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TECHNICAL MEMORANDUM

(TM Series)

This document was produced by SDC in performance of contract N00014-67-C-0559.

VOLUME ONE

PHASE I FINAL REPORT

NATIONAL DATA PROGRAM FOR THE MARINE ENVIRONMENT

1 DECEMBER 1967
(Revised)

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This study was sponsored by the National Council on Marine Resources and Engineering Development under Office of Naval Research Contract Number N00014-67-C-0559 and Contract Authority Identification Number ONR:620:FDL

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ABSTRACT

This report documents the Phase I Study of the National Data Program for the Marine Environment. This study was sponsored by the National Council on Marine Resources and Engineering Development. The end product of Phase I is a Study Approach for Phase II. In support of this approach, findings were derived from:

1. A review and analysis of the findings and recommendations of pertinent prior studies. Twenty-seven documents were reviewed.
2. A survey of the relevant literature on the informational structure, storage and retrieval, and reduction to useful forms of marine information. Four hundred and thirty-nine documents were surveyed.
3. A collation of the plans of selected agencies for the development of improved marine data handling capability. Seventeen plans were reviewed.

Additional Phase I activities were as follows:

1. A questionnaire was developed to assess the size and characteristics of the marine data problem.
2. Interviews were conducted with:

   75 persons in 28 Federal Agencies.

   20 persons in six Scientific Institutions.

   10 persons in seven Regional Authorities and in Industry.

   These interviews included organizations whose activities spanned the entire spectrum of marine data functions; collection, processing, storage and retrieval, dissemination and use.
3. A detailed methodology was developed for structuring the Phase II design efforts. This methodology was applied during Phase I for the preliminary analysis of:
   - National Marine Science Program Objectives
   - Functional Requirements
   - Data Program Requirements
   - Constraints
   - Effectiveness Analysis of Data Programs
   - Cost/Benefit/Effectiveness Analysis of Data Programs
   - Data System Requirements

ACKNOWLEDGEMENTS

The assistance and advice of all of the organizations participating in this study are gratefully acknowledged. In particular we acknowledge the continuing advice and counsel provided throughout the study by the Data Management Advisory Panel (DMAP), whose members are representatives of the federal agencies involved in the marine sciences; and Mr. John Fry, Scientific Officer, and Mr. Boyd Ladd, both of the National Marine Council Staff.

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"This study was financed by a contract with the National Council on Marine Resources and Engineering Development. However, the findings, recommendations and opinions in the Reports are those of the contractor and not necessarily those of the Council, nor do they imply any future Council study, recommendations or position. However, it is hoped that this study will contribute to the full discussion of problem areas and issues in marine science affairs."

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I. INTRODUCTION

A. STATEMENT OF THE PROBLEM

1. Purpose

This report is submitted in fulfillment of the requirements of a study for a National Data Program for the Marine Environment which was sponsored by the National Council on Marine Resources and Engineering Development under Office of Naval Research Contract N00014-67-C-0559. The Phase I study covered by this report is a Project Definition Phase conducted in order to survey the problem and structure a Study Approach for Phase II, the actual System Analysis and Design phase. The objectives of this Phase I study as specified in the contract are as follows:

a. Produce a Study Approach for Phase II.

b. In support of this approach, report the findings derived from:

   1) Reviewing and analyzing the findings and recommendations of pertinent prior studies.

   2) Surveying the relevant literature of the informational structure, storage and retrieval, and reduction to useful forms of marine information.

   3) Collating the plans of selected agencies for the development of improved ocean data handling capability.

2. Background

In response to growing recognition of the importance of the marine environment to the nation as a whole, Congress passed the Marine Resources and Engineering Development Act of 1966 which contains the following statements of national marine objectives:

a. The accelerated development of the resources of the marine environment.

b. The expansion of human knowledge of the marine environment.

c. The encouragement of private investment enterprise in exploration, technological development, marine commerce, and economic utilization of the resources of the marine environment.

d. The preservation of the role of the United States as a leader in marine science and resource development.

e. The advancement of education and training in marine science.

f. The development and improvement of the capabilities, performance, use, and efficiency of vehicles, equipment, and instruments for use in exploration, research, surveys, the recovery of resources, and the transmission of energy in the marine environment.

g. The effective utilization of the scientific and engineering resources of the Nation, with close cooperation among all interested agencies, public and private, in order to avoid unnecessary duplication of effort, facilities, and equipment, or waste.

h. The cooperation by the United States with other nations and groups of nations and international organizations in marine science activities, when such cooperation is in the national interest.

In concert, the Administration executed a number of vital actions including creation at Cabinet level of the National Council on Marine Resources and Engineering Development. The Council in turn defined the rationale for this study of the data management needs of the marine environment in "Marine Science Affairs - A Year of Transition."[1] (DN125)* This Presidential report makes the following points relevant to marine data management:

a. Critical Problems

1) "Studies have shown evidence of previous deficiencies in the Nation's marine data handling; delays in filing; archaic handling methods; lack of critical evaluation and inadequate identification of purpose."

2) "The exploration of the oceans has been a somewhat random and often uncoordinated process. There has never been widespread agreement among the marine science

1. "Marine Science Affairs - A Year of Transition." The First Report of the President to the Congress on Marine Resources and Engineering Development, February 1967, Chapter VII.

* Throughout this report Document Numbers (DN--) refer to the Bibliography.

community, as there is in some other fields, as to data handling procedures and standards with the result that materials are not as coherent and systematic as we now desire. In the meantime, technology now makes it possible to accumulate data at a vastly faster rate."

3) "As the problems to be solved become more complex, global in scope, and multidisciplinary in content, the data consumers will be less able to produce their own raw materials and will become more dependent on the work of others. To prevent unnecessary and costly duplication in the data collection - the most costly part of marine sciences - collected data should be readily available to all users consistent with the need for national security."

b. Objectives

1) "Any future system to improve the management of data should deal in one consistent way with data from its source through authentication, indexing, filing and retrieval. Such a system involves not only the data commodity itself, but intimately involves the variety of private and public users and contributors, the information handling organizations, and administrative and support activities."

2) "When we refer to system, incidentally, we do not necessarily anticipate a centralized operation, but include the articulation of a number of specialized data centers appropriately linked and meeting quality standards."

The above description of problem areas provides a basis for delineating a number of specific items which require attention in developing a National Marine Data program:

- Incomplete identification of the multiple purposes and technical requirements of data collection.
- Inadequate quality control and critical evaluation of collected data.
- Excessive delays in the "data transmission" system, i.e., extensive delays between collection and availability of data to the marine community as a whole.
- Inefficient data collection and handling methods.

- Lack of agreement on data handling procedures and standards, thus seriously limiting data flow among marine science organizations.
- Inadequate correlation of data in space and time and lack of selective data retrieval by geographical area, depth, or other criteria.
- Impending rapid growth in data collection volume arising from expanded airborne, spaceborne, and surface collection systems with the inevitable impact on an already overloaded data management system.
- The ever widening gap between the actual state of marine data management activities and the potential activities made possible by technological developments in information handling.
- Lack of a coordinated system of data traffic management from point of collection to ultimate use.
- Lack of adequate system cost/benefit/effectiveness information.

Although many problems exist relative to the management of historical and current data, <u>the most critical data problem confronting the marine community is how to manage anticipated increases in data requirements due to new data programs when existing data management facilities are already overtaxed</u>. Examples of developments which are likely to result in sizeable data requirements are a national buoy program, satellite data collection, an increase in the number and scope of ocean surveys, synoptic or real time requirements, and environmental observation and prediction for the purpose of describing and predicting both the state of the oceans and conditions in the atmosphere.

Increasingly, there is a shift from research projects performed in isolation, to projects requiring continuous large scale geographic coverage. A large part of newly collected data will be for environmental prediction and worldwide weather coverage.

Because of the vastness of the world's oceans and the inaccessability of some parts, large gaps exist in oceanographic data. In order to fill some of these data gaps in world wide coverage, programs, such as a national data buoy program, have been proposed (<u>DN83</u>). This study documented the requirements for cooperative buoy programs on a national scale for the next 15 years.

An example of a project providing greater coverage of surface oceanographic data and meteorological data in real time is the Spacecraft Oceanography Project of NAVOCEANO and NASA (DN430).

The World Weather Watch is under development to provide global data for improved short-term weather forecasting, long-range weather prediction, and research on climate and weather modification. Although the World Weather Watch is concerned only with meteorological data, it is recognized that the marine community also requires global data. (DN421) (DN423). It is planned to share the facilities of the World Weather Watch with other disciplines, such as oceanography.

A significant aspect of data collection by buoys, aircraft, and satellites is the greater volume of data collected per unit time as compared with the use of older methods. The greater data volume is due to greater geographic coverage and the continuous data collection provided by these platforms. Another aspect is the unattended nature of satellite and buoy data collection. There is no scientist on-site to appraise the quality of data generated, although shore-based observation of data while it is being collected, may be provided in future systems. These features of unmanned platforms will require increased data ingestion and quality control capabilities in data transmission, processing and dissemination.

The increased emphasis on greater geographic coverage and synoptic data reporting, does not, however, mean that ships are outdated as data collection platforms. On the contrary, they remain the best means of collecting sub-surface, bottom and sub-bottom data. Aircraft and satellites are limited essentially to the collection of surface data, although some sub-surface data collection may be developed in time. It is clear that the optimum platform configuration of the future will be a mix of platforms used in amounts consistent with the requirements for data type, volume, quality, response time, geographic coverage and costs.

In summary, the following set of conditions describes the nature of future marine data requirements which need to be accounted for in developing a National Marine Data Program:

- Broader geographic coverage of data collection.
- More synoptic data collection.

- Greater continuity of data collection.
- More unattended data collection.
- Greater use of instruments which record several parameters concurrently.
- Greater integration of marine and meteorological data collection and analysis.
- Greater emphasis on multi-agency and multi-nation cooperative survey programs.
- Greater use of expendable instruments in order to facilitate underway measurements.
- Greater need for standards and quality control to facilitate multi-organization collection and use of data.
- Greater diversity of data types collected.
- Increased data volumes.
- Greater perishability of data because of an increase in real time requirements.
- Greater need for purging criteria due to increased data volumes.
- Greater need for space-time correlation not only for marine data but combinations of marine and meteorological data, as well.

B. STUDY METHODOLOGY

The basic methodology employed in the conduct of this program is the "systems approach" which is particularly adapted to large technical systems problems which cross numerous jurisdictional boundaries and involve interactions between many organizational levels and disciplines. It is clear that the marine sciences data management problem exhibits all of these characteristics.

While the application of the full systems approach awaits Phase II, some of its concepts were employed during Phase I. This step enabled the early assessment of the general size and shape of the problem and thereby the structuring of a realistic Phase II Study Approach.

Specifically, preliminary assessments were made of several key marine data organizations and some immediate results were obtained. A number of action recommendations are therefore included in this report in order to highlight several high payoff areas which appear amenable to short term improvements.

1. Definition of Terms

In order to provide continuity between Phase I and Phase II in the design of a National Marine Data Program, an approach has been developed which encompasses both Phase I and Phase II activities. Before describing the methodology, certain terms which are basic to the approach and which are used throughout this report are defined below:

a. National Marine Science Programs: Marine activities as defined in "Marine Science Affairs - A Year of Transition" (e.g., National Security, Food from the Sea).

b. National Marine Data Program: A future integrated and coordinated system of collection, storage, processing, and dissemination of marine data in support of the National Marine Science Programs.

c. Functional Requirements: The requirements for activities performed by organizations in support of the National Marine Science Programs.

d. Data Programs: The totality of data requirements for a given national marine science program such as Food from the Sea. The data requirements consist of the needs for collection, storage, and processing and dissemination of data.

e. Data System: A system, consisting of people, procedures, hardware, software, instrumentation, and communications equipment for implementing a data program.

f. Data Management System: Synonymous with data system.

2. Marine Data Problem Evolution

A graphical portrayal of the evolution of the marine data problem appears in Figure 1. This logic flow shows the definition of National Marine Science Programs flowing from both the Marine Council level and the agencies upward to national planners. Most national programs actually evolve from the line organizations and information flows upward to national planners and policy makers. The planners synthesize this information and develop as national policy a set of goals from a composite of the information provided by the agencies.

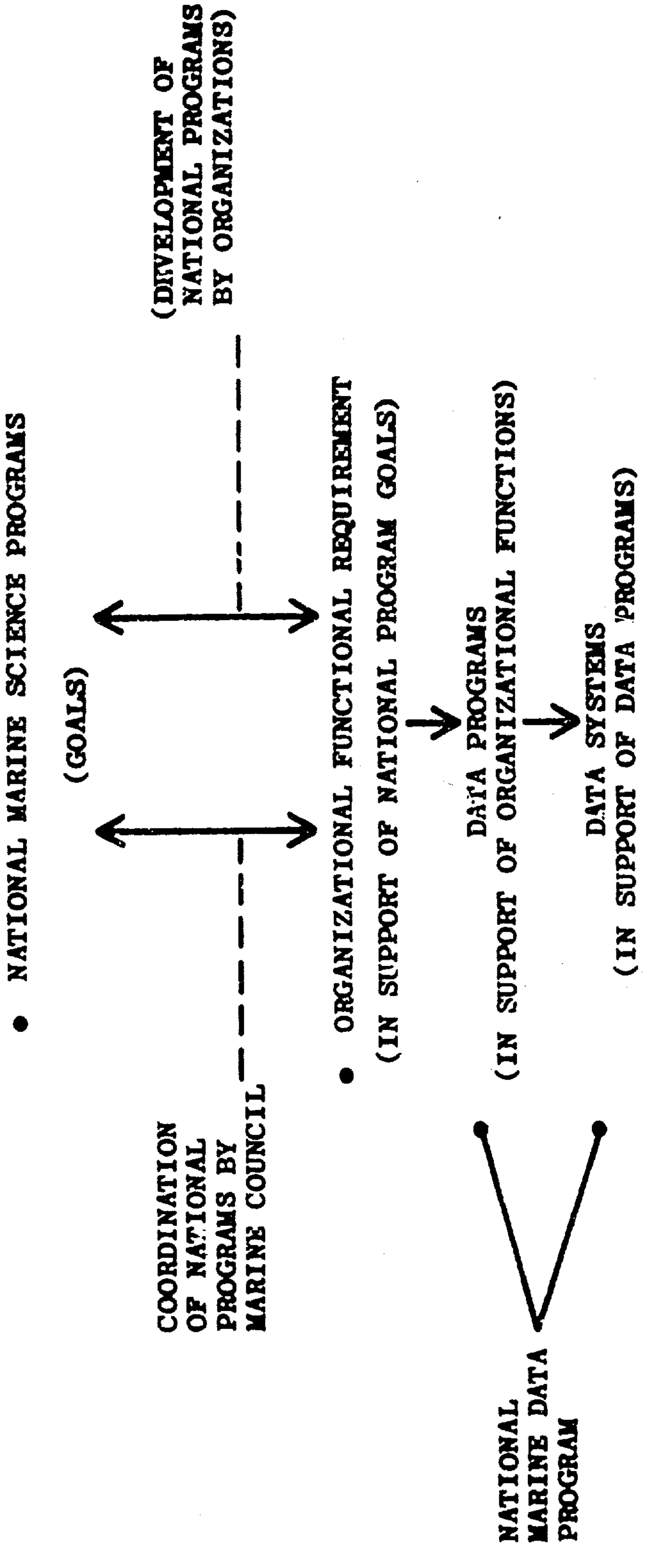
National goals form the basis for the conduct of organization functions. For example, the Coast Guard performs the function of determining and monitoring the occurrence and movement of sea ice in relation to navigational safety in response to the national program of environmental observation and prediction.

Data programs are derived from the functions performed by each organization. Continuing the above example, the collection of sea ice data by the Coast Guard Ice Patrol is an example of a data program.

The marine data problem evolution, from National Marine Science Programs through Data Programs, represents the components of the problem, as indicated in the figure. Data programs are independent of means of implementation. Data systems, however, are the alternative mechanisms for implementing the requirements of data programs. The data systems consist of the personnel, procedures, hardware and software which are required in order to collect, store, process, and disseminate data resulting from data programs.

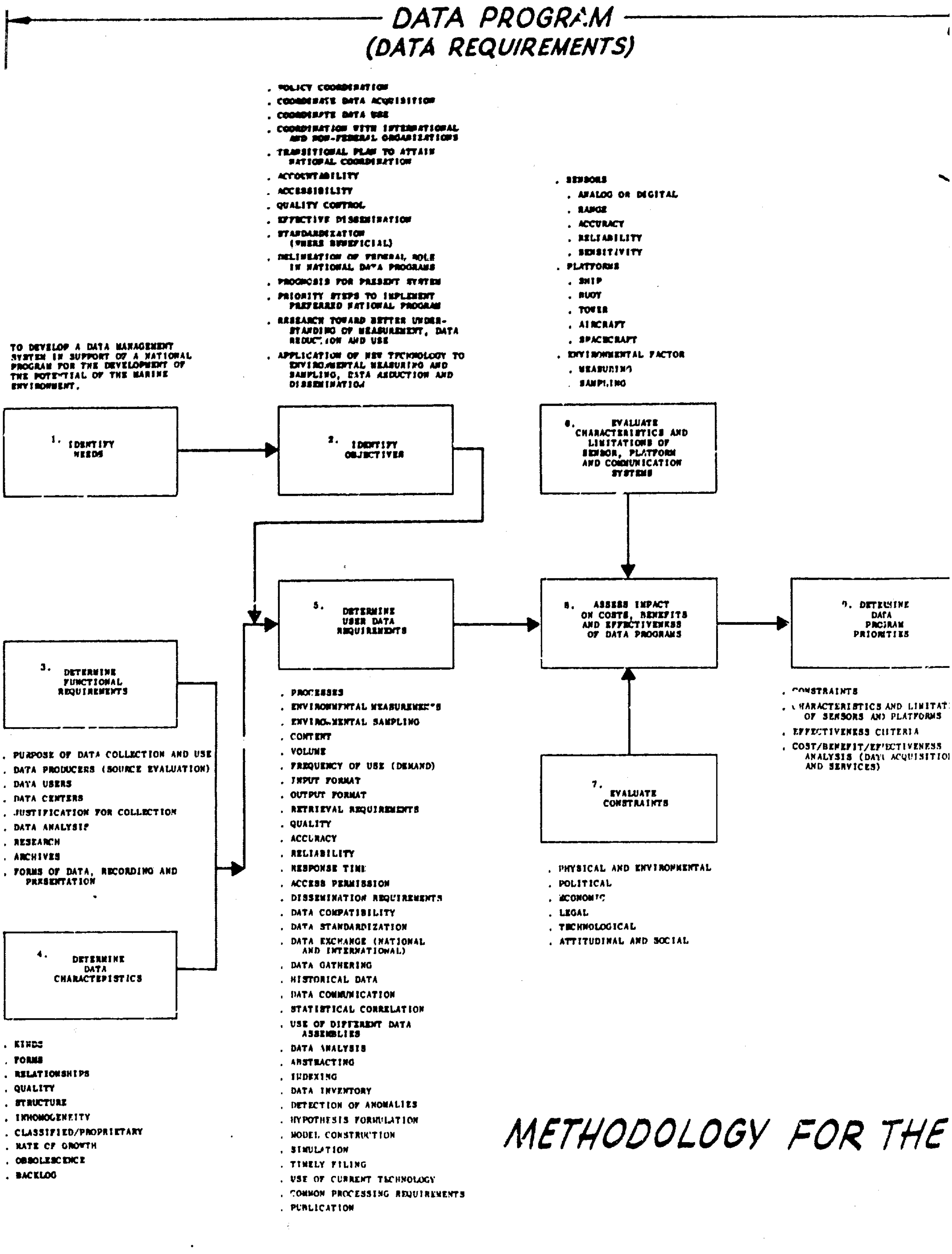
3. System Engineering and Relationship to RFP

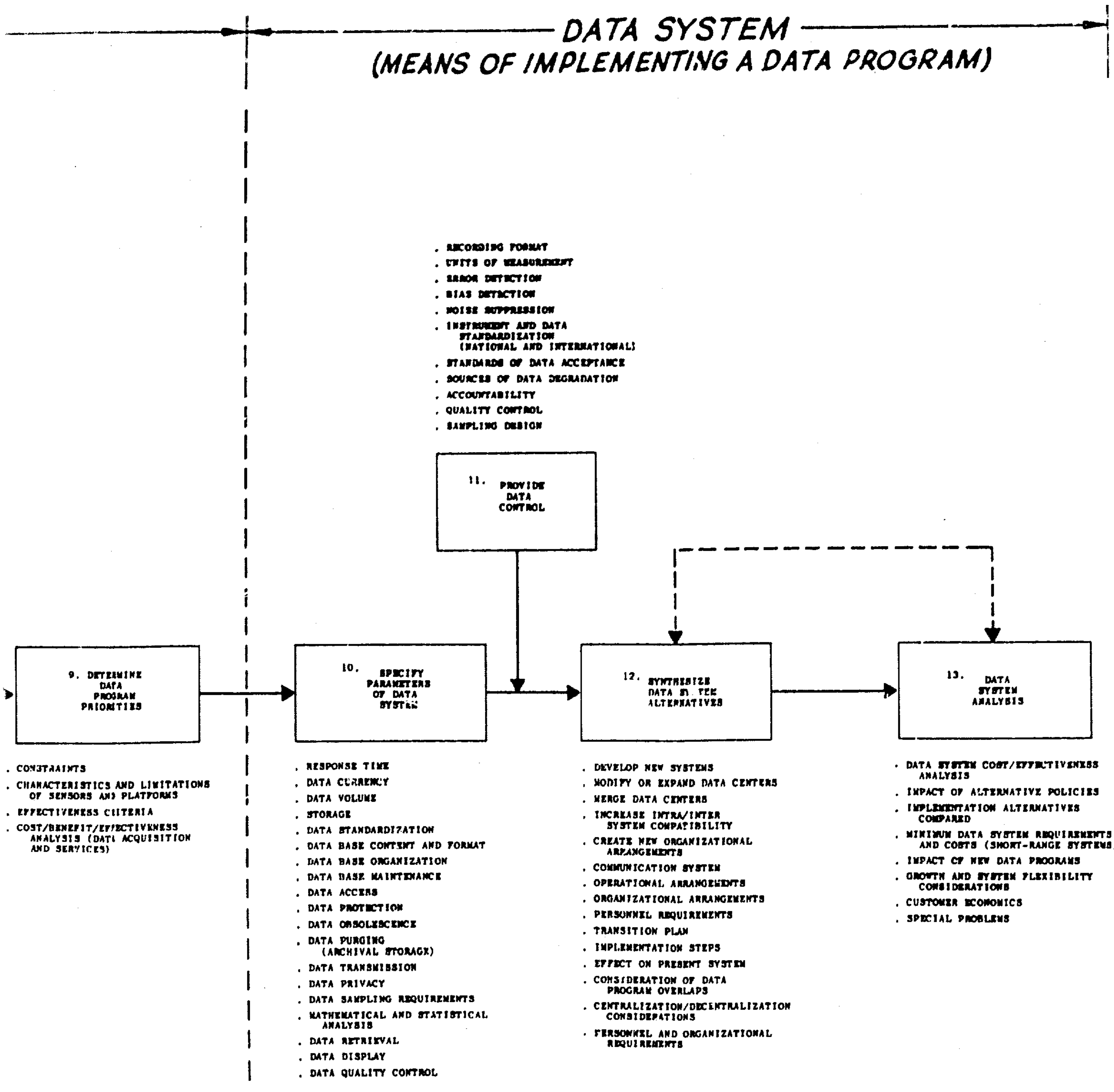
A flow chart of a methodology for the Design of a National Marine Data Program is shown in Figure 2. Relevant portions of this methodology have been employed during Phase I. The use of this approach will continue during Phase II. Key items from the RFP are associated with the relevant steps of the methodology. A description of the relationship between the requirements of the marine data problem and the steps in the approach follows:



MARINE DATA PROBLEM EVOLUTION

FIGURE 1


DATA PROGRAM
(DATA REQUIREMENTS)
TO DEVELOP A DATA MANAGEMENT SYSTEM IN SUPPORT OF A NATIONAL PROGRAM FOR THE DEVELOPMENT OF THE POTENTIAL OF THE MARINE ENVIRONMENT.
1. IDENTIFY NEEDS
. POLICY COORDINATION
. COORDINATE DATA ACQUISITION
. COORDINATE DATA USE
. COORDINATION WITH INTERNATIONAL AND NON-FEDERAL ORGANIZATIONS
. TRANSITIONAL PLAN TO ATTAIN NATIONAL COORDINATION
. ACCOUNTABILITY
. ACCESSIBILITY
. QUALITY CONTROL
. EFFECTIVE DISSEMINATION
. STANDARDIZATION (WHERE BENEFICIAL)
. DELINEATION OF FEDERAL ROLE IN NATIONAL DATA PROGRAMS
. PROGNOSIS FOR PRESENT SYSTEM
. PRIORITY STEPS TO IMPLEMENT PREFERRED NATIONAL PROGRAM
. RESEARCH TOWARD BETTER UNDERSTANDING OF MEASUREMENT, DATA REDUCTION AND USE
. APPLICATION OF NEW TECHNOLOGY TO ENVIRONMENTAL MEASURING AND SAMPLING, DATA REDUCTION AND DISSEMINATION
2. IDENTIFY OBJECTIVES
. SENSORS
. ANALOG OR DIGITAL
. RANGE
. ACCURACY
. RELIABILITY
. SENSITIVITY
. PLATFORMS
. SHIP
. BUOY
. TOWER
. AIRCRAFT
. SPACECRAFT
. ENVIRONMENTAL FACTOR
. MEASURING
. SAMPLING
6. EVALUATE CHARACTERISTICS AND LIMITATIONS OF SENSOR, PLATFORM AND COMMUNICATION SYSTEMS
3. DETERMINE FUNCTIONAL REQUIREMENTS
. PURPOSE OF DATA COLLECTION AND USE
. DATA PRODUCERS (SOURCE EVALUATION)
. DATA USERS
. DATA CENTERS
. JUSTIFICATION FOR COLLECTION
. DATA ANALYSIS
. RESEARCH
. ARCHIVES
. FORMS OF DATA, RECORDING AND PRESENTATION
4. DETERMINE DATA CHARACTERISTICS
. KINDS
. FORMS
. RELATIONSHIPS
. QUALITY
. STRUCTURE
. INHOMOGENEITY
. CLASSIFIED/PROPRIETARY
. RATE OF GROWTH
. OBSOLESCENCE
. BACKLOG
5. DETERMINE USER DATA REQUIREMENTS
. PROCESSES
. ENVIRONMENTAL MEASUREMENTS
. ENVIRONMENTAL SAMPLING
. CONTENT
. VOLUME
. FREQUENCY OF USE (DEMAND)
. INPUT FORMAT
. OUTPUT FORMAT
. RETRIEVAL REQUIREMENTS
. QUALITY
. ACCURACY
. RELIABILITY
. RESPONSE TIME
. ACCESS PERMISSION
. DISSEMINATION REQUIREMENTS
. DATA COMPATIBILITY
. DATA STANDARDIZATION
. DATA EXCHANGE (NATIONAL AND INTERNATIONAL)
. DATA GATHERING
. HISTORICAL DATA
. DATA COMMUNICATION
. STATISTICAL CORRELATION
. USE OF DIFFERENT DATA ASSEMBLIES
. DATA ANALYSIS
. ABSTRACTING
. INDEXING
. DATA INVENTORY
. DETECTION OF ANOMALIES
. HYPOTHESIS FORMULATION
. MODEL CONSTRUCTION
. SIMULATION
. TIMELY FILING
. USE OF CURRENT TECHNOLOGY
. COMMON PROCESSING REQUIREMENTS
. PUBLICATION
8. ASSESS IMPACT ON COSTS, BENEFITS AND EFFECTIVENESS OF DATA PROGRAMS
7. EVALUATE CONSTRAINTS
. PHYSICAL AND ENVIRONMENTAL
. POLITICAL
. ECONOMIC
. LEGAL
. TECHNOLOGICAL
. ATTITUDINAL AND SOCIAL
9. DETERMINE DATA PROGRAM PRIORITIES
. CONSTRAINTS
. CHARACTERISTICS AND LIMITAT
OF SENSORS AND PLATFORMS
. EFFECTIVENESS CRITERIA
. COST/BENEFIT/EFFECTIVENESS ANALYSIS (DATA ACQUISITIO
AND SERVICES)
METHODOLOGY FOR THE



FOR THE DESIGN OF A NATIONAL MARINE DATA PROGRAM

FIGURE 2

a. Identify Needs (Step 1)

Identify the fundamental need for the data management study. As indicated in the figure, the key facets of this need are embodied in the words "system," "support," "National," "development" and "potential," i.e., the marine data program is to be designed to support national objectives. The overall national objective is the development of the potential of the marine environment. The implication for data management in this statement is that the data management system must be geared to support programs which develop and more fully utilize the potential of the marine environment. This mission requires that the data management system support: (1) research, e.g., water pollution studies, (2) operations, e.g., water pollution control and (3) planning, e.g., evaluation of water pollution control programs and planning for implementation.

b. Identify Objectives (Step 2)

A delineation of data program objectives, which if achieved, will fully support the National Marine Science Program needs, e.g., coordinate data collection from multi-organization ocean surveys in order that a greater number of users and user needs may be satisfied. By making more and better data products available to more data users, such as researchers and resource managers, the possibilities for developing the potential of the marine environment are enhanced.

c. Determine Functional Requirements (Step 3)

Identify the activities of marine science organizations which have data requirements. The three major functions are data collection, data centers and data users. Within these categories are functions related to national programs. Examples are:

- Ocean surveys by NAVOCEANO in support of the National Security Program.
- Prediction and control of man-made radioactivity on the marine environment by AEC in support of the Marine Pollution Abatement and Control Program.

d. Determine Data Characteristics (Step 4)

Determine the characteristics of marine data required. Examples are:

- Kind: Chemical
- Type: Salinity
- Forms: Analog
- Relationships: Salinity, temperature, depth charts.

e. Determine User Data Requirements (Step 5)

Determine the requirements which users have for data in order to carry out their functions, e.g., volume, frequency of use, quality of geological data required by the Bureau of Mines in order to locate and identify the magnitude of the mineral resources of the ocean. This activity comprises the definition of data programs. A data program is the specification of the data collection, storage, processing and dissemination requirements for a national marine science program. Some data programs span several agencies, e.g., the Navy and Coast and Geodetic Survey are involved in mapping and charting. Other data programs involve a single agency, e.g., the Corps of Engineers, in-shore and harbor stabilization.

f. Evaluate Characteristics and Limitation of Sensors, Platforms and Communications Systems (Step 6)

Determine modifications in data requirements which result from limitations in recording instruments, platforms and data transmission systems, e.g., limitation in data transmission from ship to shore due to crowded HF bands. This is an example of a data requirement based on objectives of a program, such as transmit weather data at certain times and rates, which becomes constrained in scope due to physical limitations.

g. Evaluate Constraints (Step 7)

Constraints are an additional "filter" through which original data requirements must be passed in order to arrive at the net effectiveness of the data requirements. For example, data requirements will typically be predicated on the objectives of the marine program which the data collection supports and on anticipated funding. If funding is later curtailed, objectives must be modified to conform. A contemporary illustration of this condition is the reduction in ESSA funding for satellite data collection which will retard ESSA's progress in evaluating the collection of environmental data by satellite.

h. Assess Impact on Cost and Effectiveness of Data Program (Step 8)

After the effect of sensor, platform and communications systems limitations have been considered and the impact of other constraints have been assessed, the result of the two filtering processes is a data net program effectiveness. That is, there will remain a program of data collection, storage, processing and dissemination which will be feasible, given the physical limitations and constraints. The purpose of step 8 is to analyze the effectiveness and cost of data programs.

