Data Base System
MEQA	Marine Environmental Quality Assessment
MESC	Marine Environmental Survey Craft
MESO	Marine Environmental Support Office
MFO	Mixed Function Oxygenase
MILCON	Military Construction
MILNET	Military Network
MOU	Memorandum of Understanding
NATO	North Atlantic Treaty Organization
NAVFAC	Naval Facilities Engineering Command
NAVMAT	Naval Material Command
NAVSEA	Naval Sea Systems Command
NBS	National Bureau of Standards
NEPA	National Environmental Policy Act
NEPSS	Naval Environmental Protection Support Service
NNPU	Naval Nuclear Power Unit
NRDB	Natural Resources Data Base
NSRDC	Naval Ship Research and Development Center
NSSB	Naval Submarine Support Base
OESO	Ordnance Envonmental Support Office
OICC	Office In Charge of Construction
OM&N	Operation and Maintenance, Navy

ONR	Office of Naval Research
OPNAV	Chief of Naval Operations
O-tin	Organotin
O/W	Oil/Water Separator
Pb	Lead
PE	Program Element
PET	Portable Environmental Test
PM	Program Manager
POL	Petroleum, Oil, Lubricants
RTAPS	Real-Time Acquisition & Processing System
RTG	Radioisotope Thermoelectric Generators
SESO	Ship Environmental Support Office
SSF	Submarine Support Facility
Sn	Tin
TBTO	Tributyltinoxide
TR	Technical Report
Zn	Zinc

APPENDIX E

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