This is not evaluated on the basis of judging the utility of one agency's data program relative to another since this would indirectly involve judgments about the efficacy of the National Marine Sciences Programs which the data activities support. Rather, the evaluation of data programs is based on the effectiveness and cost of the data systems which are required in order to implement data programs, i.e., the effectiveness and cost of the procedures, personnel, hardware and software which constitute a data system. This evaluation must assess not only the current effectiveness and costs of the data system but the future effectiveness and costs as well, since both the data program requirements and the data systems for satisfying those requirements change over time.

i. Determine Data Program Priorities (Step 9)

In determining data program priorities an assessment is made of the requirements for data systems, both present and future, which are needed to implement data programs. This evaluation does not involve the development of detailed specifications for data systems. Rather, it involves the gross assessment of data system characteristics which are required in order to implement data programs. The first step in the evaluation process is the establishment of a set of effectiveness criteria. The effectiveness criteria consist of measures of data system capability such as data retrieval time and storage capacity. An example is the evaluation of the capability of NODC to store and retrieve biological and geological data.

One criterion might be the extent and volume of data which could be distributed to the user community and the time lag between data collection and dissemination to interested parties. This analysis will identify some data programs with superior effectiveness characteristics and others which are marginal; others will fall between these extremes.

The next step in the determination of data program priorities is to apply gross cost estimates to the collection, storage, processing and dissemination elements of data.

Finally, a cost/effectiveness evaluation is made of increments of data system capabilities which are required over time in order to implement data program requirements.

As mentioned under (h) above, the evaluation of data programs does not involve an assessment of their utility. Rather, the cost and effectiveness of data system improvements required to support data programs are evaluated. This analysis is performed in gross terms and does not involve the detailed examination of implementation alternatives. The analysis does not involve consideration of actual information systems. Rather, gross cost estimators are associated with the requirements of data programs in order to arrive at a rank ordering of data programs as a basis for scheduling the implementation of data system improvements.

j. <u>Specify Parameters of Data System</u> (Step 10)

The specification of data system parameters is the process of delineating the characteristics of a data system which are required in order to implement a data program.

After data program priorities have been developed as a result of the cost/effectiveness analysis, the parameters for the required data systems are defined; integrated where multiple data programs are processed by the same data system; and related to the points in time when the various data system characteristics will be required. Parameters consist of characteristics such as storage requirements as a function of time, retrieval time, purging rate, levels of storage required, etc. An example of this phase of the analysis is the determination of the amount of storage, data base organization, data base maintenance, retrieval time, and analysis functions required for the storage and processing of STD and BT data at NODC from the BOMEX program to be conducted during July-August, 1968. Other considerations are the data transmission modes from Navy and Coast Guard survey ships to NODC and the delay between data collection and receipt of data at NODC.

The above is a small sample of the types of data systems parameters which must be considered when planning the implementation of a data program. Where data systems are non-existent, parameters describe the requirements for new systems. Where data systems exist, parameters describe the characteristics of improved systems.

Data system parameters are used as inputs to the synthesis of alternative systems (step 12). It should be noted that the data system parameters are application requirements and not data system characteristics. Data system characteristics are selected on the basis of cost and the degree to which application requirements are satisfied. Consequently, the parameters of the implemented system will differ in either direction from the application parameters depending upon the relationship between cost and effectiveness of data system characteristics.

k. Provide Data Control (Step 11)

Data control involves all those measures which are incorporated in a data system in order to provide the desired degree of data quality. Data quality control measures pertain to all stages of data system operation: collection, storage, processing and dissemination.

Quality control needs to be exercised over data collection activities including instrument reliability, accuracy, precision, units of measurement, methods of calibration and use, and over data transmission modes, processing procedures and data dissemination modes.

An important aspect of the data control problem is to provide information at the time of data dissemination, about the quality of the data collected. This information would include identification of sensors employed, instrument calibration data, units of measurement, recording format, sampling rate, environmental conditions under which measurements are taken and the methods used to transmit data from collection point to processing. This procedure is important in order to provide as much uniformity as possible in the interpretation of disseminated data.

l. Synthesize Data System Alternatives (Step 12)

In system synthesis, alternative data systems are designed. The inputs to this process are data system parameters and data control requirements. Alternatives are devised which are feasible, i.e., systems are devised which satisfy system constraints.

The initial goal of system synthesis is to design workable systems without detailed attention being given to optimizing system performance. Subsequent iterations of the design process "tune" the data system to higher levels of performance. In system synthesis, personnel, hardware, software and communications subsystems are configured to maximize the satisfaction of criteria, within the bounds of cost and other constraints. An example of this process is the design of a shipboard computer system. Effectiveness criteria would be stated in the form of sampling rate, rate of data input, amount and levels of storage, retrieval time, forms of input, data output rate, forms of output, software tools, arithmetic precision, number range, etc. Various possible configurations of shipboard computer systems would be designed to satisfy the above criteria in varying degrees dependent upon the tradeoff functions involved and within the funds available, delivery time and other constraints. The feasible alternatives of shipboard computer systems would be subjected to cost effectiveness analysis of various increments of capability as described in Step 13.

m. Data System Analysis (Step 13)

The purpose of data system analysis is to analyze the effectiveness, costs and other attributes of the systems which are synthesized in Step 12. As shown in Figure 2, there is continual interaction between synthesis and analysis. During analysis the need for revising system designs is illuminated, re-design results in further analysis, etc. Each increment of data system capability is analyzed with respect to its incremental cost. Tradeoff analysis is performed on the various modules of system capability and the most favorable alternatives specified and implementation schedules defined.

An important part of system analysis is the evaluation of the sensitivity of the solution to changes in constraints. For example, would the selection of a system change if more money were made available? Less money? Would the solution change if a new development in instruments occurs. The sensitivity analysis is particularly important when considered over time due to the changes in optimal solution with changes in the system environment. Finally, the complete specification of alternatives, including effectiveness, cost and implementation schedules are presented to the user for his decision.

The foregoing is a short description of the system engineering process as applied to the marine data management problems.

This process was employed in part during Phase I, and it will be continued in Phase II. Owing to the immense organizational and technical complexity of the overall marine program sphere, it should be clear that this systematic process cannot be conducted in great detail rapidly throughout the entire national marine science program. It will be used as a set of operating principles, however, and will thus enable the highlighting of high pay-off areas and the ranking of a step-by-step process of data system evolution which will raise the present loosely connected system to sequentially higher levels of performance.

It is understood that the concepts, problems and approaches described in this report are known to the Data Management Advisory Panel (DMAP) and to other agencies familiar with the marine environment. It is necessary, however, to perform this initial step of integration in the overall planning of the National Marine Data Program in order to provide a common ground or starting point for the contractor and the agencies and organizations involved.

II. SUMMARY

This report section serves to accumulate and summarize briefly the key results of this Phase I Study.

A. PHASE I ACTIVITIES

The following steps were taken during the Phase I Study Period:

1. Project Organization

The project team was organized, briefed and a detailed plan of action was developed. The team consisted of the inter-disciplinary mix of capabilities listed in the left hand column of the following table:

TABLE 1

Allocation of Project Organization Time During Phase I

Project Personnel \ Project Activities	Project Supervision	Data Collection	Data Analysis	Literature and Plans Review	Report Writing	Project Briefings	Liaison
1-Senior Information Systems Scientist	30	5	20	10	20	5	10
1-Oceanographer	-	10	35	20	30	5	-
1-Geophysicist	-	30	15	30	10	5	10
1-Information Systems Designer	-	20	15	10	20	5	30
1-Management Scientist	-	10	30	20	40	-	-

The allocation of time spent on each project activity by the team members was approximately as indicated by the percentages entered in the table.

2. Survey Effort

a. Sample Plan

The actual analysis of the marine science data problem is a task to be performed in Phase II. It was felt highly desirable to conduct a preliminary survey in Phase I, however, in order to clearly establish areas requiring important concentration during Phase II. A sample survey plan was, therefore, developed, and, with the advice and assistance of the Data Management Advisory Panel, it was executed.

b. Organizations Contacted

In accordance with the sampling plan, interviews were conducted with:

- 75 persons in 28 federal agencies
- 20 persons in six scientific institutions and universities
- 10 persons in state, regional authorities and in industry.

These interviews included organizations whose activities spanned the entire spectrum of functions vital to the design of an overall data management system including: collection, processing, storage and retrieval, dissemination and use. In addition, conferences were held with expert consultants in the marine science field. (See Appendix F, Volume II)

c. Questionnaire Design

A questionnaire was developed to fill the need to assess the size and characteristics of the Phase II problem of determining the technical facts regarding the universe of data collectors, processors, storers, disseminators and users. In turn, it was used as the information gathering instrument during all field interviews. Because of this field test, it has now evolved through three revision stages. While the need for additional improvements in the questionnaire is evident, the work accomplished to date will greatly minimize the corresponding Phase II effort. (See Appendix G, Volume II)

d. Other Tools Developed

In addition to the questionnaire, various analytical tools and presentation aids were developed and utilized during

Phase I for the purpose of analyzing the marine data problem. These tools and aids, which will be employed further during Phase II in the design of the National Marine Data Program are listed below:

1) Relationships between objectives, marine science programs and agency missions.

2) Organization budgets for marine science programs.

3) Relationships between missions, functions and data requirements of marine science organizations.

4) Budgets by function for marine science programs.

5) Organization budgets by marine science function.

6) Volume of data collected by international cooperative surveys and individual organizations.

7) Matrix of data flow between organizations.

8) Data flow tables and charts.

9) Organization data characteristics charts showing inputs, storage and outputs.

10) Relationships of organization data processing to national programs and initiatives.

11) Tables listing marine data bases which warrant greater development.

12) Plots of data collection volume as a function of time.

13) Shipboard data generation capabilities.

14) Calculation of cruise data collection rates.

15) Inventory of data files.

16) Constraints relationships matrix.

17) Collation of plans, studies and literature matrix.

18) Coded abstract form suitable for automatic retrieval.

3. Plans, Studies, and Literature Review and Collation

a. Marine Data Management Library

A bibliography of 439 pertinent marine science documents was developed, copies were obtained and indexed, and a working Marine Data Management Library was established. (See Bibliography, Volume I)

b. Plans

The plans of 39 marine science organizations were obtained as documents or by interview, and 17 of the most complete were studied and collated. Areas of agreement expressed in the different plans were determined and organized into key categories from which major conclusions were drawn. (See Section VIII, Volume I and Appendix A of Volume II)

c. Studies and Literature

A total of 27 pertinent prior studies and other elements of the literature covering the data management aspects of marine science were selected, studied, and collated. Areas of agreement were determined and structured into key categories from which major conclusions were drawn. (See Section VIII, Volume I, and Appendices B and C of Volume II)

4. Other Actions

a. Marine Data Base Development

Looking forward to the research support aspects of a National Marine Data Program, a small oceanographic station data base was obtained from NODC covering one and one-half Marsden squares and containing approximately 800 oceanographic stations. The data base was loaded into SDC's Q-32 time-sharing computer. Existing software tools were then used to evaluate the utility to researchers of general purpose graphic display systems operating on randomly retrieved data sets. Instantaneous plots of such variables as temperature vs. depth and correlations of any data in the base such as temperature vs. salinity (T-S) have been achieved. The work suggests the substantial utility of such capability for research support in future systems. (See Appendix D of Volume II)

b. LaJolla Facility

In preparation for Phase II, a facility was opened in LaJolla, California, in order to increase the flow of advice and counsel from the broad spectrum of oceanographic researchers in that area.

5. Phase II Study Approach

From study of the results of the initial steps mentioned above, a study approach was developed for Phase II.

B. PROBLEM DESCRIPTION

1. Overview of the National Marine Data Program

The National Marine Data Program must be structured so that it is fully responsive to the broad objectives of the Marine Resources and Engineering Development Act of 1966. These objectives are:

- The accelerated development of the resources of the marine environment.
- The expansion of human knowledge of the marine environment.
- The encouragement of private investment enterprise in exploration, technological development, marine commerce, and economic utilization of the resources of the marine environment.
- The preservation of the role of the United States as a leader in marine science and resources development.
- The advancement of education and training in marine science.
- The development and improvement of the capabilities, performance, use, and efficiency of vehicles, equipment, and instruments for use in exploration, research, surveys, the recovery of resources and the transmission of energy in the marine environment.
- The effective utilization of the scientific and engineering resources of the Nation, with close cooperation among all interested agencies, public and private, in order to avoid unnecessary duplication of effort, facilities, and equipment, or waste.
- The cooperation by the United States with other nations and groups of nations and international organizations in marine science activities when such cooperation is in the national interest.

The development of a National Marine Data Program begins with a recognition of these national goals and objectives and provides a program which will support their attainment.

The complexity of the problem of building a unified national program for developing the marine environment arises from the great number and magnitude of the "dimensions" of the subject matter.

They include:

- The vast expanse and depth of the oceans, lakes, and estuaries, and air-sea interaction interface which comprise the geographical domain of the marine sciences.

- The many technical disciplines which constitute the marine sciences field.

- The many federal agencies, states, research institutions and private organizations which comprise the marine science community, each with its own missions, objectives and resources.

- The large number of parameters which characterize the marine environment.

The marine program exhibits many of the technical complexities found in a typical national defense program. In addition, however, it exhibits a spectrum of socio-economic and political problem aspects not found to this degree in single-point authority defense or space programs.

The multidimensioned nature of the current program can be better understood by inspection of some of its essentially <u>non-technical</u> aspects. They include:

- The federal portion of the national program spreads over eight presently identified federal departments with major marine interests and within some 22 subordinate agencies. Organization and coordination of the marine activities of these departments and agencies alone is a major problem.

- In addition to the Federal Government, 24 ocean coastal states and eight Great Lakes states not only have serious marine problems such as environmental pollution, but also have very substantial state revenue potential from food, mineral and petroleum resources of the marine extension of their state boundaries.

- The oneness of the world ocean and its effects on global weather and ocean operations, the concept of freedom of the seas, and the great gaps in national and international law as to rights and ownership of marine resources create a requirement for international cooperation in ocean development as great and pressing as has ever been faced by an expanding technology. The opportunities and advantages of international cooperation in data collection and data exchange are most attractive and must be expanded.

- Industry has a substantial and growing profit motive in exploiting marine resources as well as participating in federal and state programs. Associated with industry data systems, however, are proprietary and classification safeguards as stringent as their counterparts in national security. Industry must be viewed as a partner, not a subordinate in the ocean program.

- The multiplicity of forms in which the significant raw data occurs are as numerous and varied as the interests of the various national programs and the pure and applied scientific disciplines involved in gathering and using the data to develop required knowledge and understanding.

These, then, are the complicating socio-economic political aspects of an already complicated technical information management program.

Because of the breadth and dimensions of the subject matter, the magnitude of the data problem is correspondingly quite large. The data problem is intimately associated with every aspect of the marine sciences. Therefore, any problem undertaken to satisfy the missions of organizations in the marine sciences generates data requirements to support those missions. Thus, data programs must flow <u>from</u> the functional requirements of the marine science community and <u>not dictate</u> the direction which the functional activities take.

In structuring the National Data Program the following important steps are involved:

- An analysis and understanding of the national goals and objectives in the marine sciences.

- An analysis of the missions and objectives of the individual agencies, institutions and private organizations in pursuit of fulfilling the national goals and objectives. These missions and objectives include: exploration, description and prediction of marine environmental conditions; exploitation and conservation of the resources of the marine environment; marine engineering; studies of air-sea interaction; transmission of energy; and communications.

- A functional analysis of the activities which are implemented by organizations in support of their missions and objectives.

- An identification of the needs for data and data analysis. These needs are derived from the missions and objectives of individual organizations.

- The structuring of a set of objectives for a data program which, when satisfied, will be fully responsive to the data needs of the marine science community.

- The evaluation of the political, legal, economic and technological constraints which bound the data problem.

- The synthesis of alternative systems which satisfy the constraints imposed on the system.

- The analysis of system alternatives and the selection of the optimal system.

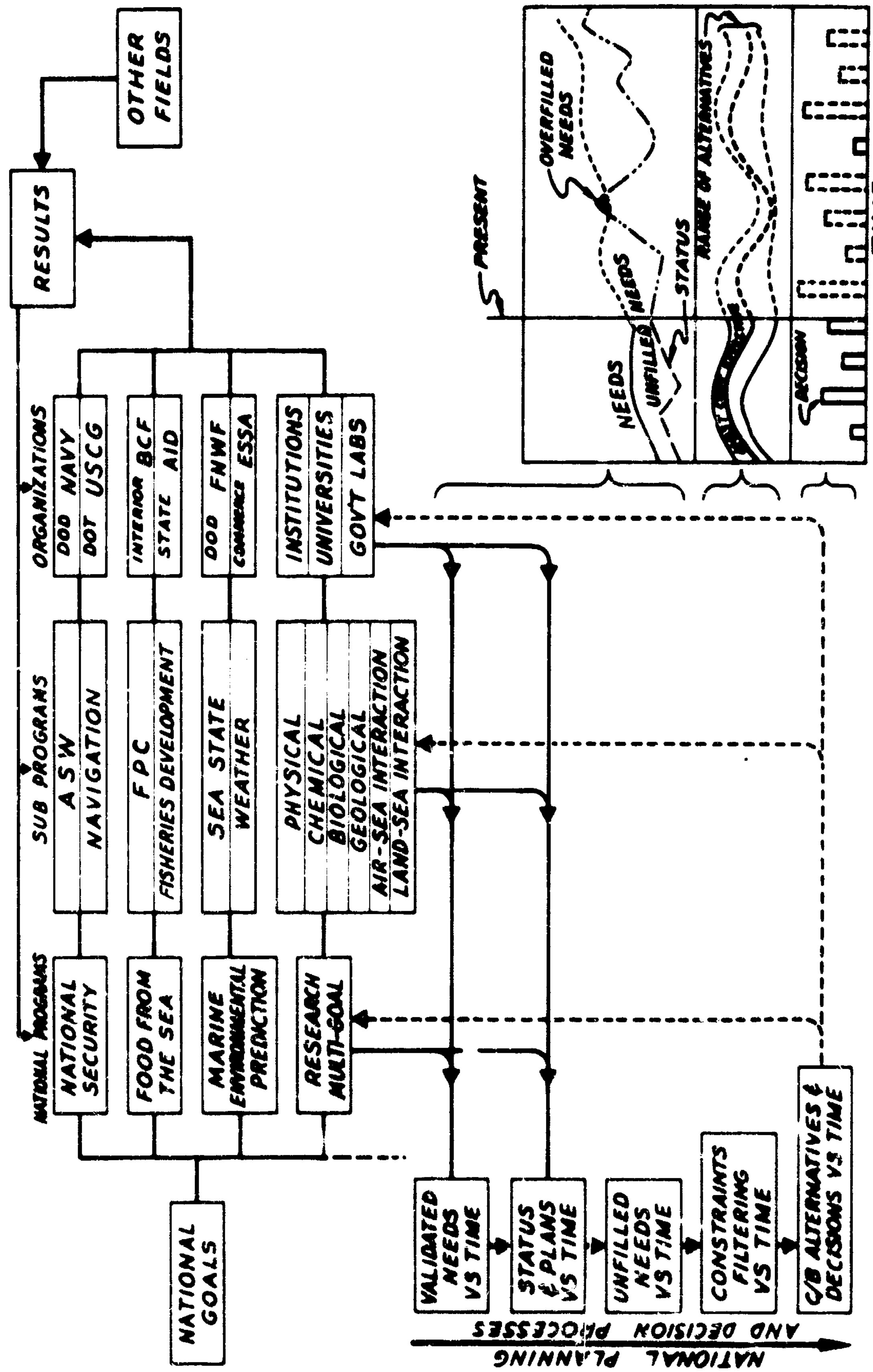
2. National Marine Science Planning and Decision Process

In approaching the problem of evolving an effective data management system in support of the National Marine Science Program it is useful to conceptualize the basic elements of the planning and decision process. As an aid, Figure 3 illustrates broadly the elements and processes involved. Across the top of the figure is a schematic illustration of the way in which the national goals are first broken down into national programs, such as national security and food from the sea; and then further broken down into subprograms, such as ASW and fish protein concentrate. These first three categories then form a way of dividing and grouping the major tasks to be performed.

All of the activities, however, are carried out by organizations and they are shown broadly in the fourth column including for example, the Navy, Bureau of Commercial Fisheries, and research institutions. These then are the resources of facilities, equipment, people and money which are utilized in achieving national goals. As the process proceeds, results are obtained by the operating organizations, as well as from other fields of endeavor. These results are fed back to the organizations as a function of time and produce a continuous evolution of organizational roles, subprograms, programs, and even the national goals themselves.

The process just described has been in effect for many years and it has caused the evolution of the national marine program to its present state. Recently the nation has taken a somewhat broader view in an attempt to integrate and systematize the overall planning and decision making processes. A schematic representation of these processes is shown in the bottom half of the figure.

Clearly it is first necessary to assess the needs which are to be served. Thus the box at the left margin entitled Validated



NATIONAL MARINE SCIENCE PLANNING AND DECISION PROCESS

FIGURE 3

Needs Versus Time, represents the ongoing collection of needs from the programs and the organizations. A schematic graph of the needs is shown as a function of time as the top curve of the chart at the right of the figure. The vertical line entitled "Present" represents the present time.

At the same time that the needs of the programs and organizations, both currently and in the future, are assessed it is necessary to similarly determine the current status of the same programs and organizations and their plans as a function of time. Again at the right the second curve from the top represents the status up to the present time and then planned future status by the broken line in the future. The difference between the needs shown by the top curve and the status and plans shown by the second curve represents the <u>unfilled needs of the system</u>.

In practice the unfilled needs are not completely fulfilled because of the effects of <u>constraints</u>. The process of passing the unfilled needs through what might be termed a "constraints filtering" process as a function of time is shown by the box in the left-hand margin. The results of the constraints filtering process are shown schematically at the right by curves representing a range of alternatives which carry a series of different costs and benefits. It is usually necessary to pick the most cost-effective set of alternatives for implementation even though the selection may leave more unfilled needs than other alternatives which cost more. This selection is illustrated by the center curve in the right-hand portion of the figure. The decisions taken following the planning process tend to be discontinuous in time, usually tied with many budget cycles, and thus are shown schematically as vertical bars in the lower portion of the curve at the right.

While it is normally true that the system needs are not completely fulfilled it sometimes happens that the effects of single or multiple decisions may accumulate in a specific part of the program and produce an inefficient overfilling of the needs. This condition is illustrated schematically on the right. A well structured planning system should essentially prevent this situation from occurring.

Clearly it is the role of the Federal Government to conduct to the extent possible this master planning process in an ongoing fashion. This does not mean that the Federal Government will make decisions in the sphere of industry, private research institutions, or states; but it does mean that the federal aspects of the national program can only be planned and regulated efficiently if the requirements of non-federal organizations are also considered.

Thus it is necessary for the Federal Government to design and assemble an information system which accumulates, processes, and presents to decision makers the information suggested by the referenced figure. The entire system might be termed a National Marine Data Planning System.

C. FUNCTIONAL REQUIREMENTS

1. User Community Characteristics

In this Phase I study, a structured approach and set of tools were developed to enable efficient Phase II assessment of the functional requirements of the marine community. Brief comments follow:

a. Federal

These tools were applied in general to all federal agencies as summarized in Section III, Volume I. In addition, actual preliminary surveys were conducted of the requirements of the following selected Federal organizations:

- NAVOCEANO
- NODC
- ESSA
- Smithsonian
- BCF
- U.S. Coast Guard

The results are presented in Section III, Volume I, supported by Appendices A, B, E, and F., Volume II.

b. States

State and local governments situated on the Atlantic, Gulf, Pacific and Great Lakes coast lines have collected large amounts of marine data in response to arising needs regarding: water pollution, beach erosion, marine construction (harbors, marinas, ocean outfalls), fisheries investigations, and off-shore oil and mineral explorations. From preliminary analysis of the information obtained during Phase I it appears that there has been little effort made in the past to coordinate and standardize collection, storage or processing of the numerous types of coastal marine data collected by these organizations. As a result, substantial duplication of effort has occurred. Recently, however, efforts by various local, state and federal agencies in such regions as the Great Lakes, Chesapeake Bay, Delaware Bay, and Gulf of Mexico have been undertaken to correct this situation.

c. Industry

Industry has for years utilized the marine environment extensively. Perhaps the most significant activities lie in the fields of: transportation, oil and mineral recovery, and drug and chemical extraction. In the process, very extensive marine data bases have been accumulated, especially in the field of oil exploration.

In addition to these possible data sources, industrial organizations contacted during Phase I expressed a need for various types of marine data. Most large producers of general marine systems, for example, require data on ocean temperature and salinity profiles, bottom topography, bottom composition and foundation characteristics and acoustic properties. The lack of these data in many parts of the world ocean has to some extent impeded the progress of ocean engineering.

d. Research Institutions and Universities

Universities and oceanographic research institutions in the past have been the most important basic contributors to the scientific advancement of the field of oceanography. Practical applications of the research conducted have contributed heavily towards significant advances in the areas of marine weather forecasting, wave forecasting, acoustic transmission in seawater, beach erosion, and food from the sea. It is anticipated that these contributions will continue to play an important role in the future development of the marine environment.

From a preliminary Phase I sampling of opinions of oceanographic scientists performing basic research, the impression gathered was that there is a rapid progression of ocean studies to the stage where emphasis is shifting from the charting of the distribution of properties, such as temperature, salinity and biological populations, to the quantitative time-series study of dynamic processes which produce the observed distributions and of the principles which govern these processes. Thus, the problems of obtaining large collections of marine data which are correlated in both space and time are receiving considerable attention by the academic marine community. The impacts of the resulting data volumes and related handling methods must be given considerable attention in the design of the National Marine Data Program.

e. International

Although primary consideration during the Phase I effort has been devoted to national aspects of the marine science programs, considerable attention has been and should continue to be devoted to the effects of international cooperative efforts on National Marine Data Program requirements. Additionally the activities of international organizations such as the Intergovernmental Oceanographic Commission (IOC), Scientific Committee on Oceanic Research (SCOR), Fisheries Division of the Food and Agriculture Organization (FAO) of the United Nations, and the International Council for the Exploration of the Sea (ICES) will be examined in detail during Phase II with respect to their past efforts and future plans for coordinating the international aspects of marine data exchange.

f. Miscellaneous Users

Occasional users of marine data and information such as consultants, school teachers, students and lay users, form a necessary consideration. When combined, the user demands of this group can be rather large and because of their nature, the requirements are often very unusual and diverse. The diversity and quantity of their requirements must be examined in order to assure that reasonable satisfaction is provided by any future system, as through an NODC user request branch.

More detailed information is contained in Section III, Volume I.

2. Implications for Phase II

The following brief comments touch on a few factors encountered during the brief Phase I pilot interview period:

a. The users of the marine environment tend to divide into the following broad categories:

- those who collect, process, and utilize their own data
- those who utilize data gathered by others.

Users in the first category tend to be self-sufficient in their needs and sometimes look at national data management as a possible impediment to their own programs. Users in the second category generally are supporters of the national program, since it promises direct benefits to them.

b. Survey techniques require several stepwise levels of interviews. High level contacts are required to obtain overall budget information and broad plans, and interviews at the operating level are required to get at the technical details of data volume, types, collection, storage, and processing aspects. The latter information is only available at dispersed geographical locations in general. In some organizations only the working level personnel were aware of the size, scope and complexities of their own marine data operation.

c. The questionnaire works reasonably well for most information categories covered, but the interviewers encountered major difficulty in obtaining estimates of future conditions from existing organizations. Only a few of the organizations contacted have firm documented plans.

d. The process of gathering meaningful forecast information is further complicated by the transition from primarily basic research in some sectors to the area of developmental technology. Some organizations are wrestling with the question of the true thrust the nation intends to put into the development of ocean potential.

D. DATA PROGRAM REQUIREMENTS

As mentioned previously, data program requirements are derived from functional requirements. The following paragraphs summarize briefly some of the data program aspects of current and future marine science activities gathered during Phase I:

1. Data Collection

a. Substantially all of the federal agencies involved in marine work collect prime marine data. The majority of the collection, however, is carried out by the Navy, ESSA, Bureau of Commercial Fisheries and the U.S. Coast Guard. Indirectly others collect data through universities and institutions by contracts or grants.

b. The major volumes of data collected by federal organizations fall in the categories of national defense, synoptic reporting and forecasting and general surveys.

c. Private research institutions and universities collect a significant, although a smaller quantity of data, than the federal agencies, but the diversity of types, collection points, and lack of standardization are much more extensive.

d. Private industry, by comparison, appears to collect a small quantity of data, with the exception of the oil industry which has developed important data collections and methods for their analysis.

e. The geographical coverage of marine data collected to date is concentrated in:

- Heavily traveled sea lanes
- Near-coastal waters
- Special high density defense zones and test ranges
- Special survey areas and routes

Temporal coverage is distorted by storm-avoidance ship courses and by winter conditions in the higher latitudes. Vast expanses of the world ocean have received little or no attention, for example, the South Pacific.

f. Some of the basic trends in collection observed during Phase I are:

1) Volume. During Phase I pilot interviews, volume forecasts made by most collectors exhibited a substantial positive slope. These forecasts are generally dependent upon new data collection techniques now in the developmental and pilot stages, such as buoy and satellite methods, which promise truly enormous increases in data volume. In turn they suggest the importance of planning the best modal splits between field preprocessing and data center processing functions.

2) Diversity. Most of the forecasts made by collectors call for an increase in the diversity of data types collected. Much greater emphasis will be placed on collection of a diversity of data types which are correlated in space and time, than has been the practice in the past.

3) Geographical Coverage. Some of the mission objectives require a substantial increase in geographical coverage of the world's oceans and the Great Lakes, or at least a further detailing of previously mapped areas. Remote sensing of surface and near-surface conditions from airborne and spaceborne platforms will greatly expand overall geographical coverage.

4) Equipment. Significant improvement trends were found in the areas of sensing, platforms, transmission, recording and processing of marine data in response to expanding user needs. Prime trends include: integrated multi-variable instrument systems, in situ instruments measuring chemical properties, shipboard digital computers, self contained instrument packages for ships of opportunity, navigational satellite tracking instruments of greatly reduced complexity, satellite and airborne data transmission links, and the development of remote sensing of surface and near-surface phenomena from airborne and spaceborne platforms.

5) Array of Instruments. Array technique applications are undergoing a rapid buildup for such purposes as ASW and research studies aimed at modeling large-scale ocean phenomena. Increasing use of array networks again suggests the advantages of placing preprocessing capabilities near the array locations as contrasted with attempts to transmit all of the data to a remote center.

6) Format. Currently numbering in the hundreds, data formats do not appear to be undergoing a rapid upward trend. In fact, the continuing pressure throughout the community to standardize is beginning to show beneficial effects in this area.

The simultaneous positive slopes of the great majority of these trends hold great portent for the magnitude of the overall data management problem.

g. Important Data Collection Limitations

1) All marine data are merely samples of the marine environment. The information they convey cannot exceed that present at the point in space and time being sampled. Hence, the first essential element in planning, collecting, and interpreting marine data is the realistic assessment of how well the planned sample points represent the phenomena in space and time. Like entropy in thermodynamics, none of the processes performed after the sampling can upgrade the individual information samples. (This is not to say, however, that combinations of information samples cannot produce information content far exceeding that of a single sample, as is done by a hydrophone array, for example.)

2) All marine data samples contain errors arising from several sources:

- Position errors (several miles in many cases)
- Depth errors
- Time errors (usually minor)
- Sample removal errors (i.e., the error introduced by the sampling process itself, e.g., true versus measured current velocities, especially from buoys; true versus measured core orientations)

The wide variation in error of different types of marine data seriously limits its true current correlatibility and also its correlatibility with older data taken with even greater and often unknown error values than are presently the case. Recognition of these limitations will help in time to convince the marine community that selective purging of certain older data files will ultimately be acceptable.

3) The entire field of marine data sampling is divided into two basic realms:

- Time-dependent variables, such as temperature, salinity, air-sea interaction data, plankton tow results, chemical composition, and pollutant content, and

- Time-independent variables, such as bottom topography, sub-bottom geology and seismic properties.

This dichotomy establishes the breadth of the collection problem. It requires on the one hand the continuous collection of time-variable data, and in that sense is like the meteorological data problem; and on the other it requires the very long term storage (archiving) of non-time variable data, and in that sense is equivalent to the geological data problem.

4) In studying time-independent phenomena such as bottom topography, it is possible to accumulate empirically a sufficiently dense sampling pattern over long periods of time since the samples are additive. Thus if budget restrictions are imposed on a bottom mapping program, for example, it can be stretched out over time with no essential loss of information.

In studying time-dependent processes, such as air-sea interaction or migratory patterns of fish, however, samples taken at different times are not directly additive. Hence, an essentially simultaneous sampling at different points in space and in time is required, or in some cases, time series samples at fixed points will be useful, as in flow variability studies.

5) By the same token, time-variable data requires rapid handling in order to preserve its "first use" value (as in weather or sea state forecasting). Its prime value for forecasting purposes steadily declines with time until it is ultimately relegated to long-term statistical uses. These are also the data for which the space/time correlations are so vital, especially for synoptic work.

Non-time variable data, on the other hand need not be handled rapidly and its original value is essentially timeless. In fact its value increases with time as additional data are added which provide greater detail and are from surrounding areas. (The principle perishable quality associated with these data is often the fallible memory of the collector. It is clearly vital that the circumstances of collection be properly logged.)

The fundamental characteristics of marine data, its collection, value and storage, as enumerated in items g-1 through g-5 above, are prime factors to be used in conceiving and evaluating various data system networks during Phase II.

2. Data Transmission

a. Current data transmission techniques vary from on-line digital transmission in real time, at one extreme, to mailed and hand-carried information arriving at an ultimate location as much as two or more years after data collection.

b. A fundamental dichotomy exists along the mission and funding axis as follows:

   1) Only those missions which are of an operational and synoptic nature with heavy funding seem able to employ transmission techniques that are anywhere near real time.

   2) At the other extreme lies the researcher who gathers his own data, analyzes it, and may, or may not, ultimately pass the information on to other users.

c. A further dichotomy exists along the standardization and repetition axis as follows:

   1) Only those data produced by standardized instruments, in standardized form for generally repetitive computations seem capable of high-speed transmission in an economical fashion.

   2) Research and other experimental data gathering missions usually cannot efficiently employ high-speed transmission because of the great variability of data kinds and formats and the changing nature of the computations to be performed on the data.

These facts highlight the importance of designing the national data system to support the needs of investigators at all levels of transmission sophistication. The importance of continuous evolution of standards is clear, as well as the value of bringing more and more of the data collection activities into standard formats as the technical stage of the particular mission is developed (i.e., from basic research to technological system deployment).

Several revolutionary techniques appear helpful to the data transmission field. Time-sharing systems for instance with many users sharing the cost of a large computer can link the individual investigator with a data base at very low cost. Such a system, operating on a few experimental data bases, would also tend to motivate the researcher to plan, gather, and analyze his data in compatible formats. This aspect is therefore an important educational as well as motivational approach which should be utilized. Also, the increasing use of telemetering techniques, aircraft and satellites for both collection and transmission relays, and facsimile are important trends to be emphasized.

3. Data Storage and Processing

a. The number, diversity of content, and geographical spread of active marine data files is very large. Phase I pilot interviews conducted with 18 organizations at 15 locations identified in excess of 286 data files.

b. The format of existing data bases is and will remain widely variable. Consideration of another set of fundamental characteristics of the entire marine data field is important. All marine data can be divided into two classes as follows:

Class 1. Physical Specimens of the marine evnironment, e.g.:

- seawater samples
- biota collections
- geological samples

Class 2. Measurements of the marine environment

This class includes both single variables and complex combinations of variables as follows:

Single variables, e.g.,

- temperature
- salinity
- current velocity
- simple chemical analyses

- pressure
- wave height
- wave period
- magnetic field intensity

Combined variables, e.g.,

- bottom photographs
- bird flock and fish school sightings
- cloud characteristics
- sonar profiles
- seismic profiles
- iceberg shapes
- interpretations and classifications of biota
- interpretations and classifications of geological samples

This very fundamental division of all marine data into two classes, actual specimens of the environment on the one hand and measurements of the environment on the other, brings the following basic principles into play:

c. Class 1 information can only be stored in physical form. Thus, the best a data management system can do is to index the identification, location, depth, and time of collection. It can, of course, store and call up correlative information about other variables or specimens taken from the same or surrounding areas at the same or different times. But little can be done with the sample itself except to preserve it in the best possible condition until it is either used, interpreted, or discarded. Thus, for the forseeable future a number of such physical "data bases" will be required in any meaningful national program.

d. Class 2 information can be stored in analog and digital forms. Storage formats in this class include virtually every information recording technique in use today. Some basic characteristics of the information so recorded are of great importance, however.

Being simply representations of the physical environment, all of this class of information suffers from the problem of measurement error (over and beyond sampling errors described earlier). Thus every piece of information in this class is a measurement and interpretation of some single or combined set of variables. Measurement and interpretation errors can be grouped as follows:

- For measurements made and interpreted by instruments, error limits and averages are often known with fair accuracy (e.g., temperature).

- For measurements made by instruments but interpreted by humans, error limits and averages rise quickly (e.g., cross sections derived from seismic sub-bottom profiles). Here the great importance of trained personnel and frequent quality checks becomes apparent.

- For measurements made and interpreted by humans, error limits and averages mount rapidly, thus greatly reducing the value and correlatability of the derived information (e.g., fish school sightings). Here the importance of highly trained personnel and tests of comparability of different observers reach their maxima.

Hence, it is important to provide a quality descriptor with each item or group of items in Class 2 data bases. The development, test and evolution of working standards for calibration, error checking and training for the entire Class 2 data spectrum poses a major and never-ending problem.

e. Information tends to move from Class 1 into Class 2 as improved methods of measurement and interpretation of physical specimens are developed. The ultimate limit of this process would be the complete extraction of all information content from the Class 1 specimens, thus eliminating the need for their retention. This unattainable limit is only slowly approached, however. It is the nature of scientific research that a consecutively finer and finer grain investigation of the specimen evolves as each layer of knowledge is obtained. Thus, a submarine geologist is going to be loathe to allow his cores to be destroyed even after he has conducted his interpretation. He may later want to work on a more microscopic scale to meet new objectives and again must go back to his prime information source, the original cores.

Hence, Class 2 data bases seem destined to grow continuously from Class 1 derivations, as well as from prime Class 2 inputs. Class 1 data bases seem destined to grow also as they are filled with more types of specimens as well as from more extensive geographical coverage.

f. The following more specific comments were developed during Phase I through interviews and observations of the collectors, processors, and users of marine data.

1) Current data centers tend to be dichotomized on the reaction time scale, e.g., the Fleet Numerical Weather Center is essentially a real-time operation with highly proceduralized and rapid operations; while the National Weather Records Center tends toward archival storage and a less proceduralized, more research-oriented operating mode. This separation of operating modes tends to optimize the effectivity of each operation in meeting its specialized objectives.

2) With the exception of NODC, currently operating Data Centers tend to be functionally specialized; e.g., the Smithsonian specializes in biological and sedimentary specimens; the U.S. Lake Survey specializes in Great Lakes data; the Fleet Numerical Weather Center specializes in synoptic weather, sea state, and near surface physical data; and the National Weather Records Center specializes in long term climatological information. This separation of function is beneficial because it enables each center to correspondingly concentrate on its specialty and to build expertise and knowledge in depth. On the other hand, the isolation tends to limit the communication between centers in areas of mutual interest.

Continued development of direct lines of communication between data centers should be encouraged along the lines already in process, as exemplified by the direct line between the Fleet Numerical Weather Center and BCF La Jolla.

3) Nonmission-oriented data centers have generally fallen far behind in the conversion to desired storage formats of incoming data volumes. Lack of needed equipment, manpower and data collection standards are all prime contributors to this condition.

4) A comment heard throughout the marine community is the fear of loss of close contact between data and investigators if the data is pooled in a center. Hence a strong planning

element must be the provision of close coupling between investigators and their data. The problem will be to convince many investigators that they stand to gain more than they lose by relying on data center support. From a national viewpoint it will be important to plan and implement a constant stream of directed incremental improvements aimed at increasing the amount of work handled by service centers and their machines, thus freeing the valuable marine scientist to concentrate on the exploratory and analytical processes.

5) A large measure of common sense is needed in the determination of which kinds of data and types of formats can and should be placed in machinable form. Clearly no one at this stage of technology wants to digitize bottom photographs, for example, or other forms of information which are already in a highly compact form. Machinable film storage-media can of course be used efficiently for storing and retrieving such data. Any tendency to try to over-digitize must be kept in check.

6) Emphasis should be placed on the use and continued development of present data inventories and services in fringe fields such as geology, geophysics, biology, meteorology, and climatology.

7) In "networking" alternative system configurations it is important that the major collectors of data for mission-oriented purposes obtain the useful output for their mission first, before the data is passed on to a data center, <u>unless</u> the data center is designated as the mission processor. Pre-processing and quality control to meet specific objectives is often more efficiently executed by the collecting group than by a remote organization.

8) Especially for major surveys, encouragement should be given to the expansion and upgrading of data reduction aboard ship including analog-to-digital conversion, editing, format conversion and some data base generation prior to transmittal to data centers. Shipboard computing should help <u>contain the growth</u> of the data volumes necessary for storage and transmission. As in any geophysical survey work it is vital for the field observers to constantly monitor the quality and utility of their measurements and to thereby control the survey techniques to optimize results. Therefore easily interpretable displays of key results <u>must</u> be constantly available during the cruise.

4. Data Purging

It is important to understand and plan for the effects of evolutionary improvements in collection, standardization, interpretation, and transmission techniques. Each such improvement tends to render more difficult the process of correlating improved new information with relatively poorer older information in the data base. This process, while detrimental in the sense of reducing the value of such correlations, provides hidden cost/benefits in the sense of making it incontestable to relegate great masses of older data to decreasing levels of storage and ultimately to purge portions of it from the system.

Thus, the building, utilization and movement of great bulks of Class 2 data from higher to lower levels of storage and accessibility is a continuing process. An important and never-ending task in this dynamic program is therefore the generation, utilization and modification of file level and purging criteria.

It is important to note at this point that safeguards for preventing accidental purging of data must be built into the data management system. One method of achieving this is to provide for duplicate data files that would be stored in separate locations to prevent total loss of a data base due to accidental purging or natural catastrophe.

5. Data Dissemination

The dissemination of data and digested results tend to exhibit the following characteristics:

a. Mission-oriented, standardized, synoptic data are often disseminated by radio and hard wire links, employing voice, TWX, facsimile and related techniques.

b. Most other data and digested information is disseminated by mail or is hand-carried in a wide variety of formats including tape, cards, listings, strip charts, photographs, reports, and even in physical sample forms.[1]

1. An interesting problem in data reproducibility arises for the collector who continues to disseminate small slices of his core samples and ultimately gets down to the last slice.

c. The time span between data collection and dissemination ranges from a few hours in the highly structured synoptic systems to years in the case of some major survey programs. Throughout the community pleas were heard for the more rapid release of data.

d. The dissemination response time (time between request and dissemination) and quality depends vitally on the following relationships:

- For non-standard requests the degree of departure from established standards of both the retrieval and the computation required.
- The extent to which the request is viewed as a disturbance to an ongoing operational mission.
- The extent to which the disseminating personnel are interested in and knowledgeable about the requested data and computations.
- The anticipated volume of output generated by the retrieval action. Small jobs are usually run first.

These and other factors affecting dissemination must all be taken carefully into account in conceiving and evaluating alternative data system networks.

6. Standards

A notable lack of standards was encountered in many areas of the marine community. Fundamental to the development of any significant network efficiency is the need for continuing evolution of communication compatibility at the interfaces between producers, processors and users of marine information. Data exchange and compatibility problems should be considered on a total basis, i.e., from data acquisition to dissemination. In practice the problem is very complex because of the wide diversity of marine data, the numerous methods employed for measuring the same or similar information, and the breadth of organizational missions ranging from broad research to synoptic reporting and forecasting. Standards are absolutely vital to synoptic programs. Elsewhere the concept, "standardize where practical" should be employed.

The first step is to create an ongoing standards working group composed of representatives of all interested segments of the marine community to augment the work of previous standards committees. Their continuing task is the evolution of standards for data content, media and format in order to build compatibility for both machine readable and non-machine readable data between:

a. Data collectors and data centers.

b. Data centers and data users.

c. Data centers.

d. Data collectors and data users.

An additional benefit of the standards activity will be an increased knowledge and a better understanding by the various factions of the data problem itself, since the standards effort will require detailed investigation of the data requirements of a multiplicity of organizations and missions. Heavy cooperation with the Naval Oceanographic Instrumentation Center on standards and uniform sampling procedures for manufacturers and users of STD and XBT gear will be an important aspect.

7. Management Information

In the final analysis, the National Marine Sciences Program is built on information. The program can therefore function optimally only if the vital information is generated, transmitted and utilized by the right organizations at the right locations and at the right times. A useful guide to one breakdown of this complex problem appears in Figure 4. Three important dimensions of the information picture are shown as follows:

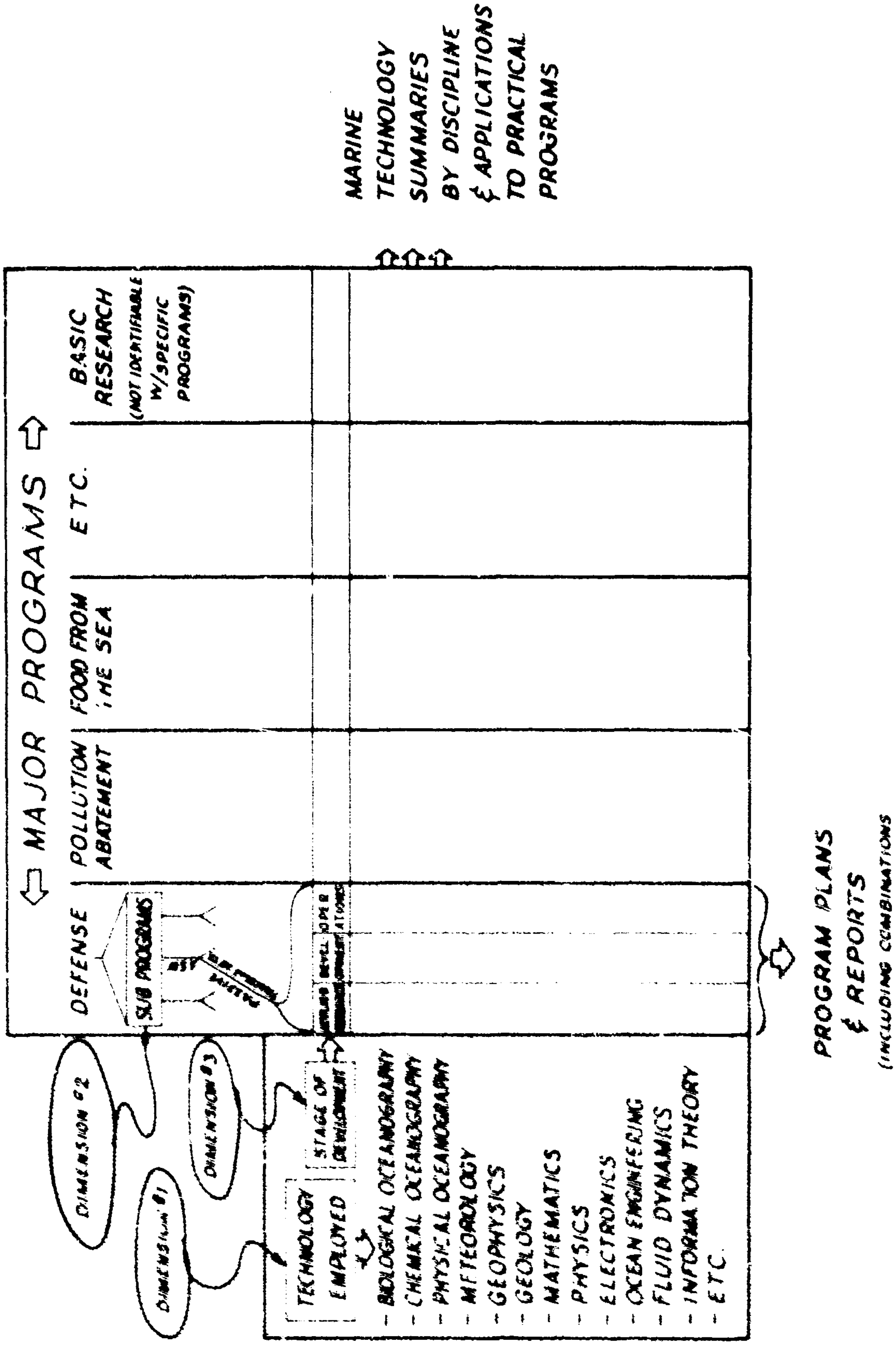
- Dimension #1 is the Technology Employed to accomplish the objectives of:

- Dimension #2 which comprises the National Programs and their sub-elements, each of which exhibits:

- Dimension #3, its Stage of Development (shown broadly as "Applied Research," "Development" and "Operational").

In addition to the major programs shown as examples along Dimension #2, Basic Research is shown since it crosses all disciplines and is defined as that basic work which is not identifiable to any distinct program.

An example is illustrated in the case of the Defense program which is shown to have a branching structure of subprograms, among which ASW is shown; and it in turn is composed of sub-subprograms



THREE DIMENSIONS OF THE MARINE TECHNICAL INFORMATION PROBLEM

FIGURE 4

including, say the Passive Tracking Nets. The Tracking Nets program employs certain technology from the disciplines listed such as: Physical oceanography, physics, electronics, mechanics, fluid dynamics and information theory. Information from some of these disciplines is required as a function of space and time in the marine environment, such as the sound transmission characteristics of the net area.

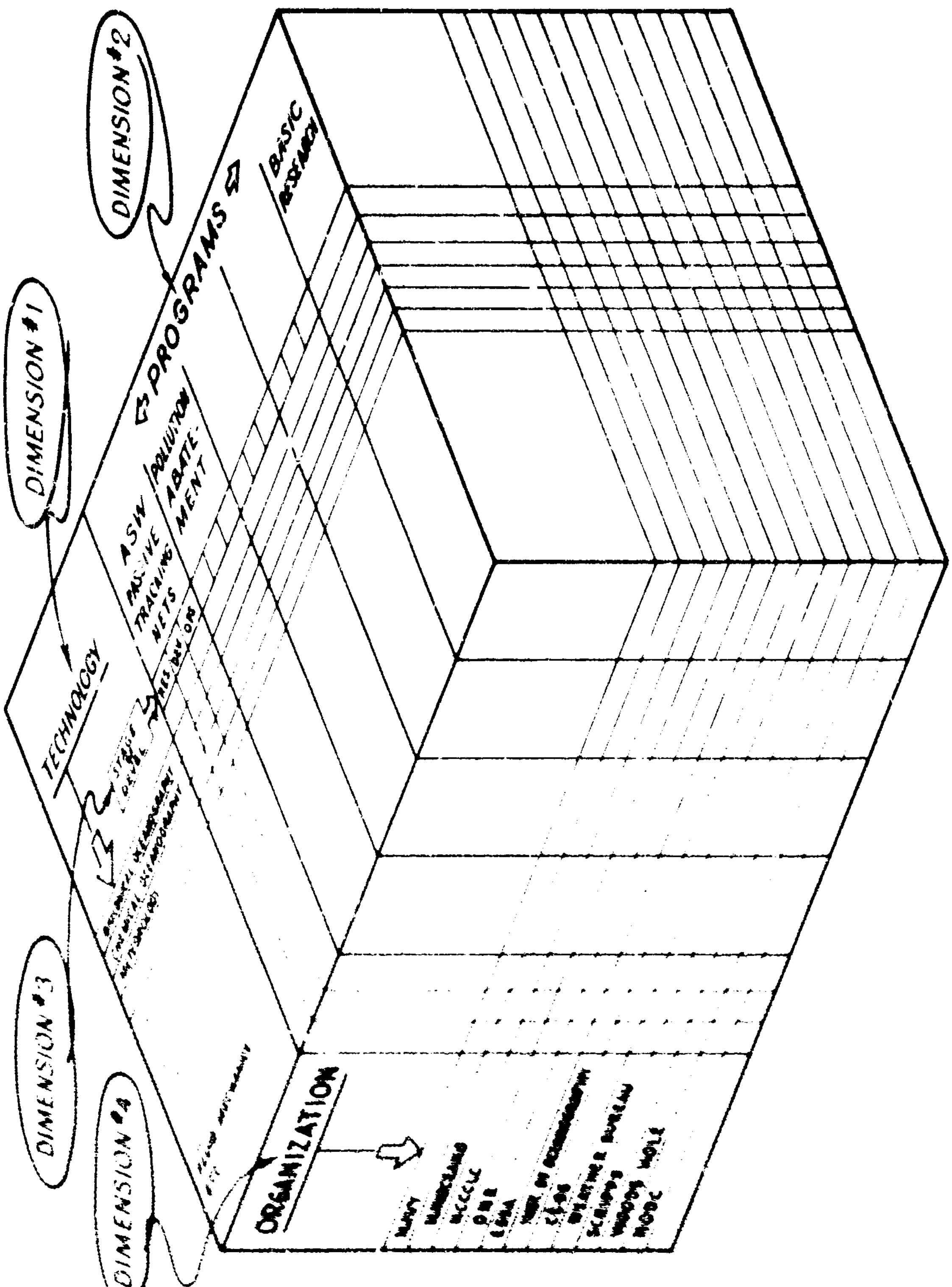
Utilizing all of these scientific and technical tools, the Tracking Net subprogram is evolving along Dimension #3, i.e., its stage of development. This aspect itself is an uneven process. For example, the hydrophones and underwater cables may have reached the pre-operational stage, while the signal handling and processing system may still be in a developmental stage.

Thus, some simple but important observations emerge from this matrix as follows:

- Technical information summaries by discipline, need to be conveyed between programs in order to assure best use of each new piece of knowledge developed. This cross fertilization is often conveyed best by the top technical workers in each field who also serve as natural integrators of the state-of-the-art of their discipline. Other mechanisms include active research-oriented data centers and technical conferences.

- Technical and program information needs to be conveyed between programs in order to assure best use of each new piece of knowledge developed utilizing a combination of disciplines in achieving practical objectives. Program information also provides the vital ingredients for planning and reporting on a program wide basis. The latter is a most important part of any national effort. Such reports are relatively easy to obtain *if* a program is being conducted in only one organization. To the extent that multiple organizations are involved, the efficiency of information flow falls off dramatically.

This aspect is brought further into focus in Figure 5 which shows the addition of the vital fourth dimension, the organizational breakdown. Now visualize a program for which research is performed by one organization, development by another and operations by a third. Clearly the flow of such a program through its stages of development will be far more sluggish than would be the case under a single organization. Only a very strong program management function can speed up the process, and that in turn demands efficient interorganizational information flow of both technical and program aspects.



FOUR DIMENSIONS OF THE MARINE TECHNICAL INFORMATION PROBLEM
FIGURE 5

A fifth dimension of the information flow problem is the frequent geographical spread of organizational units working on a program (not shown). Needless to say, strong information flow design becomes increasingly vital as these true life complications are added.

It is for these reasons that it is recommended that a National Marine Data Planning System be designed and implemented as a vital part of the National Marine Data Program. Only in this way can the nation effectively plan, create policy, implement and optimize the use of its resources in this overall program. Such a system certainly cannot solve all of the communication needs expressed above. But by keeping the basic principles expressed by the figures in mind, the structuring of information flow arteries can be focussed on the important short range and long range needs.

In carrying information needs one more step, overall management information system requirements can be divided into some basic functional parts as follows:

- Policy subsystem
- Programs subsystem
- Fiscal subsystem
- Technical information subsystem
- Educational and Public relations subsystem

In principle, each of these information subsystems dips into each existing and planned program area, and integrates and facilitates the bidirectional flow of functional information in order to enhance overall program effectiveness. An important aspect of the establishment of a Marine Data Planning System is the incorporation in each of the functional subsystems of ongoing information to serve the following purposes:

- Planning
- Decision Making
- Progress Monitoring

Thus for each of the functional subsystems, e.g., policy, it is necessary to plan what is needed, then make decisions; and then to monitor the effects of the decisions taken, revising and improving them based on actual system performance. Again, these concepts are often difficult to apply rigorously. But, they should be used as guidelines in the evolutionary development of the overall National Marine Data Program.

The following are brief examples of existing needs in marine science programs which emphasize the benefits of a systematic attack on the marine information management problem:

a. The need in the planning process to incorporate on-going forecasts of technology development. This information is needed to answer the questions of where, how, and when to apply what technology. The time requirements for developments must be realistically incorporated.

b. The need for optimally structuring the management of the various aspects of major programs such as a buoy system. For example, what is the best split of data preprocessing and post processing, how should it be "networked?", under whose management?

c. The need to anticipate, wherever possible the demands of the bureaucratic machinery by timing plans to such things as the internal budget cycles of federal agencies, the main national budget cycle, etc.

d. The need for an on-going educational and public relations program employing such methods as documents, movies, traveling seminars of experts, and national conferences.

e. Examples of sub-elements include:

- The need to get instrumentation and data processing people together in planning new equipment designs.

- The need to increase the involvement of data center personnel in the planning stages of major survey efforts.

- The need to facilitate R&D communication.

- The need to upgrade the information management knowledge of workers in the marine community (possibly involving data management training courses in Sea Grant colleges?).

8. Document Handling and Bibliographic Retrieval

Marine information processing can be divided into two broad classes. One is the storage and processing of data required for analysis.

With the exception of physical specimens, this data is often numerical. The second are documents and bibliographic references about documents. This second class is a vital and often overlooked information requirement. The handling of the two classes of information should be coordinated. Examples of the coordination of data and documents are the following:

a. Applicable documents should be referenced in data bases. When data is retrieved, references to applicable documents should automatically appear.

b. Bibliographic files should contain references to applicable data bases. When documents are retrieved, references to data which was collected in the described project should automatically appear.

c. There should be a document distribution and bibliographic function as an integral part of each marine data center. In fact, a more appropriate name for a center is data and document center. Users of a center should be able to conveniently request applicable documents after retrieving data, and conveniently request applicable data after retrieving documents.

d. A combined catalog of data bases and associated documents should be developed and distributed to the marine community. This is a task ideally suited to existing data centers. Obviously, coordination would be required among data centers in order to minimize overlap. Alternatively, a single data center could assume responsibility for distribution of the catalog with other data centers providing inputs to the distributing data center.

E. CONSTRAINTS

1. Constraints and Relationships

Political, legal, economic and technological constraints are currently operating against the efficient development of a National Marine Sciences Program. The following lists only a few such constraints:

- Lack of singularity and popular sense of high nationalistic thrust in marine program goals.
- Vested interests in marine resources by industry and the states.
- Extensive international turmoil with its effect on international cooperation.
- Economic impacts created by other priority national programs.
- Problems concerning the ownership of marine data.
- Lack of central coordination authority on the one hand, and distrust on the part of the marine community of such central authority, on the other.
- Divided loyalties of some federal agencies often responsible for major contributions to more than one national program.
- Lack of sufficient industrial incentives to justify extensive capital investment in customized equipment and technology development to serve a limited market.
- Data privacy requirements of proprietary and classified data, e.g., the problem of declassification of national security-oriented data for other oceanographic research and technology needs.
- Inertia of the traditional view of some data centers as limited service facilities rather than integral support elements of the national program.
- Reluctance of investigators to release data until after publication of results.
- Fear of standardization and loss of control over the quality of data collection and research results, etc.

In addition to identifying each constraint, it is necessary to analyze the interrelationships among constraints. For example, the technical constraint of unreliable instruments may be partially overcome by providing incentives to instrument manufacturers to design products with greater reliability. This incentive could be provided in the form of instrument standardization which would ensure larger and longer manufacturer production runs than is presently the case. Manufacturers are reluctant to incur the cost of providing high reliability when these costs would have to be amortized over short-run, highly customized orders.

Although technical constraints are important, their reduction is not as difficult as are social, attitudinal, economic, and legal constraints, since the latter require changes in human behavior, traditions, laws, and practices in order to accomplish a significant reduction in constraints. The constraints discussion in Section IV of Volume I, therefore emphasizes nontechnical constraints including a detailed treatment of data classification and data ownership constraints.

Perhaps more than any other aspect, however, incentives and benefits are the basic tools which must be used in breaking down constraints barriers. For that reason the following discussion is included to point up some of these fundamental issues and suggest ways in which they might be systematically resolved.

2. The Need for Incentives and Benefits

The design of a National Marine Science Program to meet national goals would be a fairly straightforward problem if all of the governmental organizations involved were under a single unified control. Existing conditions would first be determined, then compared with objectives, and necessary corrective actions planned and implemented. That is essentially the fashion in which the National Space Program was created; and the command and control authority employed there has lead to relatively close adherence to the challenging milestones set down in the plan.

In the Marine Sciences case, the nation is faced with nearly the opposite extreme. Massive federal governmental units are heavily involved in parts of the program, but they are not under unified control and such an occurrence is unlikely because they serve a number of other important national functions. States, regional joint-powers groups, and private research institutions are all playing important roles as well as private industry, which has a direct vested interest in the resources and utility of the marine envelope. Such a condition was never present in the space program.

And lastly, the goals of the marine program are less clear and less measurable than those of the space program. (e.g., increasing the food production of the sea vs. putting a man on the moon by 1970).

All of these factors form a very complex planning and implementation task. The breadth, scope, and diffusion of the marine science objectives alone injects one set of complexities. But the principle difficulty lies in the lack of unified control. Moreover, it is clear that major elements of the organizations involved could never be brought under a single unified control (i.e., states, private research institutions, industry) even if the federal government wished to do so. Hence one of the strongest incentives of all is not available to the marine program, namely command authority with the control of money flow that it employs as the primary benefit passing on to the controlled organizations.

It is for this reason that substitution of <u>other</u> incentives is such a vital step in motivating marine science organizations to work together toward common goals.

It must be remembered that organizations and individuals in them will not actively cooperate with a program unless such cooperation returns some tangible benefit.

Some of the other classes of incentives available are:

- Money (without command authority)
- Rights to discovered resources
- Scientific and technical support
- Operations support
- Political value

Examples follow:

a. <u>Money</u>

Can be used for purchasing equipment or services in performing part or all of a function, e.g.,

- Budget to ESSA for its part
- Funds granted to states for offshore or inland water work
- Funds to marine science institutions for research
- Funds to industry to develop and manufacture equipment and provide services

b. <u>Rights to discovered resources</u>

Royalties or other formulas providing a monetary return for the discovery or development of marine resources could be granted:

- to states
- to industry
- to research institutions

(this area brings in the very complicated questions of legal ownership and rights of access to marine resources. An active marine data base on legal issues is clearly needed.)

c. <u>Scientific and Technical Support</u>

- The provision of data handling support and the supply of data gathered by others (as by a data center)
- The supply of equipment and training for research surveys
- The supply of scientific help in the form of personnel

d. <u>Operations Support</u>

- The supply of fleet support to a major survey program
- The supply of areal sea surface temperatures to a fishing vessel

e. <u>Political Value</u>

- The arrangement for political value to accrue to the supplier of a cooperative effort. This aspect can function to varying degrees in all segments of the organizational matrix making up the marine program.

These brief examples merely scratch the surface of the incentive and benefit structure that must inevitably be designed and employed in order to weld a strong national cooperative thrust out of the organizations which will of necessity be involved.

The following paragraphs mention two precedents of carefully designed incentives successfully employed in gaining support for other national programs.

- In the VELA program, which was aimed at upgrading the national capability to detect and identify underground nuclear explosions, recording stations were needed in numerous parts of the world. One of the solutions was the so called "give away program" in which complete seismograph recording stations were given to 125 interested universities and schools in foreign lands around the world. The recipients received modern equipment and the ability to better correlate their recordings with other observers. The United States received a daily copy (mailed once a week) of the records from all locations. Moreover, all records were highly correlatable because they were all produced on identical equipment.

- In the Nation's weather program, the Weather Bureau has placed, free of charge, standard weather station equipment aboard hundreds of merchant marine vessels. The vessel operators take readings and transmit them routinely by radio. In return they receive weather reports and forecasts along their planned course. Thus, sufficient incentives are provided to both parties to ensure effective cooperation. The Bureau checks and calibrates the equipment after each cruise, a task wisely not left in the hands of the merchant vessel operators.

Appendix H, Volume II contains preliminary recommendations to the effect that certain standard classes of instrumentation be developed, and further that key shipboard units such as a satellite tracker and a modular recording system be lent to investigators for use on various size ships. In each case the two-way benefits are described. These are intended to be practical examples of incentive programs for consideration in the National Marine Sciences Program.

F. EFFECTIVENESS OF DATA PROGRAMS

It is envisaged that one of the final products of Phase II will be the delineation of data system improvements in various organizations which will most effectively support the National Marine Science Programs. The data systems may be new systems or improvements of existing systems. One measure which will be employed to evaluate data system improvements is the degree to which improvement will enhance associated data programs. The purpose of the effectiveness evaluation is not to assess the quality of data programs. Data program requirements are treated as a "given" in the evaluation. Rather, an evaluation is made to determine the effectiveness of data systems which are required to support data programs. An example is the computer systems, procedures, personnel and software employed at the National Weather Records Center to support programs in climatology. The supporting data requirements will exist independent of the mechanisms for processing the associated data. However, an assessment of the effectiveness of data systems required to support climatology relative to data systems in support of other areas, provide one basis for determining priorities of data system implementation.

The most important consideration is not existing effectiveness, although this must be determined for each data system. Rather, it is the potential effectiveness which data systems are capable of achieving in the future which is of concern.

Data systems are evaluated on the basis of the incremental effectiveness which can be provided, the difference between current and future effectiveness values. By way of illustration, historically, much of the data provided by NODC has required considerable additional processing by the recipient in order to select the data of interest. NODC is developing programs to provide greater geographic, time and depth selectivity in data base retrieval. The incremental effectiveness of this new NODC service would be one of many improvements in data systems which would be considered in the development of data system priorities and schedules.

The mechanism for making the effectiveness evaluation is to develop a set of criteria and to measure the incremental effectiveness of a data management system in terms of the criteria. Criteria are classified by data collection and data center activities. Some examples of each are presented below:

Data Collection

- the degree to which data is useful to the Marine Science Community as a whole
- quality of data
- volume of data collected per unit time

Data Center

- quality of collections
- response time for requests
- degree of data retrieval selectivity

(See Section V, Volume I)

G. COST/BENEFIT/EFFECTIVENESS (C/B/E) ANALYSIS OF DATA PROGRAMS

After the effectiveness of data programs have been assessed by the process just described, additional factors need to be considered in order to complete the evaluation. Costs, benefits, effectiveness and available resources must all be considered when developing a set of data system plans and priorities.

Again, it should be noted that, whereas, a data program is the specification of data requirements, a data system is the <u>mechanism</u> for satisfying data requirements. C/B/E analysis is addressed to evaluating increments of increased data system capability. The following are definitions of the elements of the analysis.

- <u>Costs</u>. All costs of implementing and operating a data system, e.g., personnel, hardware and software.
- <u>Benefits</u>. Benefits to be derived from National Marine Science Programs which data system implementation supports, e.g., reduction in water pollution by implementing a data system to monitor water quality.
- <u>Effectiveness</u>. Increase in effectiveness of data systems, e.g., decrease in data retrieval response time at NODC.
- <u>Available Resources</u>. Available personnel, equipment, software, funds and time for implementing desired data system improvements.

A major input to the C/B/E analysis is a forecast of data program requirements in various organizations over a 5-10 year period. The forecast consists of requirements for data collection, storage, processing and dissemination. One module of the National Marine Data Planning System (NMDPS) will provide this forecast. Another module of the NMDPS will provide assistance in making the C/B/E evaluation of data system improvements. The first step in this process is to make an inventory of existing data system resources in the pertinent organizations. This activity consists of assembling information on the current use of sensors, platforms, data transmission systems and computer systems. After this inventory is completed, existing capabilities are compared with data program requirements. Increments in required data system capability are delineated for each organization. The additional resources required for implementing data system improvements are determined and the incremental benefits, effectiveness and costs are identified. Additionally, a feasible implementation schedule is determined based on existing resources and the availability of additional resources required. The product of this analysis is the specification of data system improvements which have the most favorable C/B/E relationships. (See Section VI, Volume I)

H. DATA SYSTEM REQUIREMENTS

The final output of Phase II will be a Technical Development Plan for marine data management for the next ten years. One part of the plan pertains to the implementation of the National Marine Data Planning System. The plan will be developed to ensure complete responsiveness to National Marine Science Program objectives, and the minimization of duplicative efforts in the development of efficient data traffic flows.

The Technical Development Plan will specify the general requirements for personnel, hardware and software but will not involve the evaluation of various manufacturers' instrumentation and computer hardware. However, the plan will be structured at the conclusion of Phase II so as to serve as an RFP for required instrumentation, communications, computer hardware and computer software systems.

After the cost/benefit/effectiveness analysis has been completed in Phase II and the Technical Development Plan has been approved, detailed specifications for the design of the required data systems need to be developed.

I. SUMMARY OF CONCLUSIONS AND RECOMMENDATIONS

This section contains short descriptions of key conclusions and recommendations derived from this Phase I study.

1. System Overview

- A loosely connected "zero-order" national marine data system currently exists consisting of organizations working in close harmony in some areas, and in isolation in others.
- All of the surveys, studies and plans compiled to date have isolated and described shortcomings and have made recommendations for system improvements.
- The problem of evolving the system to increasingly higher states of performance requires a series of tactical actions in immediate high priority areas, in parallel with strategies of planning the longer range aspects of system improvements.

Among the dozens of shortcomings currently existing in the national marine data management picture, as set forth in this report, certain central issues can be isolated in a relatively short list as follows:

- No ongoing index of national marine information sources and services exists.
- No central source of plans, programs and budgets exists in sufficient detail to forecast future requirements for marine data management.
- No central provision exists for "load balancing" of national data management capabilities to meet major program needs at minimum costs.
- No central index of legislation, legal and policy decisions exists for the world ocean and inland waterways.
- No unified incentive structure exists to provide motivation to organizations and individuals to "cooperate" in data exchange with the existing system.

The present lack of these foundation stones is impeding the delineation and execution of any systematic set of improvements. As a result:

- The marine sciences community is not, in general, a sophisticated handler of its information.
- Inter-organizational data flow is being restricted by:

  Lack of standardization

  Ownership restrictions and lack of incentives

  Classification restrictions
- Document storage and retrieval is a very weak system aspect.

2. Conclusions

The following list highlights some of the more detailed conclusions derived during the study:

- The National Marine Data Program should be supported by a national planning and coordination organization.
- Effective prediction of future data trends is required to ensure timely responses by organizations to changes in data program requirements.
- The mounting cost of data collection underscores the need for improved multiple-use data collection, storage, processing, and dissemination programs.
- Application of new sensors will increase tremendously the future volumes of data collected, as well as its accuracy, due to reduction of human error.
- Application of new platforms (buoys, etc.) and transmission techniques (satellites, etc.) will result in step-function increases in data volumes, types and forms. Resulting data will be subjected to increasingly sophisticated methods of analysis.
- The wide diversity of data types needed for development of the marine environment will continue to be a major data management problem area.
- With substantial increases in marine data volume and coverage of the world ocean there will be greater requirements for both research and operational data in a format which is amenable to high speed data reduction techniques.

- Preprocessing vs. postprocessing tradeoffs will become increasingly important in "networking" alternative systems for handling data derived through new continuous data collection techniques.

- Existing data management facilities, some of which already have large backlogs of unprocessed data, will be overwhelmed with the data inflow from new programs unless their capabilities are markedly expanded.

- The priorities of data management implementations should be based on the degree to which the corresponding improvements support National Marine Science Programs.

- The development of a National Marine Data Program should be viewed as a single integrated system from point of data collection to dissemination and use. All aspects of data management including collection, storage, processing and dissemination should be represented when new data programs are planned.

- Very little attention has been paid by the marine community to the determination of data management capabilities which will best serve multiple users.

- It will be necessary to evolve data management systems at the agency and organization level which will be coordinated and in harmony with national needs before a National Marine Data Program can be fully integrated. System development must start with alleviation of problems within these integral elements of the total system.

- Data program effectiveness should be evaluated for at least five years in the future in order to properly gear improvements to both near-term and long-term data program requirements.

- The great fluidity at this stage in the development of the marine environment demands that system flexibility be a primary design criterion.

- Incentives and benefits are the basic tools which must be used in breaking down non-technical constraints.

- The key to the derivation of multiple-use benefits from data originally collected for less broad purposes lies in the protection of the original owner's rights.

- Data management and document management should be considered as a single integrated information system.

- Determination of the data inventory of the marine community is one of the first requirements in developing an effective National Marine Data Program.

- No data management system can operate effectively without an evolutionary development of standards.

3. Recommendations

Principle recommendations follow:

a. Phase II Study

Authorize commencement of the Phase II Study in accordance with the enclosed approach in order to provide objective outputs for the FY'70 budget cycle.

b. National Marine Data Planning System

1) Commence structuring, design, and implementation of an ongoing National Marine Data Planning System composed of the following functional subsystems:

   - Policy
   - Programs
   - Fiscal
   - Technical information
   - Education and public relations
   - Legal information

2) Incorporate in each subsystem the capabilities of providing in an ongoing manner the information necessary for:

   - Planning
   - Decision making
   - Progress monitoring

3) As one of the early steps in the development of the National Marine Data Planning System, consider the following evolutionary steps:

   a) Initially develop and maintain an ongoing Marine Information Inventory Service which would serve to:

      - Define existing data sources (prime producers and data centers)
      - Describe their data content
      - Describe the services available
      - Define their costs
      - Describe the procedures for obtaining data and other services from these sources
      - Disseminate current information on these sources*
      - Act as a clearinghouse for directing user questions to the proper source(s).

   b) As a natural extension of the inventory function into the future add a forecasting capability composed of:

      - Gathering and maintaining the data management plans of marine organizations.
      - Integrating these plans into an ongoing national data management plan defining the distribution of data sources, functions, services performed, and capacities, currently and in the future.

*A function similar in principle to that performed by the Light Lists and Notice to Mariners published by the Coast Guard or the Flight Information Manual and the Airman's Guide issued by the FAA. The latter lists in great detail the up-to-date status of every airport (closed runways, obstructions at ends, scheduled maintenance, hours of tower and light operation, etc.), every jet approach corridor in three dimensions (including all holding patterns, speed limits, etc.), every navigation aid (radars, beacons, VOR's departure, enroute, and approach communications systems, lights, etc.) as well as a host of current procedures, standards and other aids to pilots.

This plan maintenance function does not, of course, include the benefits of long-range strategic national planning to be developed during Phase II. It does, however, integrate and establish a working relationship with the planners of existing organizations and this is a vital step toward strategic plan development.

c) Further extend the data management functions of the organization by including the following:

- Participation in the planning of new marine science programs.
- Participation in the planning for expansion or modification of existing marine science programs.
- The coordination of "load balancing" of data collection, transmission, analysis, storage and dissemination loads of programs requiring cooperation by more than one organization.

c. Standards Committee

Establish an ongoing Standards Committee composed of representatives from all segments of the Marine Sciences Program. The committee should study the status and evolutionary possibilities for the standardization of:

- Data collection hardware and practices
- Data transmission hardware and practices
- Data storage and retrieval hardware and practices
- Data processing hardware and practices
- Data dissemination hardware and practices

For the above functional areas the committee should:

- Continuously collect, evaluate, and merge existing standards and planned improvements.
- Assess the marine system benefits associated with alternative standardization policies.

- Serve as a cross-fertilization and coordination mechanism between marine science organizations.

- Formulate and recommend a series of unified standards together with suggested phasing schedules.

d. Incentives Committee

Establish an Incentives Committee composed of representatives from all segments of the National Marine Sciences Program, to perform the following functions:

- Study and document the motivations and behavioral responses of the spectrum of organizations and individuals working in the marine environment.

- Conceive various incentive structures designed to optimally motivate the organizations and individuals toward better cooperation in the sense of attaining national marine science goals.

- Evaluate alternative incentive structures through sampling, panel, and other review techniques.

- Formulate and recommend alternative unified incentive structures together with an assessment of the cost/benefits/effectiveness of each.

e. Organizational Improvements

- Identify and evaluate alternative data management improvements in each of the relevant agencies. Recommend a set of data management improvements at the conclusion of Phase II which will provide maximum support to national marine science activities. Specific activities are described in the Phase II Study Approach.

J. SUMMARY OF PHASE II STUDY APPROACH

A summary of the study approach to Phase II is presented below. A detailed description is contained in Section IX. Phase II will be conducted in six parts:

Part I: Analysis of the Needs of Data Service Customers (Months 1-4)

Part II: Delineation of Marine Data and the Means for Handling Them (Months 5-7)

Part III: Evaluation of Data Functions (Months 8-10)

Part IV: Design of Data Program Implementation Plans (Months 10-14)

Part V: Design of a National Marine Data Planning System (Months 8-14)

Part VI: Data Program Synthesis (Months 8-14)

1. Part I - Analysis of the Needs of Data Service Customers

The Part I study will focus on the needs of Federal, State, academic, industrial, and private users of marine data and data products and services which contribute to major purposes of marine science affairs. It is necessary to estimate the magnitude, frequency, characteristics, and criticality of these needs and how they are likely to develop and change in the future. Further, we must understand more clearly at this point how diverse data move, and through which channels they move, from producers to users; how long this takes; and the role of responsible agencies in this process.

a. Objectives

The objectives of Part I are to:

- Identify data producers and user communities and estimate the size of each.

- Classify the user community in terms of data needs and use. Some of the determinants of classes of data use are the following: purpose of data use; data type; frequency; volume, format, geography, quality, sample size, etc.; time requirements for data acquisition, transmission, and retrieval.

- Determine common and unique data needs within the marine science community.

- Evaluate the validity of stated needs.

- Determine the adequacy of existing data products and services to meet user needs.

- Establish the need for new or improved data products or services in advancing toward marine science goals.

- Estimate data acquisition and data service costs and describe benefits derived.

- Identify priorities among stated needs.

- Identify and illustrate the nature of data flow from diverse producers to a variety of data users.

b. Approach

As an approach to the Part I study, subject to change as additional information is acquired, we will consider specific identifiable user categories and representative data applications for each. User categories are the following: scientist; naval planner and operator; environmental forecaster; ocean engineer; industrial manager; fisherman; merchant mariner; Federal, State and municipal planners; and citizens concerned with recreational use of the coastal zone. As an example, representative data applications for the user category of scientist are those of research in: physical, biological and chemical oceanography; marine geology and geophysics; and air-sea interaction.

The research in Part I will be conducted in the form of a survey of known producers and users of marine data. Owing to the extent and detail of marine data activities, this survey will be conducted by means of personal interviews with individuals in the categories identified above. The questionnaire that will be used in the interviews is shown in Appendix G of Volume Two of this report.

In addition to standard data derived during interviews, respondents will be asked to illuminate the operation of the present marine data network with a case study, or "life history", of a specific marine data activity in which they have been or are personally involved. The intent of these histories is to identify the nature of marine data flow from original acquisition through various processing channels to end use.

c. Products

The results of Part I will be presented in a formal report accompanied by briefings. The report will consist of a brief summary of major findings, together with a more detailed narrative report describing and analyzing the composition and characteristics of the marine data user community according to the statement of objectives given previously.

2. Part II - Delineation of Marine Data and the Means for Handling Them

a. Objectives

Based on the survey and analysis of the needs of marine data users performed in Part I, it is the objective of this part of the study to identify and describe the primary marine data that should be subject to coherent management at the national level and to inventory and analyze the processing functions that various organizations currently perform on these data.

1) Data. The primary data that should be subject to management and coordination in a national marine data program will be delineated. Based on the description of data requirements, apparent unfulfilled national-level data needs will be identified and explained. Unfulfilled data needs may prove to be the result of any one or several of the following: data are not being collected; data are collected but are not available to all who require them; data usage may be restricted by security classification controls; data move too slowly through the marine data network; data are incompatible in time, space, quality, or storage media.

A description and rationale will be given for excluding any categories of data that are not regarded as appropriate or required for incorporation in a coherent national marine data management program.

2) Services. An inventory of organizations that currently perform service functions on marine data is to be made and their processing activities described. These service agencies will not be limited to marine data centers but will include all Federal and government-supported organizations which perform acknowledged and routine marine data services, in order to examine the degree to which these lend themselves to coordination within a national marine data management program.

b. Approach

In order to achieve the objectives stated, a threshold level of performance/cost relationship will be established to serve as a criterion for recommending inclusion of marine data categories within the scope of a national marine data program. In accomplishing the performance/cost analysis, several future funding levels for marine data management operations will be hypothesized in order to provide planning options. Similarly, performance/cost analysis will be performed on marine information service operations in order to assess the relative importance of existing service agencies in a national data management program; to identify service agencies that require upgrading in order to function properly as a component in a national program; and to indicate changes that will create a more effective operational facility.

c. Products

The results of Part II will be presented in a formal report accompanied by briefings. The report will consist of a brief summary of major findings, together with a more detailed report describing and analyzing marine data and data services that are recommended for a national marine data management program.

3. Part III - Evaluation of Data Functions

a. Objectives

Part I of the study will have produced a report of the expressed needs of users of marine data and data products. Part II will have produced a delineation of the categories of marine data appropriate for national-level management, and of the marine information services in current operation that lend themselves to national-level coordination. Part III of the study will evaluate these data and information services in order to identify characteristics which marine data and data services should possess in the national-level program. From this will be derived a statement of functional requirements for the national program that will represent goals considered achievable within the next decade. Specific functional characteristics are enumerated and illustrated below; the study will investigate their scope of application, sources of current inadequacies, appropriate criteria, and expected standards of performance, as well as the opportunities for significant improvements.

1) Data Processing. With respect to the technology of data handling, the study will cover historic, contemporary and future collections and will consider three primary processing activities: ship-board processing; land-based processing before data are deposited with a service agency; and processing performed at service agencies within the national marine data management program. The principal technological developments in terms of which the handling of marine data is being performed are to be identified, and the opportunities for their improvement are to be appraised. The study will focus on automated equipment utilization, communications systems, media and data codes, and storage and retrieval.

2) Accountability. There does not now exist a comprehensive national marine data inventory. Provisions for creating and maintaining an account of the accumulating marine data will be recommended. Appropriate methods for their application will be suggested.

3) Accessibility. Functional requirements for access to marine data holdings within the scope of a national marine data program will be identified. The study will include consideration of response time, redundancy, retrieval and restrictions on access due to proprietary or security controls.

4) Quality Control. Requirements for quality control of marine data will include consideration of instrumentation, sampling design, and control of post-observation manipulation.

5) Dissemination. Dissemination of marine data and data products will be investigated to determine the adequacy of existing dissemination methods in comparison with alternative or additional techniques.

6) Input Structure. Consideration will be given to the requirement for establishing standards for controlling the input structure and eligibility of marine data for the national program.

7) Archival Storage. Functional requirements for archival storage of marine data and data products will be based on an assessment of the adequacy of current storage methods and retrieval services.

8) Data Analysis. Requirements pertaining to data analysis refer to the methods employed for analyzing, reducing, and packaging marine data to make them more useful.

9) Development. Firm recommendations for functional requirements to be established within the national marine data program should recognize not only the status of current operations, but also the technological feasibility of achieving significant improvements. A review of research and development will be conducted, concentrating on the major problems of collecting, processing, recovering, publishing, and displaying marine data.

b. Approach

Part III will consist of an analytic effort supported by highly selective interviews with appropriate experts in such technical fields as sensors, platforms, communications, library services, information processing, and displays. The emphasis will be on identifying functional requirements and establishing the technical feasibility of means for satisfying these requirements.

c. Products

The results of Part III will be presented in a written report accompanied by a briefing. The report will describe the functional requirements and the technical feasibility of implementing improvements for the nine topic areas enumerated under Part III.a, Objectives, above.

4. Part IV - Design of Data Program Implementation Plans

a. Objectives

The technical analyses conducted during the Phase II study will result in the publication of a recommended ten-year Technical Development Plan for the national data management program. On the basis of the information developed in preceding parts of the study, alternatives for improvements will be analyzed, and recommended data management initiatives will be presented with a view to their adoption by the various responsible agencies. The Technical Development Plan will recommend priorities and schedules for implementation, and will specify the resources -- personnel, equipment, facilities, and money -- considered necessary to implement the plan. Several options of the plan will be developed based on alternative levels of assumed Federal funding.

b. Approach

A performance/cost analysis will be made for each option of the Technical Development Plan.

c. Product

The results of Part IV will be presented in the written Technical Development Plan accompanied by briefings.

5. Part V - Design of a National Marine Data Planning System - NMDPS

a. Objectives

Experience has shown that among the factors involved in implementing improvements to an information processing network as complex as the national marine data management program, effective coordination of the many activities is critical. Coordination, in this context, is the technical management and design control that ensure that implementation schedules are appropriately phased and that resultant operations do indeed fulfill the objectives for which they were intended. The Phase II study will analyze requirements for a National Marine Data Planning System (NMDPS) to perform the planning and management functions for the national marine data management program.

b. Approach

A concept of operations and a recommended organization of the NMDPS will be specified, based on discussions with personnel of the Marine Sciences Council and with personnel experienced in the design and control of comparable developmental programs in the military and civilian environment.

c. Product

The product will be presented in a written report, accompanied by briefings, setting forth the responsibilities, organization, and operational concept of the proposed NMDPS.

6. Part VI - Data Program Synthesis

a. Objectives

This part of the study is to be conducted concurrently with Part IV, Design of Data Program Implementation Plans. The purpose is to appraise the requirements and configuration of the total national marine data management program that has been recommended in preceding parts of the study and to ensure the consistency of each part with the whole: users' needs, scope of the data and service agencies supporting the national interest, functional requirements for improved data management, the Technical Development Plan, and the National Marine Data Planning System.

b. Approach

The approach employed will be that of reviewing for consistency each of the reports delivered in preceding parts of the study, with particular attention to the technical configuration for a national marine data management program contained in the Technical Development Plan.

c. Product

No independent product will result from this part of the study. If the synthesis indicates the necessity, revisions or addenda to preceding reports may be issued. The Technical Development Plan will reflect the findings of the synthesis in its recommendations.

III. PROBLEM DESCRIPTION

As stated in the Introduction, the approach used in this study is first to identify National Marine Science Programs and objectives; second, describe and analyze relevant organizations and functions which support national programs; and, third, analyze the data program requirements needed to support organization functions. These three facets of the marine data problem are discussed in this section under National Marine Science Programs, Functional Requirements and Data Program Requirements, respectively.

A. NATIONAL MARINE SCIENCE PROGRAMS

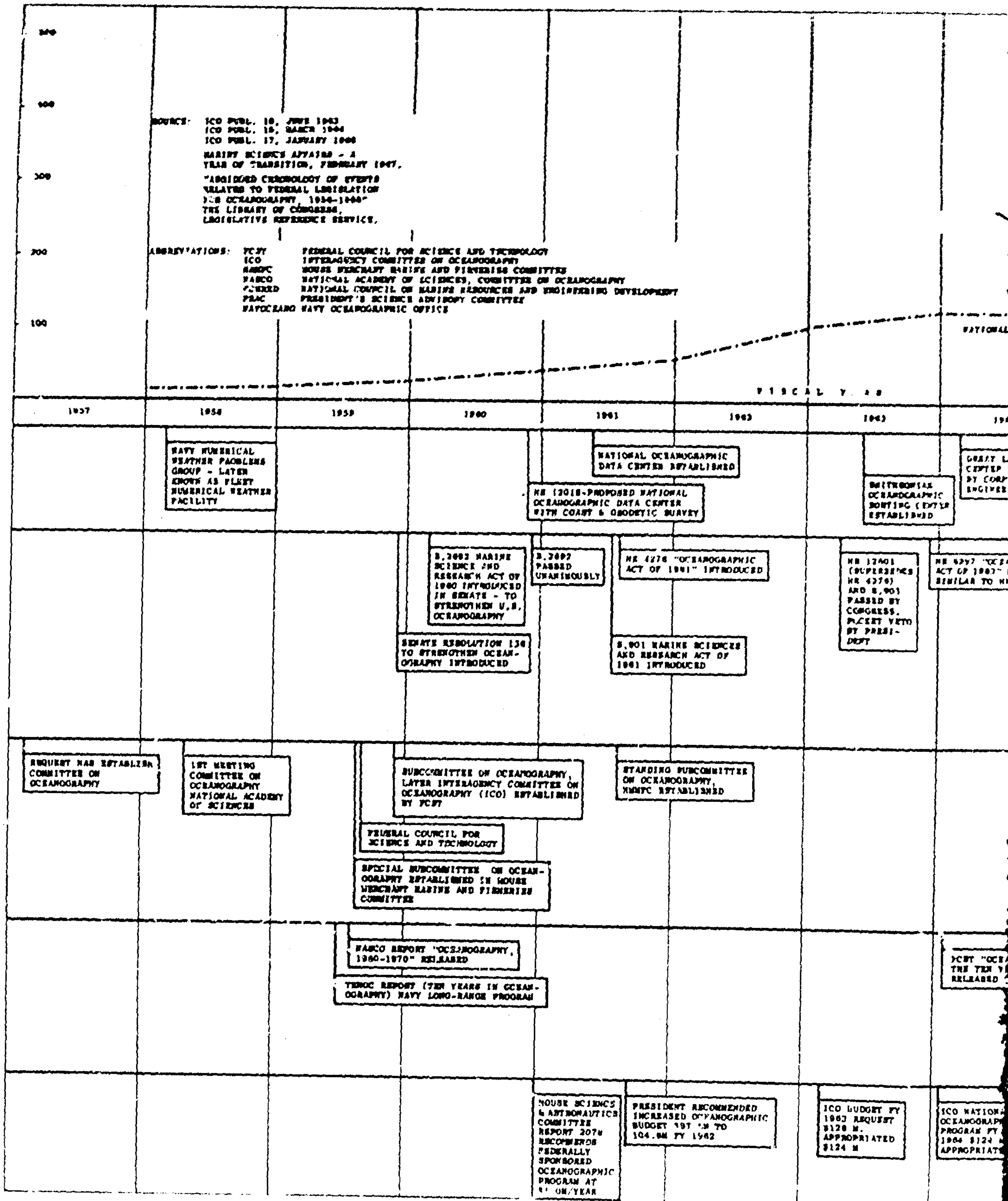
The evolution of the National Marine Science Programs involves, to varying degrees, the responses of national planners and decision makers to past legislative enactments and resulting national marine policy. The following synopsis of these important directives suggests the logic upon which the national programs and their supporting organizations have developed:

1. Legislation and Policy

During recent years, a greater sense of national urgency has developed for increasing the intensity and effectiveness with which the National Marine Science Programs are conducted. Recognition of the undersea threat to national security, the importance of oceanic science and technology to world affairs, and the increased international interest in the exploitation of marine resources have provided the major stimulants to this increased national concern.

During the last several years, a number of new laws and national events have appeared which are indicative of the urgency attributed to marine affairs. Figure 8 documents some of the more important milestones in the evolution of the National Marine Science Programs. The relationship of these events to the growth of the marine program budget is also shown.

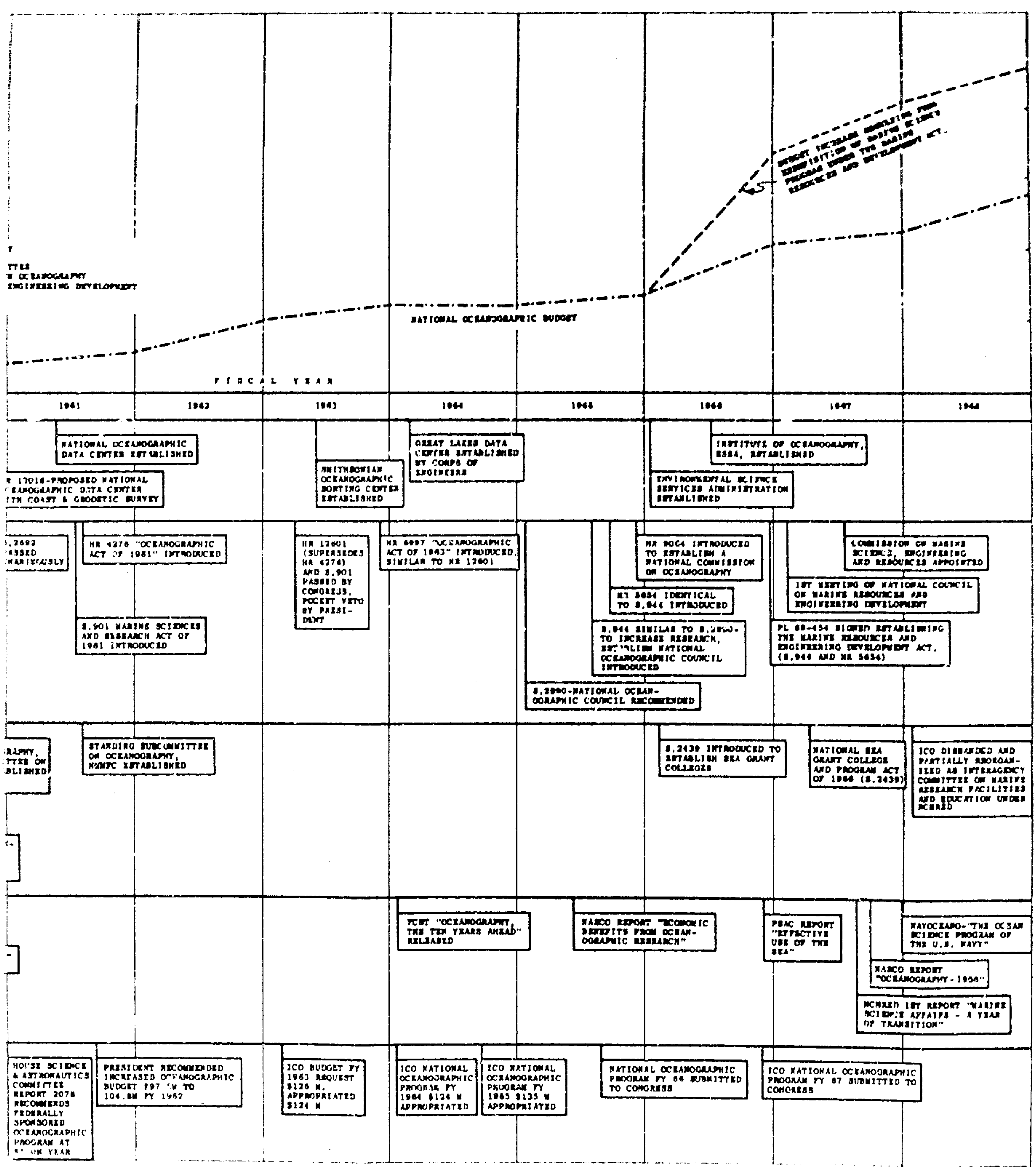
Starting with the establishment of the National Academy of Science Committee on Oceanography in 1958, a number of study groups and advisory committees have been established to define the needs and objectives of the National Marine Science Programs. Correspondingly, legislation has been enacted to support these research and advisory functions. During these interim years, however, the implementation and related funding of the various recommendations of the advisory organizations have been less extensive than might be desired.



SOME MAJOR EVENTS IN UNITED STATES MARINE
COMPARED TO THE NATIONAL MARINE

FIGURE 8

A



'NTS IN UNITED STATES MARINE SCIENCE PROGRAMS
'ARED TO THE NATIONAL MARINE BUDGET

FIGURE 8

B

A primary requirement for developing and implementing an effective National Marine Data Program is the organization of a concerted and coordinated federal effort in marine affairs. To meet the need for a coordinated federal effort, the Interagency Committee on Oceanography (ICO) of the Federal Council on Science and Technology was, since 1959, responsible for integrating programs of government agencies into the framework of a national oceanographic program. However, enactment of the 1966 Marine Sciences Act has moved the national marine program one step closer to effective coordination by unifying existing marine activities at the Presidential level. To implement this unifying approach to the national marine problems, the National Council on Marine Resources and Engineering Development* was established as a policy planning and coordinating arm of the President. The Council, although not an operating agency, represents the focal point for the definition of national goals, for the identification of alternate strategies for their achievement, and for selecting among alternatives and implementing programs through the federal agencies. In support of the Council functions, panels of the ICO are being reestablished to serve as the essential mechanism for compiling and disseminating information on the many marine programs. Also, the National Academy of Sciences Committee on Oceanography continues to serve the Council as a scientific advisor on oceanographic matters.

It should be noted that although legislative acts provide the framework for national programs, in actuality, it is the organizations themselves that evolve national policy. Thus, rather than conceiving of national programs evolving from a one-way communication from national planners to agencies it should be recognized that the development of national programs also involves communication from agencies to national planners.

2. The National Marine Science Programs

The various federal agencies and the Marine Sciences Council, as the primary coordinating entity, are committed to the achievement of the national marine environment objectives, specified in the Marine Resources and Engineering Development Act of 1966 (PL89-454). Also, the federal agencies have identified a number of National Marine Science Programs, within the scope of marine science, engineering, technology and resources development, which

*For brevity in this report, the National Council on Marine Resources and Engineering Development will be called the "Marine Sciences Council," or simply, the "Council."

are directed to the achievement of the national objectives. A matrix displaying the broad relationships between the national objectives, the National Marine Science Programs and the federal agencies appears in Figure 9.

As illustrated in the figure, the National Marine Science Programs are directed to the achievement of the national marine environment objectives. The benefits to be derived from the national programs are also specified in the figure.

The federal effort devoted to the national programs is illustrated by Figure 10, which documents these programs and the related federal funding for their conduct by the various agencies. Inspection of this figure also reveals the relative magnitudes and growth rates of the economic resources committed to the national programs by the various agencies. Specific implications of agency participation are discussed in later parts of this section.

The relationships between the National Marine Science Programs and the federal agencies are further summarized in Figu: 11. It should be noted that the various federal agencies are often sponsible for major contributions to more than one National Marine Science Program. Inspection of the missions of the federal agencies, which also appear in the figure, suggests the diversity of responsibilities experienced by each agency. This diversity of responsibility will be given careful attention during the analyses of each organization's functional and data requirements, which is described in later parts of this section.

In theory, the missions of the various federal agencies should be derived from the requirements of the National Marine Science Programs which, in turn, should be formulated in response to the national marine science objectives. In fact, however, the missions of the federal agencies have arisen partially during time periods when national objectives were not well-defined. Consequently, the federal agency coordination in these programs is not designed, but rather is a relationship which grew over time to meet needs. It cannot, therefore, be expected to be optimal. Implications of this condition h. e an important effect on the approach developed during this study phase.

3. Some Important Considerations

Some important considerations related to the national programs are discussed below. These observations have special relevance to the remainder of this Problem Description section.

NATIONAL MARINE OBJECTIVES

(FROM MARINE RESOURCES AND ENGINEERING DEVELOPMENT ACT OF 1966)

- ACCELERATE DEVELOPMENT OF MARINE ENVIRONMENT RESOURCES
- EXPANSION OF HUMAN KNOWLEDGE OF MARINE ENVIRONMENT
- ENCOURAGEMENT OF PRIVATE INVESTMENT IN MARINE EXPLORATION, TECHNOLOGY, COMMERCE, AND RESOURCE USE
- PRESERVATION OF U.S. ROLE AS LEADER IN MARINE SCIENCE AND RESOURCE DEVELOPMENT
- ADVANCEMENT OF EDUCATION AND TRAINING IN MARINE SCIENCE
- DEVELOPMENT OF INSTRUMENTATION, FACILITIES AND EQUIPMENT FOR USE IN RESEARCH, EXPLORATION, AND EXPLOITATION OF MARINE ENVIRONMENT RESOURCES
- EFFECTIVE USE OF SCIENTIFIC AND ENGINEERING RESOURCES OF NATION THROUGH CLOSE COOPERATION OF GOVERNMENT AND PRIVATE ORGANIZATIONS
- ADVANCEMENT OF INTERNATIONAL COOPERATION IN MARINE SCIENCE ACTIVITIES

FEDERAL AGENCY MISSIONS

NATIONAL MARINE SCIENCE PROGRAMS	DEPARTMENT OF DEFENSE — ALL OCEANOGRAPHY RELATED TO NATIONAL DEFENSE, RESEARCH, TECHNOLOGY, CHARTING, ... OCEAN, RIVERS, HARBOR, COASTAL ... DEVELOP. SHORE, PRINCIPAL RIVERS, HARBORS, COASTAL	DEPARTMENT OF STATE — U.S. PARTICIPATION IN INTERNATIONAL ORGANIZATIONS, SUPPORT OF INTERNATIONAL COMMISSIONS	AGENCY FOR INTERNATIONAL DEVELOPMENT — SUPPORT OF ...	DEPA...
NATIONAL SECURITY DEVELOPMENT OF U.S. MILITARY CAPABILITY TO OPERATE, OFFENSIVELY AND DEFENSIVELY, THROUGHOUT THE TOTAL MARINE ENVIRONMENT TO ASSURE EQUITABLE BALANCE IN INTERNATIONAL COMPETITION FOR STRATEGIC OCEAN POSITIONS AND FOR OCEAN RESOURCES.	$191,600,000			
FISHERY DEVELOPMENT AND SEA FOOD TECHNOLOGY MANAGEMENT, CONSERVATION, AND DEVELOPMENT OF THE MARINE FISHERIES RESOURCES FOR A GROWING DOMESTIC POPULATION AND TO MEET WORLD NUTRITIONAL DEFICITS.				
MAPPING AND CHARTING DEVELOPMENT AND MAINTENANCE OF RELEVANT DATA COLLECTIONS OF WORLD OCEAN AREAS TO FACILITATE THE UNDERSTANDING OF MARINE ENVIRONMENT PROCESSES AND ECOLOGY.	$22,900,000			$16,200,00
TRANSPORTATION ADVANCEMENTS IN THE NATIONAL CAPABILITY TO INSURE SAFE, SWIFT, AND ECONOMICAL MOVEMENT OF PEOPLE AND COMMODITIES OVER WORLD WATERWAYS THROUGH IMPROVED UNDERSTANDING AND CONTROL OF THE MARINE ENVIRONMENT.	$2,700,000			$8,500,00
OCEAN ENVIRONMENTAL OBSERVATION AND PREDICTION IMPROVEMENT IN THE SHORT-RANGE AND LONG-RANGE PREDICTION OF MARINE ENVIRONMENTAL CONDITIONS, INCLUDING HURRICANES AND TROPICAL STORMS, TO BETTER SERVICE LAND ACTIVITIES (INDUSTRIAL, COMMERCIAL, AGRICULTURAL, RECREATIONAL) AND SEA OPERATIONS (FISHING, MARITIME COMMERCE, AND NAVAL OPERATIONS) AFFECTED BY WEATHER CONDITIONS, AND TO SAVE LIVES AND PROPERTY.	$11,000,000			$2,100,00
RECREATION THE CONSERVATION AND EFFECTIVE MANAGEMENT OF RESOURCES WITHIN THE MARINE ENVIRONMENT TO ARREST TRENDS TOWARD DEGRADATION OF RECREATIONAL NATURAL FACILITIES AND THEIR RELATED AESTHETIC VALUE.	$1,400,000			
MARINE POLLUTION ABATEMENT AND CONTROL THE CONSERVATION AND EFFECTIVE MANAGEMENT OF RESOURCES OF THE OCEAN, LAKES, AND RIVERS TO CONTROL ALL ADVERSE MODIFICATIONS OF THE MARINE ENVIRONMENT ARISING FROM ALL FORMS OF SEA AND AIR POLLUTION, INCLUDING NUCLEAR WASTE.	$100,000			
INTERNATIONAL COOPERATION AND COLLABORATION ADVANCEMENT OF WORLD PEACE, UNDERSTANDING, AND ECONOMIC DEVELOPMENT AT HOME AND ABROAD, AND THE REDUCTION IN POSSIBLE CONFRONTATION BETWEEN NATIONS STIMULATED BY ACCELERATED USE OF THE WORLD OCEANS.		$5,400,000	$2,000,000	
HEALTH IMPROVEMENT IN ALL FACETS OF NATIONAL HEALTH THROUGH THE DEVELOPMENT OF MARINE MEDICATIONS, THE EXPLOITATION OF THE NUTRITIONAL VALUE OF MARINE FOODS, AND THE REDUCTION OF MARINE POLLUTION.				
MINERAL, CHEMICAL, WATER, AND ENERGY RESOURCES DEVELOPMENT OF INCREASED KNOWLEDGE AND CAPABILITIES FOR EXPLOITING OIL, GAS, AND MINERAL RESOURCES CONTAINED WITHIN THE MARINE ENVIRONMENT, AND FOR HARNESSING HYDRAULIC ENERGY AND FRESH WATER RESOURCES FOR NATIONAL AND INTERNATIONAL ECONOMIC WEALTH AND GROWTH.				
EDUCATION DEVELOPMENT OF RESEARCH, ENGINEERING AND OTHER TECHNICAL MANPOWER RESOURCES TO STRENGTHEN THE BASE OF SPECIALIZED EDUCATION AND OCEAN ENGINEERING RESEARCH, AND TO IMPROVE COMMUNICATION OF SCIENTIFIC AND TECHNOLOGICAL RESULTS TO MANY MARINE SCIENCE INTERESTS LACKING THEIR OWN RESEARCH CAPABILITIES.	$1,100,000			$100,00
SHORE AND HARBOR STABILIZATION AND PROTECTION DEVELOPMENT OF PROCESSES AND ENGINEERING TECHNIQUES FOR DIMINISHING BEACH EROSION AND HARBOR DAMAGE FROM BOTH NATURAL AND ARTIFICIAL ADVERSE MARINE ENVIRONMENTAL CONDITIONS	$1,700,000			
MULTIPURPOSE OCEANOGRAPHIC RESEARCH (AND ENGINEERING) THE DEVELOPMENT OF NECESSARY TOOLS AND PROCESSES THROUGH BASIC RESEARCH AND OCEAN ENGINEERING TO PROVIDE THE NECESSARY STRUCTURE AND SUPPORT UPON WHICH THE NATIONAL PROGRAMS CAN FLOURISH	$27,000,000			$8,900,00

SOURCE (PARTICALLY ADAPTED FROM)
(1) MARINE SCIENCE AFFAIRS - A YEAR IN TRANSITION, FIRST REPORT TO CONGRESS ON MARINE RESOURCES AND ENGINEERING DEVELOPMENT, FEBRUARY 1967 [illegible]
(2) EFFECTIVE USE OF THE SEA, PANEL ON OCEANOGRAPHY, PRESIDENT'S SCIENCE ADVISORY COMMITTEE.

RELATIONSHIPS OF NATIO
NATIONAL MARINE SCIENCE PROGRA
FIGURE

A

...NS

...ED TO NATIONAL DEFENSE

...NG OCEAN RIVERS, HARBOR, COASTAL
...PERIMENT RIVERS, HARBORS, COASTAL

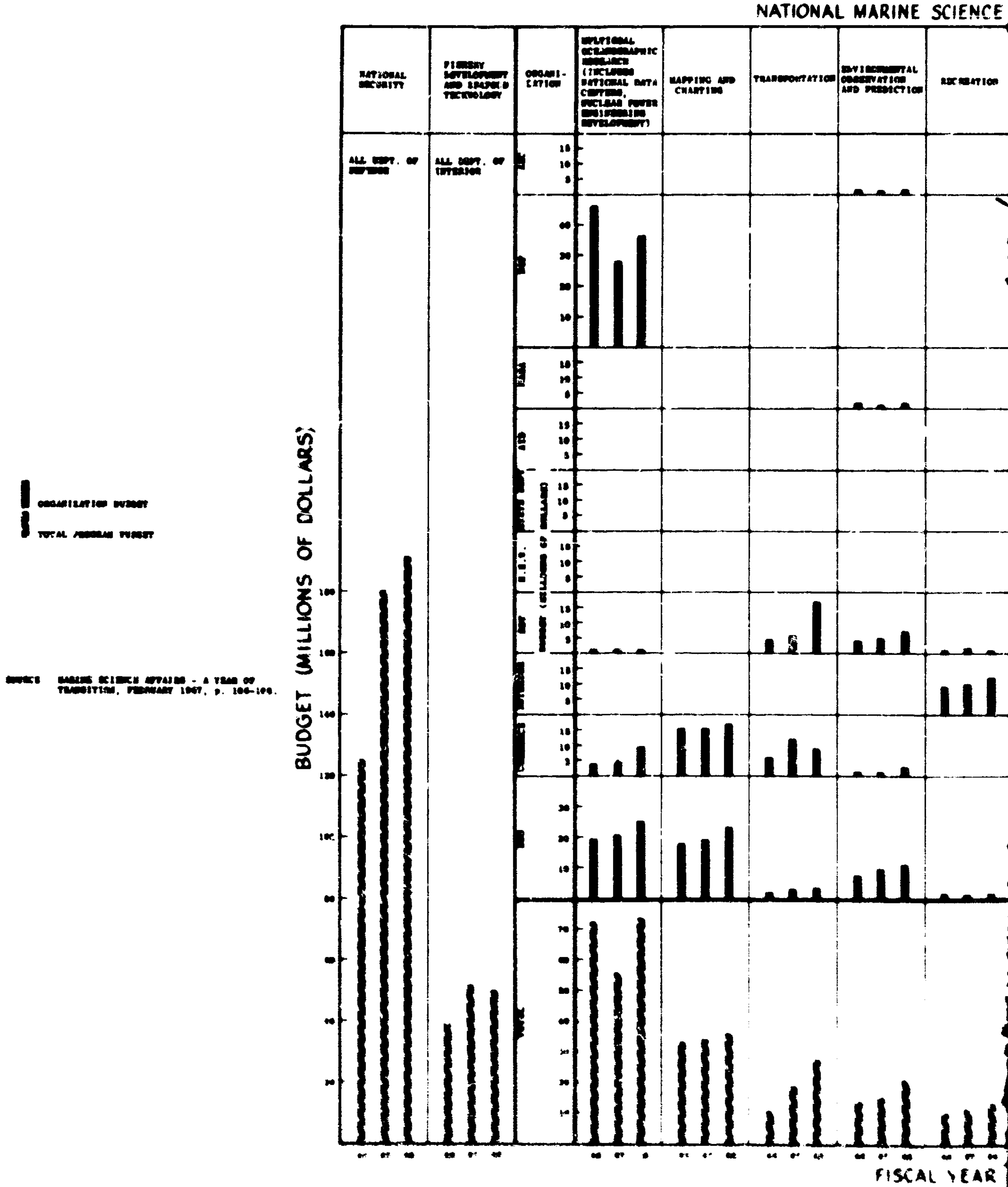
...TMENT OF STATE U.S. PARTICIPATION IN INTERNATIONAL ORGANIZATIONS SUPPORT OF INTERNATIONAL COMMISSIONS	AGENCY FOR INTERNATIONAL DEVELOPMENT FOREIGN ASSISTANCE RELATED TO MARINE ENVIRONMENT	DEPARTMENT OF COMMERCE ENVIRONMENTAL PREDICTION AND DESCRIPTION RESPONSIBILITY FOR AIR-SEA INTERACTION PROGRAM CHARTING AND MAPPING COASTAL AND DEEP OCEAN RESEARCH ON SHIPBUILDING, OPERATIONS, AND TRANSPORT SYSTEMS	DEPARTMENT OF INTERIOR MANAGEMENT, CONSERVATION, DEVELOPMENT OF MARINE NATURAL RESOURCES MONITORING OF WATER QUALITY STANDARDS PRESERVATION, DEVELOPMENT OF COASTAL AREAS TECHNOLOGY DEVELOPMENT FOR MINERAL RESOURCE EXPLOITATION	DEPARTMENT OF TRANSPORTATION SAFETY AT SEA DELINEATION AND PREDICTION OF ICE MASSES OCEANOGRAPHIC SERVICES	DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE RELATION OF MARINE ORGANISMS TO HEALTH AND POLLUTION MARINE SCIENCE AND ENGINEERING EDUCATION	ATOMIC ENERGY COMMISSION EFFECTS OF RADIOACTIVITY IN THE MARINE ENVIRONMENT DEVELOPMENT OF MARINE NUCLEAR TECHNOLOGY	NATIONAL SCIENCE FOUNDATION BASIC AND ACADEMIC OCEANOGRAPHY HIGHER EDUCATION IN MARINE SCIENCE AND ENGINEERING SEA GRANT PROGRAM	SMITHSONIAN INSTITUTION IDENTIFICATION, CLASSIFICATION, ECOLOGY OF MARINE ORGANISMS INVESTIGATIONS OF GEOLOGICAL FACTORS OF OCEANIC ENVIRONMENT	NATIONAL AERONAUTICS AND SPACE ADMINISTRATION FEASIBILITY, DESIGN, ENGINEERING OF SPACECRAFT AND SENSORS FOR OCEAN OBSERVATIONS
			$49,200,000						
		$16,200,000							
		$8,500,000		$16,600,000					
		$2,100,000		$6,400,000		$900,000			$800,000
			$11,900,000	$300,000					
			$5,000,000			$4,400,000			
...0	$2,000,000								
					$4,200,000				
			$5,800,000						
		$100,000	$200,000	$100,000	$600,000		$3,400,000		
		$8,900,000		$1,100,000		$10,500,000	$36,500,000	$1,800,000	

NOTE: NUMBER ENTERED IS FY 68 BUDGET
WHERE CELL IS BLANK, NO DIRECT RELATIONSHIP APPEARS TO EXIST.

...DS OF NATIONAL MARINE OBJECTIVES,
...ENCE PROGRAMS AND FEDERAL AGENCY MISSIONS
FIGURE 9

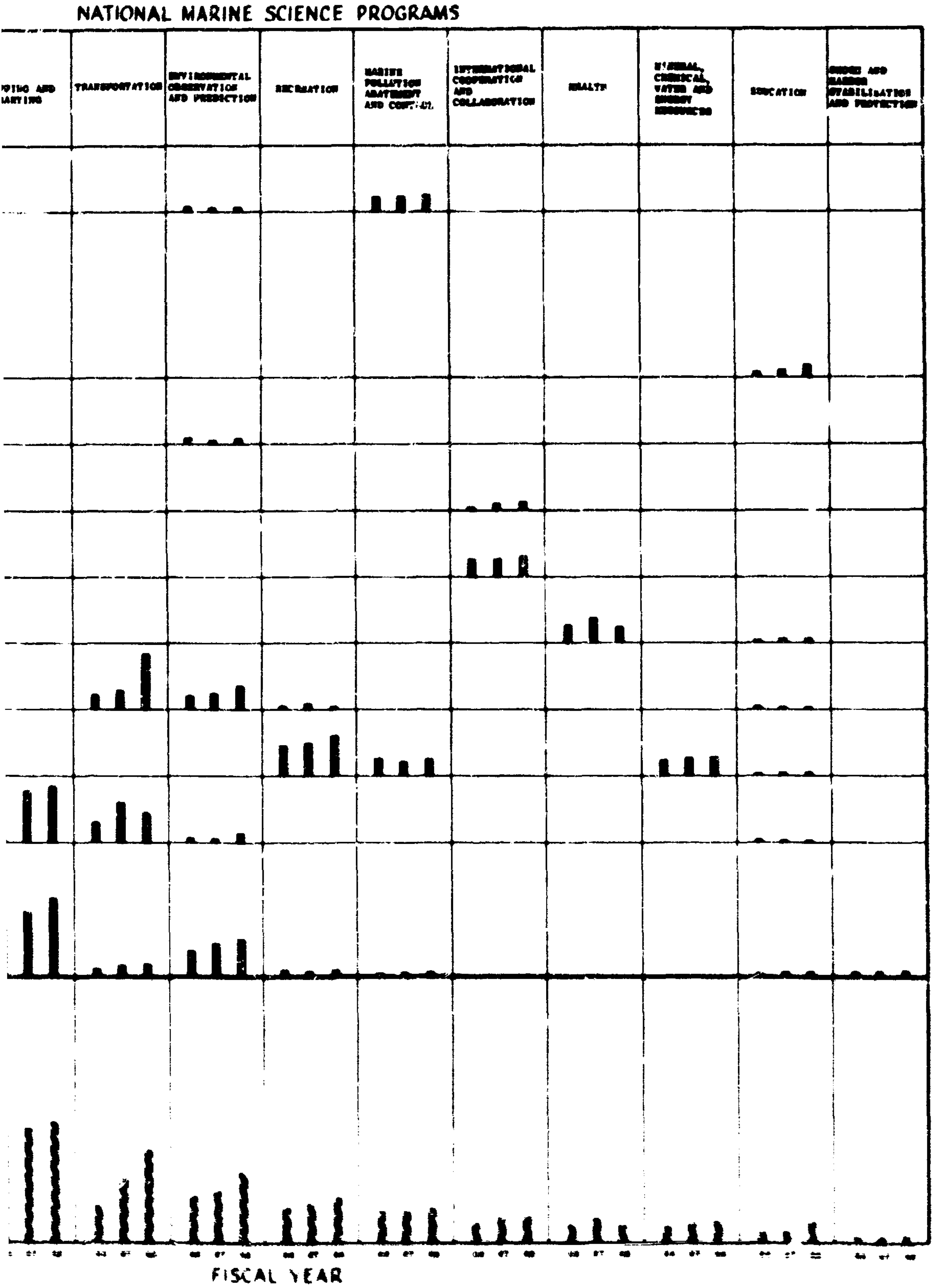
B

NATIONAL MARINE SCIENCE



ORGANIZATION BUDGET FOR MA
MARINE SCIENCE PROG
FIGURE 1C

.(L)-3705/003/00



'ION BUDGET FOR MAJOR UNITED STATES 'NE SCIENCE PROGRAMS 1966-1968

FIGURE 10

B

NOTE: BASED ON DATA AVAILABLE AND NOT INTENDED TO BE COMPREHENSIVE.

SOURCES: MARINE SCIENCE AFFAIRS - A YEAR OF TRANSITION, FEBRUARY, 1967, p. 19-20

ESIA/CEI/E384 OPERATIONS RESEARCH REPORTS FOR THE NATIONAL OCEAN SURVEY PROGRAM, [illegible], Vol. I, p. 94-99.

ORGANIZATION	NATIONAL PROGRAMS SUPPORTED	MISSIONS
DEPARTMENT OF DEFENSE, NAVY NATIONAL OCEANOGRAPHIC DATA CENTER	. NATIONAL SECURITY . OCEANOGRAPHIC RESEARCH . FISHERIES DEVELOPMENT AND SEAFOOD TECHNOLOGY . TRANSPORTATION . OCEAN ENVIRONMENTAL OBSERVATION AND PREDICTION	. ACQUIRE, COMPILE, PROCESS [illegible] PRESERVE OCEANOGRAPHIC D[illegible]
DEPARTMENT OF DEFENSE, NAVY NAVAL OCEANOGRAPHIC OFFICE	. NATIONAL SECURITY . OCEANOGRAPHIC RESEARCH . ENVIRONMENTAL OBSERVATIONS AND PREDICTION	. COLLECT, PROCESS, STORE AN[illegible] DISSEMINATE OCEANOGRAPHIC [illegible] REQUIRED BY THE NAVY
DEPARTMENT OF COMMERCE, ENVIRONMENTAL SCIENCE SERVICES ADMINISTRATION	. OCEANOGRAPHIC RESEARCH . MAPPING AND CHARTING . TRANSPORTATION . OCEAN ENVIRONMENTAL OBSERVATION AND PREDICTION	. UNDERSTAND AND DESCRIBE PHY[illegible] ENVIRONMENT . PREDICT THE STATE OF THE OC[illegible] AND ATMOSPHERE . DETERMINE PRECISELY THE SIZ[illegible] SHAPE OF THE EARTH . CHARTING AND MAPPING COASTA[illegible] AND DEEP OCEAN WATERS.
DEPARTMENT OF TRANSPORTATION, COAST GUARD	. ENVIRONMENTAL OBSERVATION AND PREDICTION . TRANSPORTATION	. DELINEATION AND PREDICTION [illegible] MASSES . SAFETY AT SEA . DATA CONTRIBUTIONS TO UNDER[illegible] AND PREDICTION OF OCEAN F[illegible]
DEPARTMENT OF THE INTERIOR, BUREAU OF COMMERCIAL FISHERIES	. FISHERY DEVELOPMENT AND SEAFOOD TECHNOLOGY	. ASSESSMENT, DEVELOPMENT AND MANAGEMENT OF FISHERY RE[illegible] . TECHNICAL AND ECONOMIC ASSI[illegible] TO THE COMMERCIAL FISHING INDUSTRY
DEPARTMENT OF THE INTERIOR, OFFICE OF SALINE WATER	. MINERALS, CHEMICALS, WATER, AND ENERGY RESOURCES	. MEASUREMENT AND ENFORCEMENT [illegible] WATER QUALITY STANDARDS
DEPARTMENT OF THE INTERIOR, GEOLOGICAL SURVEY	. MINERALS, CHEMICALS, WATER AND ENERGY RESOURCES	. MANAGEMENT, CONSERVATION [illegible] DEVELOPMENT OF MARINE [illegible] RESOURCES
DEPARTMENT OF THE INTERIOR, BUREAU OF MINES	. MINERALS, CHEMICALS, WATER AND ENERGY RESOURCES	. IDENTIFICATION, DEVELOPMENT [illegible] APPLICATION OF TECHNOLOGY [illegible] EVALUATION OF MINERAL [illegible]
DEPARTMENT OF THE INTERIOR BUREAU OF SPORT FISHERIES AND WILDLIFE	. FISHERY DEVELOPMENT AND SEAFOOD TECHNOLOGY RECREATION	. MANAGEMENT, CONSERVATION [illegible] DEVELOPMENT OF MARINE NAT[illegible] RESOURCES, PRIMARILY FOR [illegible] RECREATIONAL ACTIVITIES
DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE, PUBLIC HEALTH SERVICE	. HEALTH	. RELATIONSHIPS OF MARINE [illegible] TO HEALTH [illegible]
SMITHSONIAN INSTITUTION	. OCEANOGRAPHIC RESEARCH ESTUARINE STUDIES FISHERIES DEVELOPMENT AND SEAFOOD TECHNOLOGY	. IDENTIFICATION, [illegible] AND [illegible] OF MARINE [illegible]
[illegible] COMMISSION	. MARINE POLLUTION TREATMENT AND CONTROL . ENVIRONMENTAL OBSERVATION AND PREDICTION	. EFFECTS OF [illegible] MARINE ENVIRONMENT
[illegible]	. [illegible] . [illegible] . [illegible]	. [illegible]

MISSIONS, FUNCTIONS AND [illegible]
ORGANIZATIONS WITHIN THE [illegible]

03/00

...D	MISSIONS	FUNCTIONS	DATA REQUIREMENTS
...ATION	. ACQUIRE, COMPILE, PROCESS AND PRESERVE OCEANOGRAPHIC DATA	. DISCOVERS AND DEVELOPS SOURCES OF OCEANOGRAPHIC INFORMATION . DEVELOPS AND APPLIES QUALITY CONTROL AND EDITING PROCEDURES FOR USE WITH RECEIVED DATA . INDEXES, CATALOGUES, AND ARCHIVES RECEIVED DATA . USES STORED DATA TO DEVELOP CHARTS, STANDARD AND SPECIAL REPORTS SATISFIES REQUESTS FOR INFORMATION FROM THE PUBLIC, THE FEDERAL AGENCIES AND THE ACADEMIC COMMUNITY	PHYSICAL BIOLOGICAL GEOLOGICAL CHEMICAL CLIMATOLOGICAL ACOUSTIC GEOPHYSICAL
	. COLLECT, PROCESS, STORE AND DISSEMINATE OCEANOGRAPHIC DATA REQUIRED BY THE NAVY	. CONDUCT WORLD-WIDE OCEANOGRAPHIC SURVEYS . DEVELOP AND PROVIDE SYNOPTIC DATA . RESEARCH AND DEVELOPMENT OF TECHNIQUES AND EQUIPMENT . TIME-SERIES MEASUREMENTS	PHYSICAL, CHEMICAL, BIOLOGICAL ACOUSTIC, GEOLOGICAL, GEOPHYSICAL BATHYMETRIC, METEOROLOGICAL, GEODESY ENGINEERING PROPERTIES
...TION	. UNDERSTAND AND DESCRIBE PHYSICAL ENVIRONMENT . PREDICT THE STATE OF THE OCEAN AND ATMOSPHERE . DETERMINE PRECISELY THE SIZE AND SHAPE OF THE EARTH . CHARTING AND MAPPING COASTAL AND DEEP OCEAN WATERS	. GATHERS, PROCESSES, AND ISSUES INFORMATION ON WEATHER CONDITIONS, RIVER WATER HEIGHT, COASTAL TIDES AND CURRENTS, MOVEMENT OF OCEAN CURRENTS, THE STRUCTURE AND SHAPE OF OCEAN BASINS, SEISMIC ACTIVITY, THE PRECISE SIZE AND SHAPE OF THE EARTH AND CONDITIONS IN THE UPPER ATMOSPHERE AND SPACE. . MAINTAIN WARNING SYSTEMS AGAINST HURRICANES, TORNADOES, FLOODS AND SEISMIC SEA WAVES. . MEASUREMENT OF EARTH'S GRAVITY FIELD, ESPECIALLY FOR GEODETIC APPLICATIONS. . MEASUREMENT OF EARTH'S MAGNETIC FIELD, BOTTOM TOPOGRAPHY, CURRENTS AND TIDES.	PHYSICAL, GEOLOGICAL ACOUSTIC, GEOPHYSICAL ELECTRICAL, SOCIO-ECONOMIC OPTICAL, METEOROLOGICAL CHEMICAL, BATHYMETRIC GEODESY
	. DELINEATION AND PREDICTION OF ICE MASSES . SAFETY AT SEA . DATA CONTRIBUTIONS TO UNDERSTANDING AND PREDICTION OF OCEAN PROCESS	. DETERMINING AND MONITORING THE OCCURRENCE AND MOVEMENT OF SEA ICE IN RELATION TO NAVIGATIONAL SAFETY. . CONDUCTING REQUIRED OCEAN SURVEY ACTIVITIES TO FACILITATE THE UNDERSTANDING AND PREDICTION OF OCEAN PROCESSES. . OCEAN STATION VESSEL OPERATION	PHYSICAL, BIOLOGICAL CHEMICAL, BATHYMETRY METEOROLOGICAL, ICE DATA ENGINEERING PROPERTIES
	. ASSESSMENT, DEVELOPMENT AND MANAGEMENT OF FISHERY RESOURCES. . TECHNICAL AND ECONOMIC ASSISTANCE TO THE COMMERCIAL FISHING INDUSTRY	. THE IDENTIFICATION AND APPLICATION OF ENVIRONMENTAL FACTORS IN OCCURRENCES AND MIGRATION, FORECASTING OF POPULATIONS, LOCATION AIDS FOR COMMERCIAL FISHING	PHYSICAL, CHEMICAL BIOLOGICAL, GEOLOGICAL ACOUSTIC, POLLUTANTS
	. MEASUREMENT AND ENFORCEMENT OF WATER QUALITY STANDARDS	. ANALYSIS OF MINERAL AND CHEMICAL CONTENT OF OCEAN, RIVER, ESTUARY, AND LAKE WATERS THAT RELATE TO WATER QUALITY . ENFORCEMENT OF DEFINED WATER QUALITY REQUIREMENTS	PHYSICAL, GEOLOGICAL CHEMICAL, POLLUTANTS BIOLOGICAL, ENGINEERING PROPERTIES
	. MANAGEMENT, CONSERVATION, AND DEVELOPMENT OF MARINE GEOLOGICAL RESOURCES	. ANALYSIS OF THE GEOLOGICAL STRUCTURE AND MINERAL RESOURCES OF THE OCEAN, INCLUDING THE ORIGIN AND STRUCTURE OF THE SEA FLOOR AND THE DYNAMIC PROCESSES IN THE EARTHS INTERIOR.	CHEMICAL, POLLUTANTS GEOLOGICAL, GEOPHYSICAL BATHYMETRY, PHYSICAL
	. IDENTIFICATION, DEVELOPMENT AND APPLICATION OF TECHNOLOGY FOR EVALUATION OF MINERAL RESOURCES	. LOCATION, IDENTIFICATION, AND MAGNITUDE OF THE MINERAL RESOURCES OF THE OCEAN. . DETERMINATION OF ENVIRONMENTAL CHARACTERISTICS THAT AFFECT MINING OPERATIONS	GEOLOGICAL, ENGINEERING PROPERTIES CHEMICAL, PHYSICAL
	. MANAGEMENT, CONSERVATION, AND DEVELOPMENT OF MARINE NATURAL RESOURCES, PRIMARILY FOR RECREATIONAL ACTIVITIES	. DETERMINATION AND PREDICTION OF THE ECOLOGY OF MARINE GAME FISH FOR THE CONSERVATION AND DEVELOPMENT OF RECREATIONAL FISHING RESOURCES	PHYSICAL, BIOLOGICAL CHEMICAL, POLLUTANT
	. RELATIONSHIPS OF MARINE ORGANISMS TO HEALTH AND POLLUTION	. SPECIFICATION OF METHODS AND PROCESSES FOR WASTE DISPOSAL FOR THE PROTECTION OF PUBLIC HEALTH, RECREATIONAL VALUES, AND FOOD PRODUCTION	CHEMICAL, BATHYMETRIC POLLUTANTS, PHYSICAL METEOROLOGICAL
	. IDENTIFICATION, CLASSIFICATION AND [illegible] OF MARINE ORGANISMS	. CARRYING OUT BASIC INVESTIGATIONS OF MARINE POPULATIONS AND DISTRIBUTIONS OF ORGANISMS AND SEDIMENTS IN THE OCEAN . SORTING, CLASSIFICATION, AND [illegible] OF BIOLOGICAL SAMPLES FROM THE WORLD OCEAN	BIOLOGICAL GEOLOGICAL
	. EFFECTS OF [illegible] IN THE MARINE ENVIRONMENT	. DEVELOP USES OF ATOMIC ENERGY IN MARINE ENVIRONMENT . DETERMINE FATE OF RADIOACTIVITY IN THE OCEAN AND ITS EFFECTS ON AND [illegible] ENVIRONMENT . [illegible]	POLLUTANTS, BIOLOGICAL PHYSICAL, [illegible] CHEMICAL
	[illegible]	[illegible] . FLOOD PROTECTION AND BEACH PROTECTION . [illegible] OF GREAT LAKES	PHYSICAL, METEOROLOGICAL GEOLOGICAL, ENGINEERING PROPERTIES BIOLOGICAL

...CTIONS AND DATA REQUIREMENTS OF SELECTED ... WITHIN THE NATIONAL MARINE SCIENCE PROGRAMS

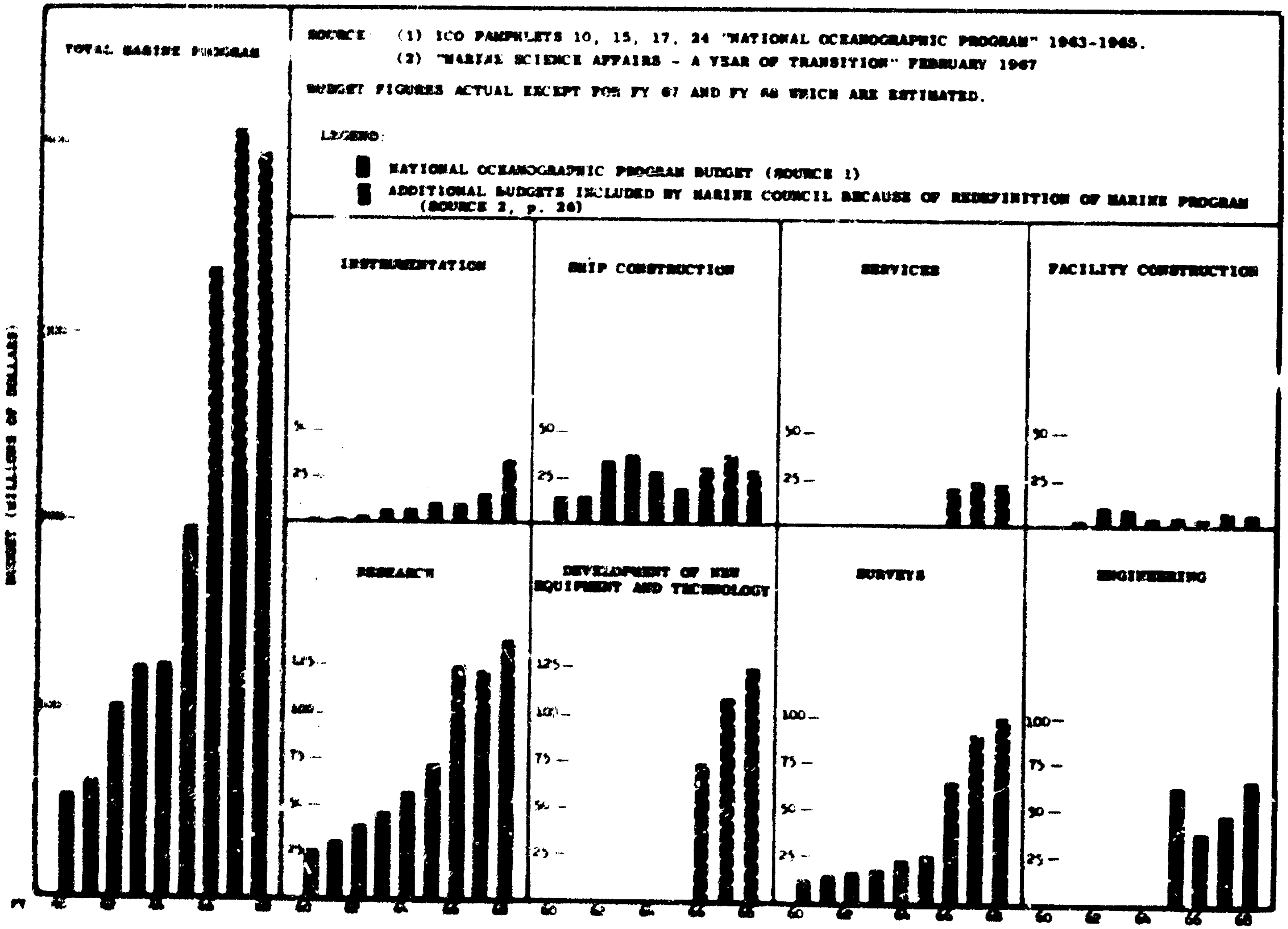
FIGURE 11

B

a. Starting in FY 1968, marine program efforts devoted to civilian activities may be expected to increase more rapidly than defense activities, reflecting increased emphasis on utilizing the marine sciences to meet industrial, economic, and social goals. In addition, the definition of marine activities has been expanded to include the Great Lakes, estuaries and water resources management and pollution control. The significance of these changes must be accounted for in the determination of National Marine Data Program requirements, e.g., the potential benefit to be gained from the declassification of defense-oriented marine data for civilian uses.

b. With the advent of the Marine Sciences Council, a substantial federal effort is being made to identify existing and required state, local, industrial, and private organization resource expenditures related to National Marine Science Programs. Greater emphasis is being placed on identifying those aspects of marine activities where encouragement is needed and partnership with federal agencies can be attained. This federal coordination effort is clearly an important ingredient in the development of a National Marine Data Program

c. The National Marine Sciences Programs are exhibiting a definite early stage transition from specialized research to research and technology programs involving large-scale ocean surveys. Figure 12 categorizes the federal budget into national program functions which depict this change in orientation. The development of new equipment and technology, survey efforts, instrumentation, and services exhibit a decided increase in funding which reflects this shift away from the more specialized research functions. It should be noted in the figure, however, that a substantial portion of this apparent change can be attributed to the redefinition of the national program by the Marine Sciences Council. The true underlying shift in national orientation will, nevertheless, be given close attention throughout Phase II in defining data program requirements.



FEDERAL BUDGET BY FUNCTIONS FOR UNITED STATES
MARINE SCIENCE PROGRAM BY FISCAL YEAR

FIGURE 12

B. FUNCTIONAL REQUIREMENTS

The conduct of functional requirements analysis, which encompasses a thorough description of suppliers and users of marine data, represents the first step in defining National Marine Data Program requirements. Functional requirements are analyzed in relation to the National Marine Science Program objectives.

Figure 11 exemplified the first step in the definition of functional requirements of the various users and suppliers of marine data. Some of the more pertinent federal agencies currently involved in the National Marine Science Programs are described in terms of the following important factors:

- National Programs Supported. Those national marine science programs mentioned in Section III A, to which the particular department or agency is making a major contribution.

- Missions. An identification of the responsibilities of each agency in relation to National Marine Science Programs.

- Relevant Functions. More specific statements of the agencies' operational activities associated with the missions.

- General Data Requirements. The identification of general marine data categories which are most important to the agency's performance of its defined functions.

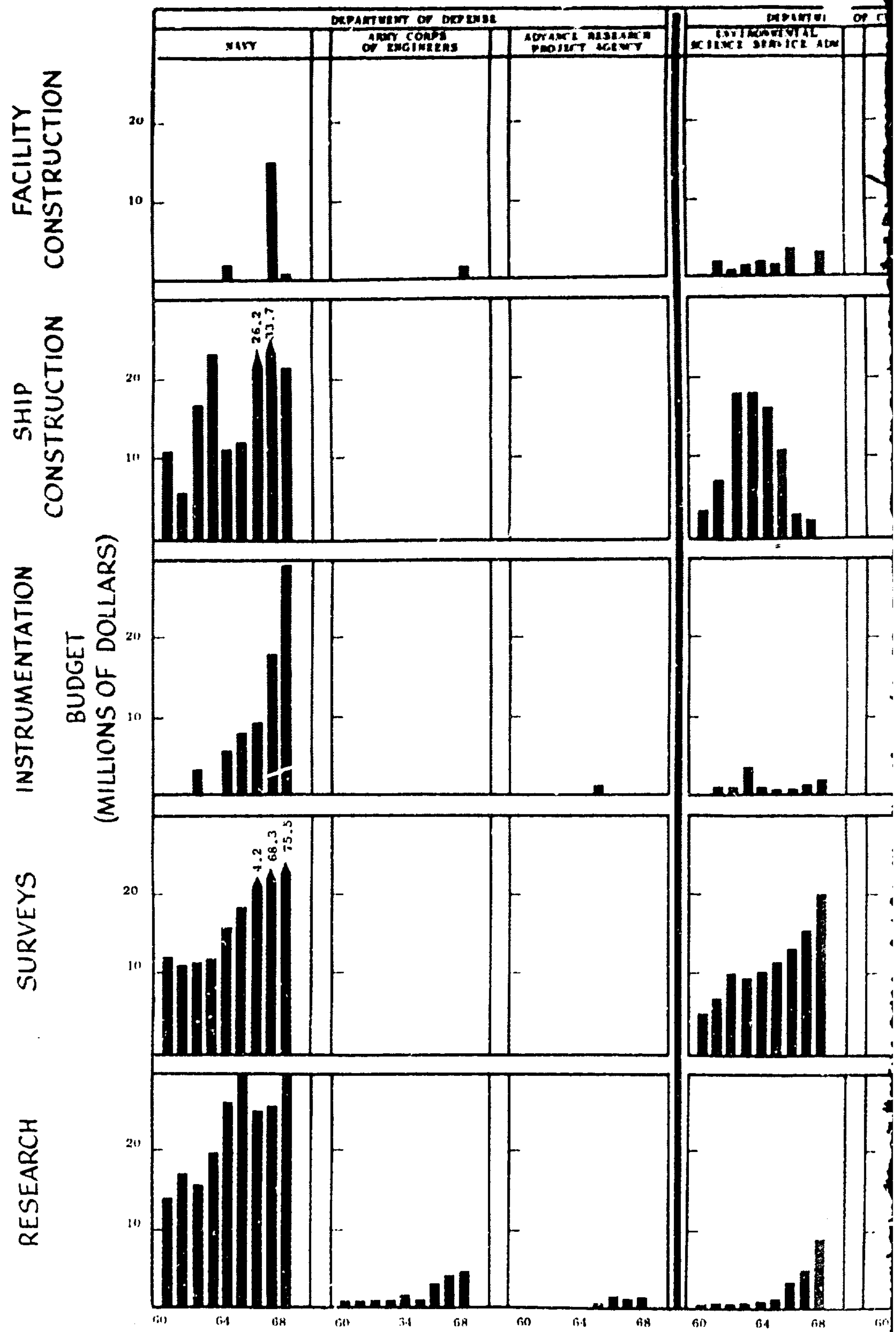
By approaching the problem in this fashion, it is possible to associate data requirements with particular National Marine Science Program objectives. In this manner, the relative importance of each data requirement can be assessed. The last column in Figure 11, General Data Requirements, is the key to tracing data requirements to National Marine Science Program objectives.

Phase II effort will define further the federal organization, their missions and functions, within the National Marine Data Programs. State and local governments, regional organizations, private industry and institutions will also receive attention in this regard with special emphasis being placed on their activities in relation to those of the key federal agencies.

1. Magnitude of Federal Agency Effort

Figure 13 presents a detailed breakdown of the expenditures of various federal agencies and departments by general functions. Inspection of this figure provides some indication of the

SOURCE:
ICO PUBL. 10, JUNE 1963
ICO PUBL. 15, MARCH 1964
ICO PUBL. 17, JANUARY 1965
MARINE SCIENCE AFFAIRS -
A YEAR OF TRANSITION,
FEB. 1967



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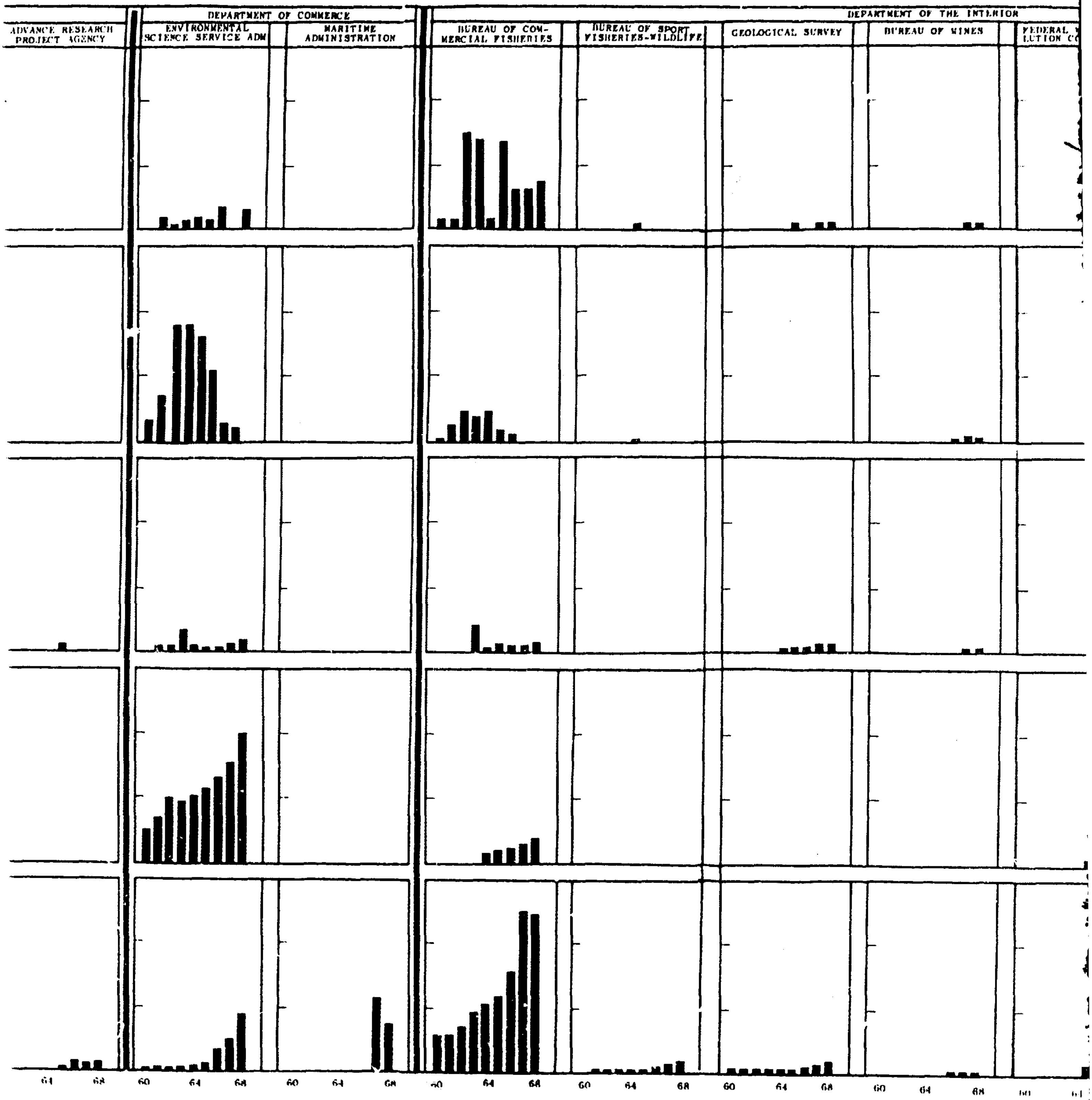
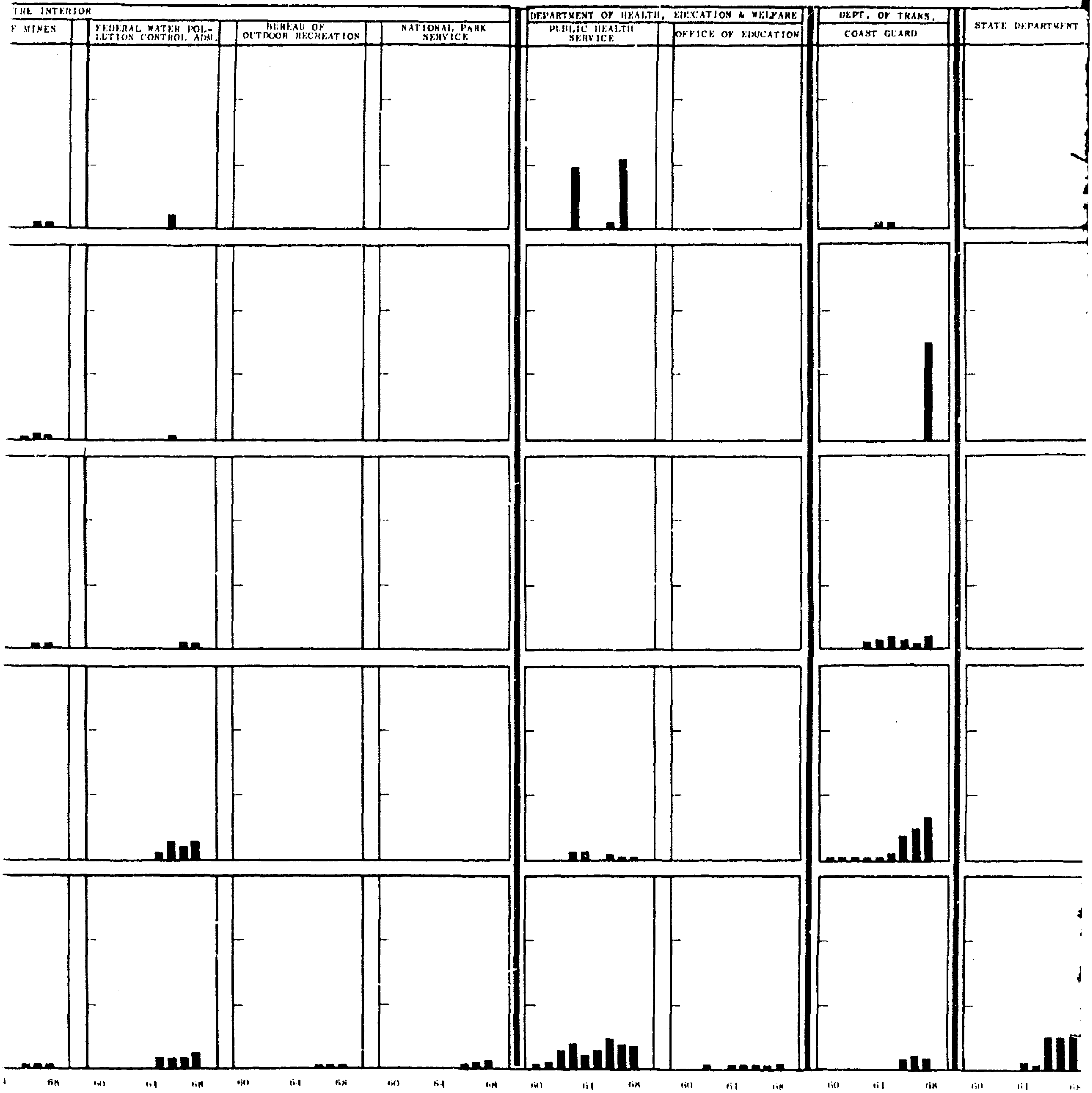


GANIZATION BUDGETS BY FUNCTION AND FISCAL YEAR

B

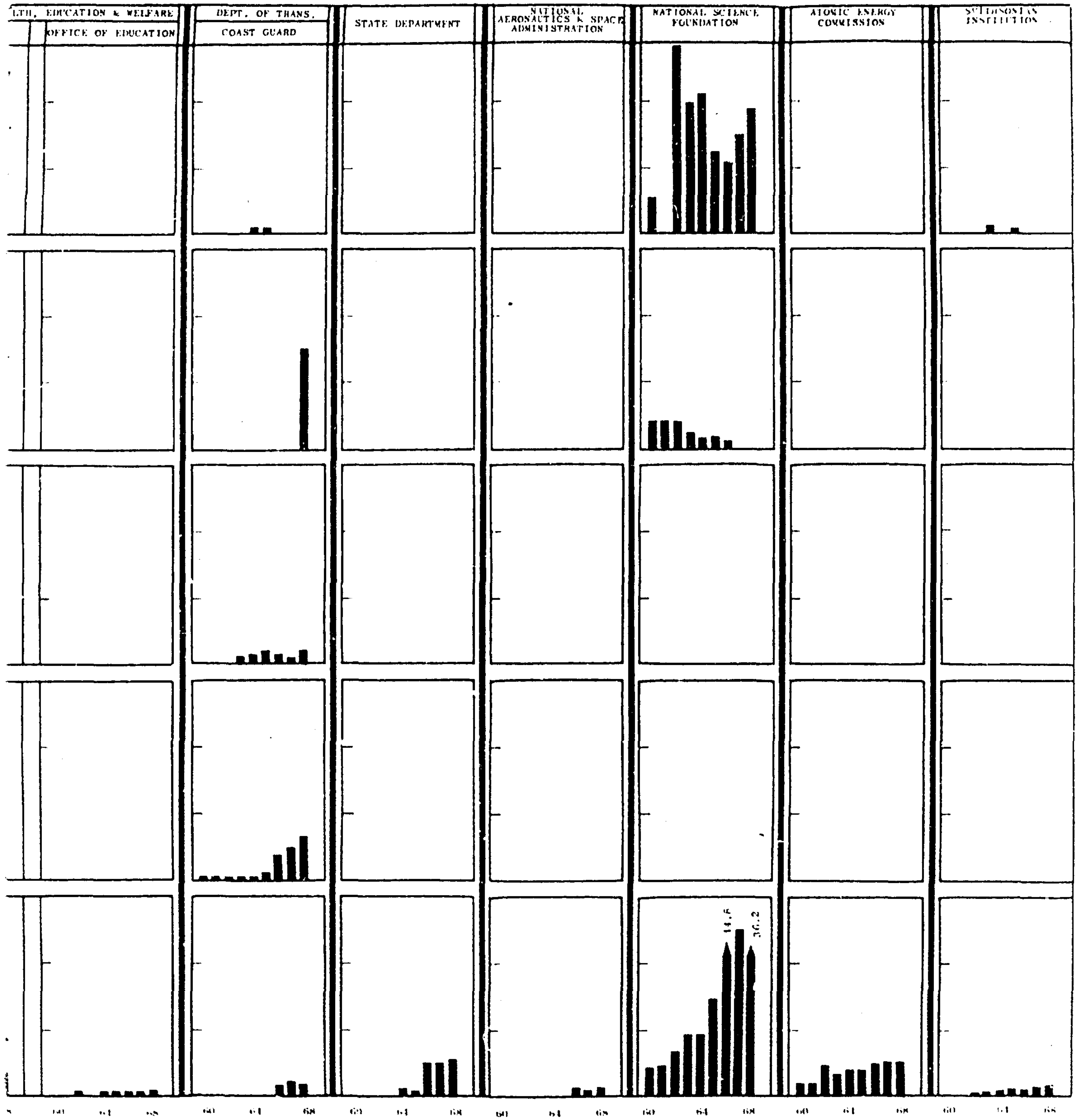
F

ORGANIZATION



L YEAR FOR UNITED STATES MARINE SCIENCE PROG

FIGURE 13



MARINE SCIENCE PROGRAM, 1960-1968

D

magnitudes and thus the emphasis accorded the functions performed by the various agencies. The agencies provided the greatest funding in performance of specified functions are:

- <u>Facilities Construction</u>: BCF, NSF
- <u>Ship Construction</u>: Navy, ESSA
- <u>Instrumentation</u>: Navy
- <u>Surveys</u>: Navy, ESSA
- <u>Research</u>: Navy, BCF, NSF

The oceanographic functions of the Navy, which account for approximately one-half of the total National Marine Science Programs funding, are extremely important to the National Marine Data Program. An analysis of the Navy's data collection and handling activities will, therefore, provide information on the nature of a substantial portion of total marine data collected. In Phase I, NAVOCEANO, the major research and data collection arm of the Navy was analyzed because of its extreme importance to the National Marine Data Program.

The scope of ESSA's functional activities is shown in Figure 11, while Figure 13 suggests the notable growth in ESSA's research and survey expenditures. Because of the impact that ESSA programs, such as SEAMAP and the World Weather Watch, have on the overall planning of the National Marine Data Program, it has been attributed considerable importance in the determination of National Marine Data Program requirements.

The Bureau of Commercial Fisheries (BCF) also plays a decidedly important part in the National Marine Science Programs effort. BCF is responsible for the management, development and conservation of the fishery resources of the sea. Broad programs of research related to these resources and their environments are funded within BCF. It must therefore be given considerable attention during Phase II.

The National Science Foundation (NSF) is also a significant contributor to the development of the National Marine Science Program. NSF's extensive research and education activities, facilities, and contractual funding must be analyzed to determine trends in marine research and construction activity and the resulting data needs evolving from such trends. In addition, the expected effects of such marine activities as the Coast Guard's planned ocean survey effort and the Federal Water Pollution Control Administration's marine pollution control program, must not be overlooked in determining future National Marine Data Program needs.

Even though total funding is used here as a first criterion, caution must be exercised during Phase II in relying solely on such criteria to indicate those facets of the National Marine Science Programs which are of the greatest importance to the National Marine Data Program.

2. Contributions of Other Organizations

Private institutions, state and local governments, industry and associations are all playing a decided, yet often fragmentary role, in the conduct of the National Marine Science Programs. Although Phase I survey coverage of these organizations was necessarily limited, it became readily apparent that significant benefits could be derived from organized federal liaison and cooperation with state and local governments, private institutions and industry, as significant data bases and unprocessed data backlogs exist within these organizations. These organizations could contribute more broadly than is currently the case to the enhancement of the overall National Marine Data Program. Substantial effort must therefore be devoted during Phase II towards identifying the realistic potential of such organizations for contributing and using data, instrumentation, facilities and research in support of the National Marine Science Programs.

Based on a preliminary analysis of the limited information gathered during Phase I, the following discussion highlights some of the activities and future potential regarding the participation of industry, state and local governments, universities and private research institutions in the overall National Marine Data Management Program.

a. Industry

Industry has for years utilized the marine environment extensively. Perhaps the most significant activities lie in the fields of: transportation, oil and mineral recovery, and drug and chemical extraction. In the process, very extensive marine data bases have been accumulated, especially in the field of oil exploration. In addition to extensive seismic surveys, a significant number of continental shelf cores and well logs have been taken, many from shore and near-shore well sites. It is estimated that the information contained in the well logs collected and stored by the oil industry rivals the total information content of the national marine data collections. Much can be learned from a study of the well-developed technology of storing, retrieving and processing geophysical data developed through expenditures of many millions of dollars by the oil industry.

In addition to these possible data sources, industrial organizations have specified a need for various types of marine data. One large producer of general marine systems, for example, requires data on ocean temperature profiles, bottom topography, bottom composition and foundation characteristics, acoustics, and absorption and reflection. The lack of data in many parts of the world ocean has impeded the progress of ocean engineering.

A primary difficulty arises, however, from data privacy requirements of industrial organizations. Much of the data collected by industry is of a proprietary nature in relation to existing or planned products or services. Attention during Phase II must be directed to methods for ensuring security protection of such data through aggregation, sampling, or conversion techniques.

Another problem area associated with industrial participation is lack of sufficient incentive. Since much of the marine instrumentation and supporting systems required today are customized, industry is not motivated to invest R&D capital in marine equipment for specialized and limited markets.

This industrial apathy towards marine technology is felt throughout the marine community and has a decided effect on the data collection process. Attention will be devoted during Phase II to the identification of methods for achieving standardization of instrument systems and to possible forms of government subsidization of pertinent industrial marine technology.

On the positive side, current and expected future emphasis on ocean engineering research and development will greatly enhance industrial participation and the capabilities for conducting oceanic research and data collection. The present developmental efforts in ocean engineering will permit:

1) Improved data collection through structural and civil engineering programs in the design of stable and effective ocean platforms, towers, buoys, and shipboard instrument handling equipment.

2) Increased data collection and work productivity through the further development of man-in-the-sea and undersea research vehicle capabilities.

3) Introduction of relatively new data sources through innovations in ocean technology such as deep ocean drilling.

4) Increased collection frequency of reliable data through innovations in materials and instrumentation -- e.g., in situ chemical analysis packages; increased instrumentation payloads through applications of wet electronics.

5) A shift in emphasis from the current situation, in which industry is largely a user of marine data, to one where ocean industry will become a large provider of marine engineering data as the result of the experience and knowledge gained through the pursuit of the development, deployment and maintenance of the many proposed large-scale systems and programs such as buoys, man-in-the-sea, undersea resource development.

These, and numerous other innovative accomplishments, will continue to enhance the abilities of both ocean scientists and engineers to expand and improve their marine data bases. In turn, they will increase the participation of private industry in these efforts. The effects of these developments must be assessed during Phase II.

b. State and Local Governments.

State and local governments situated on the Atlantic, Gulf, Pacific, and Great Lakes coastlines have collected large amounts of marine data in the past in response to needs proposed by problems arising regarding: water pollution, beach erosion, marine construction (harbors, marinas, ocean outfalls), fisheries investigations, and offshore oil and mineral explorations. A majority of these investigations have been conducted in cooperation with federal agencies that have usually supplied a portion of the necessary funds and manpower. In addition, universities, private research insitutions, and industry have also been involved while under contract directly to the state and local governments or indirectly through contracts with various federal agencies.

From a preliminary analysis of the information regarding data collection, processing, storage, and retrieval obtained from state and local government agencies during Phase I, it appears that there has been little if any effort made in the past to standardize sampling, processing or storage of the numerous types of coastal marine data collected by these organizations. This condition is understandable when the number of agencies and individuals involved in sampling programs in the same geographical region is considered. For example, it has been reported[1] that in a 75-mile stretch of one eastern seaboard river a total of 46 groups, including federal, state, interstate, industry and waterworks agencies, had collected similar water quality data.

Thus, as might be expected, most of the data obtained from the coastal marine environment are currently stored in individual research file cabinets, in various state, local and federal agency archives and in published contract reports. Besides being a strong deterrent to the exchange of knowledge between various disciplines investigating the coastal environment, the present poor state of data management has resulted, more often than not, in considerable duplication of effort at the expense of the taxpaying citizens. However, efforts by various local, state and Federal agencies in such regions as in the Great Lakes, Chesapeake Bay, Delaware Bay and Gulf of Mexico have been made recently to correct this situation. For example the Gulf of Mexico Estuarine Inventory (GMEI), which was established under Public Law 88-309, involves a joint cost effort between the states of Texas, Louisiana, Mississippi, Alabama, Florida and the Bureau of Commercial Fisheries' Laboratory in St. Petersburg, Florida to catalogue the estuarine environment of these states in terms of: 1) Area description, 2) Hydrology, 3) Sedimentology and 4) Biology. All data are submitted to BCF on standard forms, but the specimens are retained by the individual states. When the inventory is complete an atlas will be published jointly by the states and BCF.

1. Green, R. S., 1964, The Storage and Retrieval of Data for Water Quality Control. U. S. Department of the Interior, Federal Water Pollution Control Administration.

During Phase II SDC will devote effort towards defining the quantity, quality, location and accessibility of the various major shallow water data bases in existence today. In addition, the interrelations and data flow between various states, local and federal government agencies involved in coastal marine research will be documented for use in the final planning design of the National Marine Data Program.

c. Universities and Oceanographic Research Institutions

Universities and oceanographic research institutions in the past have been the most important basic contributors to the scientific advancement of the field of oceanography. Practical applications of the research conducted have contributed heavily towards significant advances in the areas of marine weather forecasting, wave forecasting, accustic transmission in seawater, beach erosion, and food from the sea. It is anticipated that these contributions will continue to play an important role in the future development of the marine environment.

From a preliminary Phase I sampling of opinions of oceanographic scientists performing basic research, the impression gathered was that there is a rapid progression of ocean studies to the stage where emphasis is shifting from the charting of the distribution of properties, such as temperature, salinity and biological populations, to the quantitative time-series study of dynamic processes which produce the observed distributions and of the principles which govern these processes. Thus, the problems of obtaining large collections of marine data which are correlated in both space and time are receiving considerable attention by the academic marine community. The impacts of the resulting data volumes and related handling methods must be given considerable attention in the design of the National Marine Data Program.

Substantial data management problems are created by the very nature of the oceanographic research conducted by most universities and oceanographic research institutions. In many cases, individual researchers are investigating oceanographic phenomena of particular interest and are unconcerned with the use that the data may receive once they have analyzed and published their results. This condition has resulted in long delays between data collection and the release of these data to the general marine community. It has also resulted in a diversity of data types and formats which are often incompatible without considerable effort being spent on conversion. Success in totally removing this bottleneck is improbable, and in some cases, considering the amount of work involved to reduce the data for general use, better not attempted. In general, however, an investigation of methods for immediate identification of priviledged data sources and specification as to their likely date of data release would be especially beneficial to the research community. This information will form one link in the determination of ways to provide better in-flow of data to data centers from research programs.

During Phase II, visits to pertinent research institutions and professional associations will be made to solicit ideas and suggestions for alleviating the present data flow problem and to assess their needs and potential contributions to the National Marine Data Program.

It is clear from the foregoing that a first requirement in developing an effective National Marine Data Program is the completion of an inventory of the various data collections, as well as the desired data needs of non-federal organizations including industry, state and local governments, and university and private research institutions. In this process, the various professional societies must not be overlooked. For example, the American Geological Institute is involved in the preparation of a Bibliography and Index of Geology and, more importantly, has substantial information on other existing and anticipated programs for literature summary and retrieval.

Assessment of the real ownership and security restrictions placed on non-governmental data sources must also be made during Phase II. Numerous practical examples exist of information interchange based on careful protection of the data collectors' rights. One example is the use by industry of data collected by others but not for the original purpose of the collection, e.g., original collection may be for research use in a student's thesis but industry uses the data for mineral exploration. The criteria used in these cases should be studied and hopefully extended to other organizations and data sets.

d. Cooperative Marine Programs

The many research activities associated with the National Marine Science Programs receive primary support from an extensive array of oceanic survey programs. In general, there is substantial mutual support between research and survey efforts. While surveys provide substantial data for research purposes, a significant portion of research results permit improved performance of survey operations.

A number of cooperative and intensive ocean survey programs involving various platforms such as ships and buoys are evolving in response to national marine missions and objectives. The traditional programs of the Navy, the Environmental Science Services Administration (Coast and Geodetic Survey), the Bureau of Commercial Fisheries, the Coast Guard, and the Federal Water Pollution Control Administration are now vitally concerned with the problem of obtaining large collections of marine data which are correlated in both time and space.

In the past, oceanographers have been frustrated frequently in their attempts to study physical processes, not necessarily by the lack of data, but by deficiencies in the right kind of data. For example, synoptic pictures of the distribution of properties may be available for several areas of the oceans; however, such data are uncorrelated in time. Conversely, time series data exist, particularly of surface temperatures at a number of locations, but are poorly correlated in space.

The interim results of these efforts are exemplified by the rapid progression of ocean studies to the state where emphasis is shifting from the charting of the distribution of properties such as temperature and salinity, to the study of the dynamic processes which produce the observed distributions and the principles which govern these processes.

It is recognized by many investigators of the marine environment that if future oceanographic expeditions are to be regarded as scientific experiments, oceanographers must evaluate predetermined hypotheses; and the research planning, deployment of ships and buoys, etc., must be designed to accommodate the need for quantitative, statistically significant answers to these questions.

Some of the problems involved in programs of this nature have been given in a thought-provoking paper by Professor Henry Stommel.[1] Of particular interest to the design of a data management system are his spectral distribution diagrams which illustrate the often overlooked fact that the sampling interval in time and space must be chosen on the basis of the period of interest. For example, Stommel has shown that to obtain a

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1. Stommel, H., "Varieties of Oceanographic Experience," Science, V. 139 #3555, 1963, pp. 572-576.

statistically significant map of annual variation of sea level in the South Pacific would require about 3×10^6 hourly observations collected over a period of 4 years. No single plan for mounting an oceanographic expedition or setting up a buoy observational program can hope to economically include all the scales and periods. Thus, it is first necessary to describe which part of the spectrum of each variable one wishes to measure and then to ensure that the desired statistical significance level obtained in the experiment is an improvement on that already obtainable from the data now in the archives.

More often than not, the design characteristics of past oceanographic experiments have been such that few statistically significant answers were obtained. Also, the data in the archives are usually not in a readily usable format for uncovering possible duplication of previous efforts.

The development of increasingly dense data bases within specified ocean areas should in time facilitate the refinement of various ocean models to represent these sections. Also, while the requirements for pervasive ocean coverage have in no way been degraded by such a selective survey process, concentrated data and analysis from strategic ocean locations should help improve the nation's capability to make regular marine environmental predictions. A brief discussion of the major survey programs which will receive attention during Phase II appears below:

1) SEAMAP. The Scientific Exploration and Mapping Program (SEAMAP) consists of ocean-wide surveys which attempt to be all-inclusive of the ocean parameters which are relevant to oceanic research in general. Whereas the traditional surveys are mission-oriented in relation to particular objectives and are thus tactical, the SEAMAP approach looks at the strategic aspects of oceanic research to assure the existence of more effective tactical programs in the future. Substantial portions of the data collected by the surveys will be deposited at NODC and thus, form the nucleus of the data base of the SEAMAP program.

2) Continental Shelf Program. Closely aligned to the philosophy of SEAMAP, is the Continental Shelf Program.[1] The objective of this program is to integrate separate data sources into an overall interagency continental shelf

1. Interagency Committee on Oceanography, National Oceanographic Program, Fiscal year 1967, p. 50.

exploration and exploitation effort. The program will provide information on the physical, chemical, and biological processes necessary for the scientist and engineer working on the shelf. The data collected will include essential oceanographic parameters, the biological content of the ocean waters, and the sediments of the ocean floor.

3) EASTROPAC. The Eastern Tropical Pacific Survey, conducted during 1967-1968, represents a prime example of the concept of strategic sectioning and concentration of data collection in the world's oceans. This concentrated survey effort is considered to be a prerequisite to the complete assessment of the feasibility of harvesting tuna from this region. The purpose of this survey is to provide a foundation upon which future oceanographic and fisheries investigations can be conducted in prime tropical fishing areas. The interagency and international cooperation in the conduct of this survey is evidenced by the following list of participating countries and organizations:

- Ecuador
- Peru
- Chile
- Inter-American Tropical Tuna Commission
- U. S. Coast Guard
- Fleet Numerical Weather Facility
- Office of Naval Research
- Bureau of Commercial Fisheries
- Scripps Tuna Oceanography Research Program
- Scripps Institution of Oceanography
- Texas A and M
- Smithsonian Institution
- Environmental Science Services Administration

4) BOMEX. During July-August 1968, a survey program, the Barbados Oceanographic and Meteorological Experiment (BOMEX), will be conducted under the auspices of the Environmental Sciences Service Administration. A combined meteorological and oceanographic data collection program will be conducted through the cooperative efforts of the Navy, the Coast Guard, and one or more foreign countries. This survey program, which is designed to study air-sea interaction, will employ buoys, ships, and aircraft; the Navy alone will make a major contribution of eight to ten vessels. It is anticipated that some satellite thermal mapping will be provided during the exercise. NODC

will assist in processing survey data, notably the S-T-D and BT data collections. Some pilot efforts in providing real-time quality control through teletype transmission may also be implemented by NODC. It is anticipated that NODC will acquire all survey data collections for archival purposes and perform various analytical functions such as comparative analysis of temperature and salinity profiles with related historical data.

5) Trade Wind Zone Investigation (Porpoise Proposal). Another example of a planned space-time related oceanographic experiment employing a combination of ships, buoys, and aircraft is the North Pacific Trade Wind Zone Investigation designed by Bureau of Commercial Fisheries oceanographers in Hawaii. As proposed in 1963[1] the Trade Wind Zone Investigation would consist of a multiple-ship operation designed to quantitatively investigate the seasonal changes of processes both at sea surface and at depths within the area bounded by 10°N, 30°N, 130°W, and 180°W. Oceanographic stations to 1500 meters would be occupied on a monthly interval for a period of two years. If this plan becomes reality, the Salinity/Temperature/Depth (STD) and Expendable Bathythermograph (XBT) will undoubtedly play a large role in the collection of the basic physical oceanographic data. Based on the Trade Wind Zone estimates for Nansen cast measurements, it is expected that upon completion of the survey, some 4000 STD stations and 17,000 XBT observations will have been acquired, as well as numerous other observations on weather, sea surface conditions, and currents, obtained from participating ships, aircrafts, and buoys.

6) World Weather Program. Perhaps the largest cooperative scientific and technological undertaking that the nations of the world have thus far proposed to enter into is the World Weather Program. The goals of this program are to improve meteorological services to all nations, to increase the accuracy and to extend the range of present forecasts, and to explore the feasibility of large scale weather and climate modifications. Expected benefits from the successful implementation of this program are manifold: reduction of the loss of lives and property through better storm forecasting; provision of assistance to agriculture for developing a more efficient timetable of planting and harvesting crops; routing of air and sea transportation for more efficient and economical operations, and substantial improvement in water management practices.

1. Seckel, G., "The North Pacific Trade Wind Zone Investigation," U.S. Bureau of Commercial Fisheries, Biological Laboratory, Honolulu, 1963, Unpublished Manuscript.

Essentially the World Weather Program consists of two major aspects. One is the World Weather Watch which is an international program for the observation of the world atmosphere and for the rapid and efficient communication, processing, and analysis of the resulting data. The other aspect will be the conduct of a comprehensive, long-term program of research on the global wind systems and on the interactions between the atmosphere and the underlying land and sea. At the present time the planning of these programs is being coordinated by the World Meteorological Organization (Weather Watch) and the Committee on Atmospheric Sciences of the International Union of Geodesy and Geophysics (Research Program).

Four platforms are now under consideration for use in the proposed World Weather Watch Program's satellite location and data collection system:

- Automatic land weather station - for obtaining data from sparsely inhabited or uninhabited regions.
- Horizontal sounding balloon - designed to be flown along constant density surfaces in the atmosphere.
- Ocean buoy - designed to obtain meteorological and oceanographic data from data-sparse regions of the oceans.
- Merchant ships - for obtaining marine synoptic data from shipping lanes in the world oceans.

A program for immediate improvements to remedy the most critical deficiencies in the present international weather program is currently planned for implementation during 1968-1971 and will rely heavily on improved coverage by weather satellites, buoys and merchant ships.

ESSA through its Weather Bureau is the principal U. S. Government agency that will be involved in the World Weather Program. Contracts were recently let by ESSA to develop three satellite-interrogated-environmental buoys with the eventual plans calling for a global network of some 360 buoys. In addition, the World Meteorlgical Center in Washington, D. C. began operations in 1965 in support of the World Weather Program. This center combines ESSA's Weather Bureau's numerical prediction and satellite facilities with the National Weather Records Center's data storage and recall capabilities. The two other World Meteorological Centers designated by the World Meteorology Organization are located in Moscow and Melbourne, but as yet are not operational.

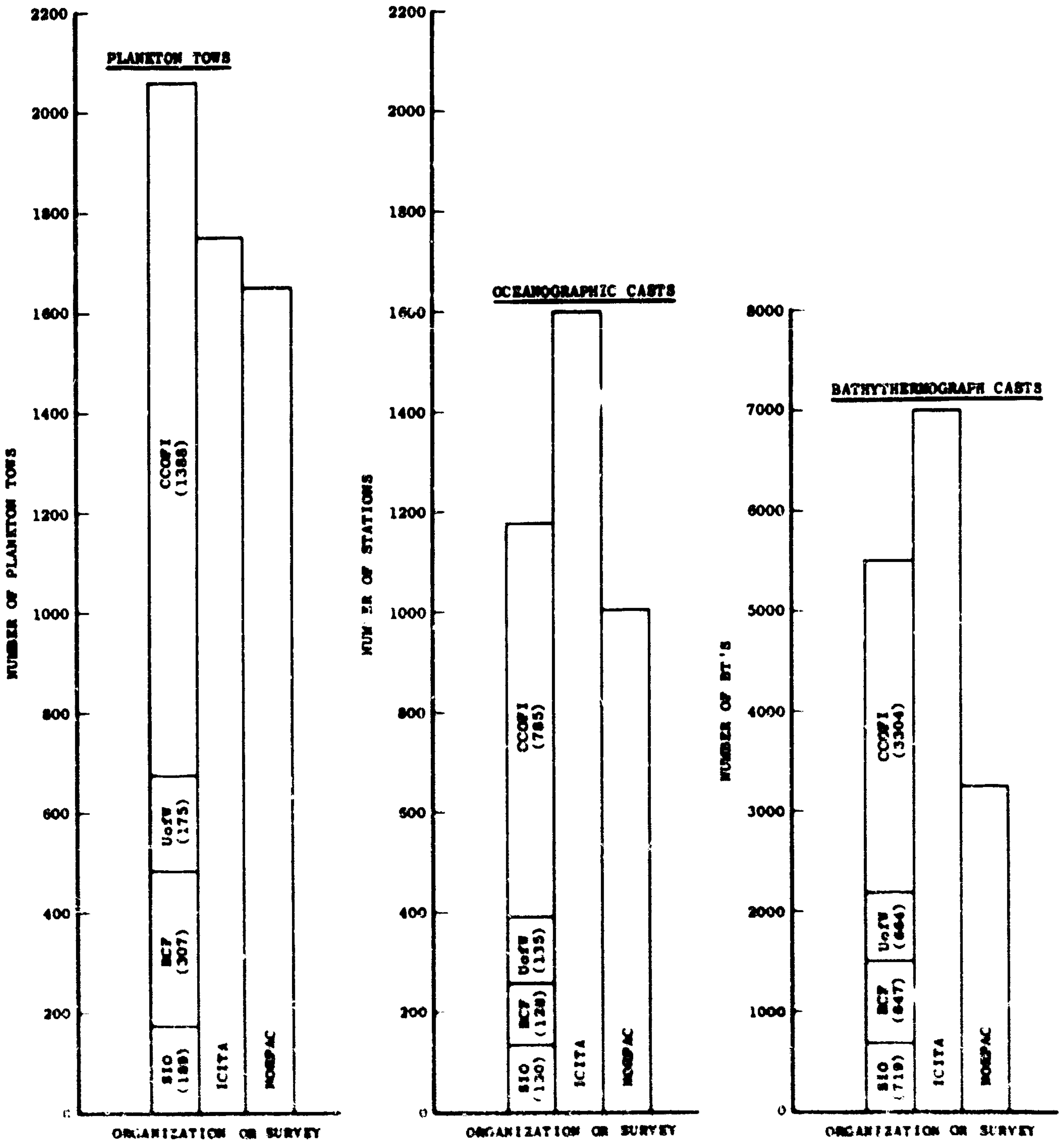
7) International Programs. Although primary consideration during this Phase I effort has been devoted to national aspects of the marine science programs, considerable attention has been and should continue to be devoted to the effects of international cooperative efforts on National Marine Data Program requirements. Of particular relevance are the international cooperative data collection programs. Over the past decade numerous large-scale oceanographic sampling programs have been conducted on a cooperative international basis. Besides fostering international good-will, these programs have made possible the study of large ocean areas on a quasi-synoptic basis. During the course of an international cooperative survey tremendous amounts of standard oceanographic data are collected over a relatively short time span. An effective National Marine Data Program must be geared to cope with input of data from such programs without serious interruption of its normal data management functions.

To illustrate this point, Figure 14 has been prepared from information obtained during discussion of the data program requirements of BCF and from the summaries published on NORPAC (NORTHPACIFIC) and ICITA (INTERNATIONAL COOPERATIVE INVESTIGATION OF THE TROPICAL ATLANTIC). NORPAC, a cooperative investigation of the north Pacific Ocean conducted during July-September 1955, involved 21 vessels of the United States, Canada, and Japan. ICITA consisted of three major surveys conducted during 1963-1964 and involved 20 vessels from 13 nations.

From the figure it can be seen that, hypothetically, if a data system were in operation and geared only to handle the average annual data input from say CCOFI, Scripps, BCF and the University of Washington, it would be hard pressed to process and store the additional data input generated by large-scale surveys, such as NORPAC and ICITA, without total interruption of its normal routine. Further complicating the situation is the non-homogeneity involved in obtaining, recording, and processing the data caused by changes in format and requirements from routines already established.

These problems have been partially overcome in some of the more recent surveys (ICITA) by making every attempt to standardize data collecting, recording, and processing techniques prior to the actual undertaking of the surveys.

During Phase II in addition to assessing the data management problem associated with both national and international cooperative surveys, it will be important to investigate



COMPARISON OF VOLUME OF DATA COLLECTED BY INTERNA
AVERAGE VOLUME OF DATA COLLECTED PER YEAR FOR S

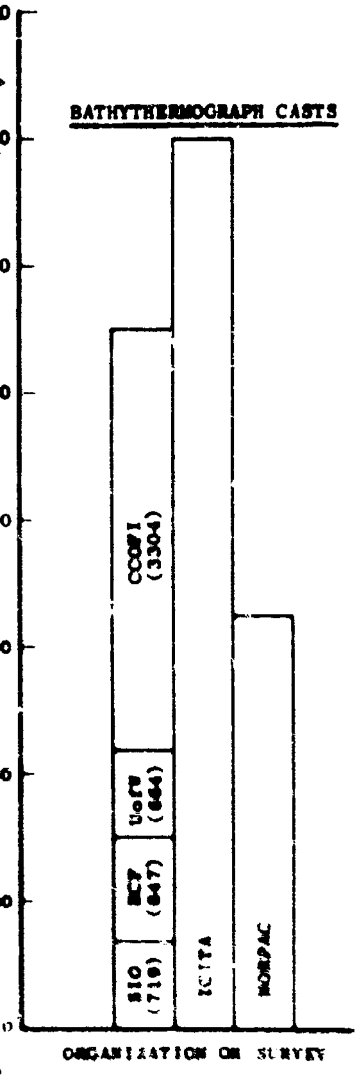
FIGURE 14

05/003/00

LEGEND:

ABBREVIATION	NAME OF ORGANIZATION	YEARS OF SURVEY	NUMBER OF VESSELS USED
SIO	SCRIPPS INSTITUTION OF OCEANOGRAPHY	1931-1966	2
BCF	BUREAU OF COMMERCIAL FISHERIES, HAWAII	1950-1958	1
UofW	UNIVERSITY OF WASHINGTON	1952-1959	1
CCOFI	CALIFORNIA COOPERATIVE OCEANIC FISHERIES INVESTIGATION	1950-1966	5
ICITA	INTERNATIONAL COOPERATIVE INVESTIGATION OF THE TROPICAL ATLANTIC	1963-1964	20
NORPAC	NORTH PACIFIC	1955	21

NUMBER IN ( ) IS THE AVERAGE DATA VOLUME/YEAR COLLECTED BY EACH ORGANIZATION.



SOURCE:

OCEANIC OBSERVATIONS OF THE PACIFIC (1950-1959, UNIVERSITY OF CALIFORNIA PRESS)

SCRIPPS INSTITUTION OF OCEANOGRAPHY, REFERENCE SERIES

SCRIPPS INSTITUTION OF OCEANOGRAPHY, DATA PROCESSING SECTION

U.S. FISH AND WILDLIFE SPECIAL SCIENTIFIC REPORT SERIES

NATIONAL OCEANOGRAPHIC DATA CENTER (EQUALANT I-III DATA REPORTS)

...LLECTED BY INTERNATIONAL COOPERATIVE SURVEYS TO THE ...TED PER YEAR FOR SELECTED UNITED STATES ORGANIZATIONS

FIGURE 14

B

the existing system for exchange of international oceanographic data. During the course of this particular Phase II study the activities of international organizations such as the Intergovernmental Oceanographic Commission (IOC), Scientific Committee on Oceanic Research (SCOR), Fisheries Division of the Food and Agriculture Organization (FAO) and other important international organizations such as the International Council for the Exploration of the Sea (ICES) will be examined as an aid in designing the most efficient data management system. Special attention will be paid to the past efforts and results of the IOC with respect to coordinating international data exchange (DM-120). Additionally it is planned to evaluate the data management aspects of the ICITA program, as it represents the first attempt by NODC to standardize the collection, processing, and publishing of all of the survey data obtained by the various participating countries.

The preceding discussion (Section III-B) broadly outlined some of the framework within which detailed functional requirements analysis will be conducted during Phase II. In order to illustrate the process, and also to gather pertinent information on the size of the data problem, SDC has conducted semi-detailed functional analyses of several selected federal agencies which have major roles in the conduct of the National Marine Science Programs.

Based on such factors as total funding, importance of National Marine Science Programs supported, and relevance to the National Marine Data Program, the following federal organizations were analyzed in some detail during Phase I to provide inputs to the Phase II planning:

- NAVOCEANO
- NODC
- ESSA
- Smithsonian Oceanographic Sorting Center
- BCF
- Coast Guard

Certain other organizations will also be discussed, but in less detail, in order to illustrate pertinent considerations for the Phase II effort.

In order to achieve a measure of brevity in this report, the functional requirements of these organizations are described in the following section at part III-C-3 under Functional and Data Program Requirements of Selected Federal Agencies. While functional requirements are a proper part of the current section (III-B), their relationship to the data program requirements which they produce is perhaps more clearly demonstrated by placing these elements together.

C. DATA PROGRAM REQUIREMENTS

Each of the organizations briefly described in the previous sections has responsibilities within the National Marine Science Programs. To satisfy these responsibilities, they require resources for the collection, storage, processing, and dissemination of data. These resources include personnel, data bases, hardware and software. The combination of resources in support of organization functions is referred to in this study as a data program.

Figure 11 defines broadly the general data requirements in relation to federal agency functions. It is the purpose of this report section to structure and begin to analyze the characteristics of the various data programs required to meet the functional requirements of each organization. This quasi-analytical effort will set the theme for the Phase II analysis of National Marine Program requirements.

The methodology utilized to identify current and future national data program requirements will be emphasized in this section. This will include the requirements of data collection systems necessary to provide data for data programs. The organization of this section is as follows: 1. Current Data Flows; and 2. Future Data Flow Requirements.

1. Current Data Flows

The current data flows within the marine environment will be assessed during Phase II, utilizing three (3) primary aids:

- A "From-To" data flow matrix relating pertinent organizations
- Data Flow Tables
- Data Flow Charts

The structure and use of these aids are discussed in the following paragraphs.

An understanding of current data flows is an initial requirement before any attempt can be made to determine future requirements or priorities. As a first step in satisfying this requirement, data were collected from selected organizations, utilizing an earlier form of the questionnaire illustrated in Appendix G (complemented by the results of the literature survey) as the primary survey instrument.

In order to obtain an initial broad overview of the inter-organizational data flow, the data from the questionnaires was first structured into a "From-To" matrix as illustrated in Figure 15. The numbers in the boxes refer to the data types listed at the right side of the figure. This matrix clearly exposes the multi-dimensioned nature of current marine data flow between collecting, processing and using organizations.

As a next step, the raw data from the questionnaires is organized and recorded on Data Flow Tables, one for each organization, as shown in Table 2, which represents the U.S. Coast Guard Oceanographic Unit. Note that the form contains a more detailed description of the type of data than Figure 15, and that it includes information on destination, transmission mode, format, volume and frequency. Note also that in this case some of the data is transmitted to users from Coast Guard ships and some from the Oceanographic Unit.

These data and the qualitative information generated during the interviews were then used to develop data flow charts for the various selected organizations. Figures 16 and 17 exemplify this conversion into flow schematics. The purpose of these flow diagrams is to depict all major flow processes from data collection to dissemination to the users.

A further example of data flow between organizations is illustrated in Figure 18, which includes a total of 270 cruises conducted by the Scripps Institution of Oceanography, the California Department of Fish and Game, the Bureau of Commercial Fisheries and the University of Washington, from 1950 to 1966. Flow of the data is shown through the processes of collection, processing, storage, research-use, publication, archival storage and ultimate multi-user activities. Average delay times of data flow are also shown between collection and first publication. Note that delays of 27, 28 and 33 months are indicated.

For purposes of evaluating National Marine Data Program requirements, the data flow interrelationships depicted by the flow diagrams described above must be complemented by detailed description of data characteristics and volumes, flowing between organizations within the marine environment. The flow diagrams will be expanded during Phase II to include other organizations and functions.

DATA USER (TO) / DATA SUPPLIER (FROM)	NAVY	CORPS OF ENGINEERS	AR[illegible]	DEPARTMENT OF STATE	AGENCY FOR INTERNATIONAL DEVELOPMENT	ESSA	MARITIME ADMINIS-TRATION	GEOLOGICAL SURVEY	FEDERAL WATER POLLUTION CONTROL ADMINIS-TRATION	BUREAU OF COMMERCIAL FISHERIES
NAVY		2,3,4,5,7, 8,9,17		5		1,2,3, 7,8,9		5	5	2,4,5,7 14,15,1
CORPS OF ENGINEERS	1,5, 8,9					5,7,8, 9		4,5,8,9	5	2,4,5, 9,16,1
ARPA						5,6				
DEPARTMENT OF STATE	5				5,17	5			5,16,17	
AGENCY FOR INTERNATIONAL DEVELOPMENT				5,17					5,16,17	
ESSA	1,2,3, 4,5,7	4,5, 8,9	6	5				2,4,5,8,9	5	2,3,4, 7,17
MARITIME ADMINISTRATION										
GEOLOGICAL SURVEY	4,5,8	1,5				4,5,8,9				1,5
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION	5	5								5,17
BUREAU OF COMMERCIAL FISHERIES	5,7,11, 16	5,16, 17		5,16, 17	5,16 17	4,5		5	5,16,17	
BUREAU OF SPORT FISHERIES AND WILDLIFE	5	5		5	5			5	5,16,17	5,16,1
BUREAU OF MINES	5	5						4,5	5	5
BUREAU OF LAND MANAGEMENT		5							5	5
NATIONAL PARK SERVICE									5	5
BUREAU OF OUTDOOR RECREATION									5	5,16
OFFICE OF SALINE WATER	5			5				5	5	5
COAST GUARD	5,7,10,11, 12,13,15,19	5,11,19		5	7,9,11		11,19			3,5,7,
PUBLIC HEALTH SERVICE	5			5,17	5,17				5,17	5
OFFICE OF EDUCATION	5			5,17	5,17					5
ATOMIC ENERGY COMMISSION	5	5		5,17				5	5,17	5
NATIONAL SCIENCE FOUNDATION	5			5				5		5
SMITHSONIAN INSTITUTION	5					5		5		5,
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION	5					5,7				
NO[illegible]	5,8, 10,14			5		5,8, 10,14		5	5	5,8 10,11
OCEANOGRAPHIC INSTITUTIONS	5	5				5,7		5	5	5,7,1 16,17
UNIVERSITIES	5	5			5	5		5	5	5,7, 16,17
INDUSTRY	5	5						5	5	5,7
STATE AGENCIES	5	5						5	5,17	5,7,
INTERNATIONAL OCEANOGRAPHIC ORGANIZATIONS	5			5,17		5		5		5,16,
FREQUENT DATA INPUTS	REPORTS	REPORTS	SEISMIC	STATISTICS, REPORTS	REPORTS, STATISTICS	REPORTS, WEATHER REPORTS, COASTAL SURVEY	INSTALLATION POSITIONS, LIGHT LISTS	REPORTS	STATISTICS, REPORTS	REPORTS, WEATHER REPORTS, BIOLOGICAL

SOURCE: INTERVIEWS AND LITERATURE

PARTIAL LIST

GEOLOGICAL SURVEY	FEDERAL WATER POLLUTION CONTROL ADMINISTRATION	BUREAU OF COMMERCIAL FISHERIES	BUREAU OF SPORT FISHERIES AND WILDLIFE	BUREAU OF MINES	BUREAU OF LAND MANAGEMENT	NATIONAL PARK SERVICE	BUREAU OF OUTDOOR RECREATION	OFFICE OF SALINE WATER	COAST GUARD	PUBLIC HEALTH SERVICE	OFFICE OF EDUCATION	ATOMIC ENERGY COMMISSION	NATIONAL SCIENCE FOUNDATION
5	5	2,4,5,7,12, 14,15,16,18		2,4,5, 8,9				5	4,5,11			4,5,8	5,17
4,5,8,9	5	2,4,5,8, 9,16,17	5	4,5,8,9		5		5	5,11			5	
	5,16,17								5		5	5	5
	5,16,17									5,17	5		5
2,4,5,8,9	5	2,3,4,5, 7,17	4,5,8,9						4,5,9				5
									5				
		4,5	4,5,8,9		4,5,17	5		4,5				5	5
		5,17	5	5	5		5	5		5,17		5	
5	5,16,17		4,5,7,16, 17,18	4,5,17	5	5,16,17	5,16,17	5,16	4,5,11	5,16	4,5,16,17	4,5,16,17	5,16,17
5	5,16,17	5,16,17		5	5	5	5						
4,5	5	5	5		5	5				5,17		5	5
	5	5	5	5		5	5						
	5	5	5		5,17		5,17						
	5	5,16	5,17		5,17	5,17							
5	5	5	5									5	5
		3,5,7,19											5
	5,17	5							5		5	5	5
		5											5
5	5,17	5	5	5				5	5	5	5		5
5		5						5	5	5	5	5	
5		5,16	5			5			5		5		5
													5
5	5	5,8 10,14	5,8, 10,14	3,5,8, 12,14					5,10	5		5	
5	5	5,7,12,14, 16,17	5	5					5			5	5
5	5	5,7,12,14, 16,17	5	5				5	5	5	5	5	5
5	5	5,7		5				5	5,11				5
5	5,17	5,7,16,17	5,17	5,17		5,17	5,17	5,17	5,11				
5		5,16,17							5,11			5	
REPORTS	STATISTICS, REPORTS	REPORTS, WEATHER REPORTS, BIOLOGICAL & FISHERIES DATA, STATISTICS	REPORTS	CHARTS, REPORTS	REPORTS, STATISTICS	REPORTS, STATISTICS	REPORTS STATISTICS	REPORTS	REPORTS, INSTALLATIONS POSITIONS	REPORTS, STATISTICS	REPORTS	REPORTS	REPORTS

TIAL LIST OF DATA TYPES AND FLOW BETWEEN MARINE

B

FIGURE 15

EDUCATION	ATOMIC ENERGY COMMISSION	NATIONAL SCIENCE FOUNDATION	SMITHSONIAN INSTITUTION	NATIONAL AERONAUTICS AND SPACE ADMINISTRATION	NODC	OCEANOGRAPHIC INSTITUTIONS	UNIVERSITIES	INDUSTRY	STATE AGENCIES	INTERNATIONAL OCEANOGRAPHIC ORGANIZATIONS	FREQUENT DATA OUTPUTS
	4,5,8	5,17	5	5	5,12, 13,14	4,5,8,9, 12,14,18	1,5,8,9, 12,11,18	4,5,9,18	4,5,9	5	CHARTS, REPORTS, BOTTOM CONDITIONS, COASTAL SURVEYS, SYNOPTIC WEATHER
	5				5	5	5	4,5,8,9	1,5,8,9		CHARTS, REPORTS, BOTTOM CONDITIONS COASTAL SURVEY
											REPORTS, SEISMIC
5	5	5					5			5	REPORTS
5		5					5				REPORTS
		5			5,12,14	3,4,5,7	4,5	3,4,18	4,5	5	CHARTS, REPORTS
								5			REPORTS
	5	5	5		5,6,8	4,5,8	4,5,8	4,58	4,5,8	5	CHARTS, REPORTS, BOTTOM CONDITIONS
	5					5	5	5	5,16,17		REPORTS
5,16,17	4,5,16,17	5,16,17	4,5,16,17		5,12,11,16	1,5,7,10, 16,17,18	4,5,7,10, 16,17,18	4,5, 16,17	1,5,7,10, 16,17,18	1,5, 16,17	REPORTS, BIOLOGICAL & FISHERIES DATA, STATISTICS, CHARTS
			5		5	5	5		5,17		REPORTS
	5	5					5	5	5,17		REPORTS
											REPORTS
			5						5,17		REPORTS, STATISTICS
									5,17		REPORTS, STATISTICS
	5	5			5		5	5	5		REPORTS
		5	5		5,12,13, 14,15	5	5	5,19	5,11,19	5	REPORTS, INSTALLATION POSITIONS LIGHT LISTS
5	5	5				5					REPORTS, STATISTICS
		5	5			5					REPORTS, STATISTICS
5		5			5	5	5	5	5	5	REPORTS, STATISTICS
5	5		5		5	5,16	5	5		5	REPORTS
5		5				5	5			5	REPORTS
		5	5		5		5	5	5		REPORTS
	5		5			5,6,8,10, 12,13,14,17		5,6,8, 13,14,17	5	5,11	REPORTS, BOTTOM CONDITIONS, BT PRINTS, HYDROGRAPHIC STATION
	5	5	5		5,6,8,12, 10,11		5	5	5	5	REPORTS
5	5	5	5	5	5,6	5			5	5	REPORTS
		5	5	5	12	5	5		5		REPORTS
						5	5	5			REPORTS, STATISTICS
	5		5		5,14	[illegible]	5				REPORTS
	REPORTS	REPORTS	REPORTS	REPORTS	REPORTS, MECHANICAL BT, HYDROGRAPHIC STATION	REPORTS	REPORTS, CHARTS	CHARTS, REPORTS	CHARTS, REPORTS	REPORTS	

EN MARINE SCIENCE ORGANIZATIONS

C

	OCEANOGRAPHIC INSTITUTIONS	UNIVERSITIES	INDUSTRY	STATE AGENCIES	INTERNATIONAL OCEANOGRAPHIC ORGANIZATIONS	FREQUENT DATA OUTPUTS
	4,5,8,9, 12,14,18	4,5,8,9, 12,[illegible],18	4,5.9,18	4,5,9	5	CHARTS, REPORTS, BOTTOM CONDITIONS, COASTAL SURVEYS, SYNOPTIC WEATHER
	5	5	4,5,8,9	4,5,8,9		CHARTS, REPORTS, BOTTOM CONDITIO S COASTAL SURVEY
						REPORTS, SEISMIC
		5			5	REPORTS
		5				REPORTS
4	3,4,5,7	4,5	3,4,18	4,5	5	CHARTS, REPORTS
			5			REPORTS
	4,5,8	4,5,8	4,58	4,5,8	5	CHARTS, REPORTS, BOTTOM CONDITIONS
	5	5	5	5,16,17		REPORTS
,16	4,5,7,10, 16,17,18	4,5,7,10, 16,1[illegible],18	4,5, 16,17	4,5,7,10, 16,17,18	4,5, 16,17	REPORTS, BIOLOGICAL & FISHERIES DATA, STATISTICS, CHARTS
	5	5		5,17		REPORTS
		5	5	5,17		REPORTS
						REPORTS
				5,17		REPORTS, STATISTICS
				5,17		REPORTS, STATISTICS
		5	5	5		REPORTS
	5	5	5,9	5,11,19	5	REPORTS, INSTALLATION POSITIONS LIGHT LISTS
	5					REPORTS, STATISTICS
	5					REPORTS, STATISTICS
	5	5	5	5	5	REPORTS, STATISTICS
	5,16	5	5		5	REPORTS
	5	5			5	REPORTS
		5	5	5		REPORTS
	5,6,8,10, 12,13,14,17		5,6,8, 13,14,17	5	5,14	REPORTS, BOTTOM CONDITIONS, BT PRINTS, HYDROGRAPHIC STATION
2,		5	[illegible]	5	[illegible]	REPORTS
	5			[illegible]	[illegible]	REPORTS
	[illegible]	5		[illegible]		REPORTS
	5	5	5			REPORTS, STATISTICS
	8	5				REPORTS
STATION	REPORTS	REPORTS, CHARTS	CHARTS, REPORTS	CHARTS, REPORTS	REPORTS	

ORGANIZATIONS

TYPE OF DATA

1. MAGNETIC
2. HYDROGRAPHIC
3. CLIMATOLOGY
4. CHARTS
5. REPORTS
6. SEISMIC
7. WEATHER REPORTS
8. BOTTOM CONDITIONS
9. COASTAL SURVEY
10. BT PRINTS
11. INSTALLATION POSITIONS
12. MECHANICAL BT
13. S-T-D
14. HYDROGRAPHIC STATION
15. XBT
16. BIOLOGICAL & FISHERIES DATA
17. STATISTICS
18. SYNOPTIC WEATHER
19. LIGHT LISTS

NOTE BLANK INDICATES NO INFORMATION ON DATA FLOW

D

TABLE 2

DATA FLOW TABLE - U.S. COAST GUARD

Interviewer AMR

Organization Producing Data U.S. Coast Guard Date 7/19/67
Reviewed with C.G. 10/06/67

Person Interviewed Cmdr. R. Dinsmore

Title Commanding Officer, Coast Guard Oceanographic Unit, Building 159-E

Address Navy Yard Annex, Washington, D. C. 20390

Data sent to the following from Coast Guard Ships:

Organization	How Sent	Data Type	Data Format	Volume	Frequency
NODC	Mail	Mech. B.T.	Glass Slide	92/day*	Taken every 6 hours
NAVOCEANO	Mail	Fathogram	Analog Strip Chart	360,000 miles/year	
Bureau Commercial Fisheries & National Sorting Center (Smithsonian)		Plankton Tow	Specimen	4/day	
Bureau Commercial Fisheries		Productivity Observation	Digital Print	2/day	
U.S. Geological Survey		Bottom Core	Specimen	90/year	
NAVOCEANO		Bottom Core		45/year	
U.S. Geological Survey		Grab Sample	Specimen	180/year	
NAVOCEANO		Grab Sample		90/year	
Weather Bureau	Radio	Weather Ship Meteorology	Digital	24/day	Sent every 6 hours

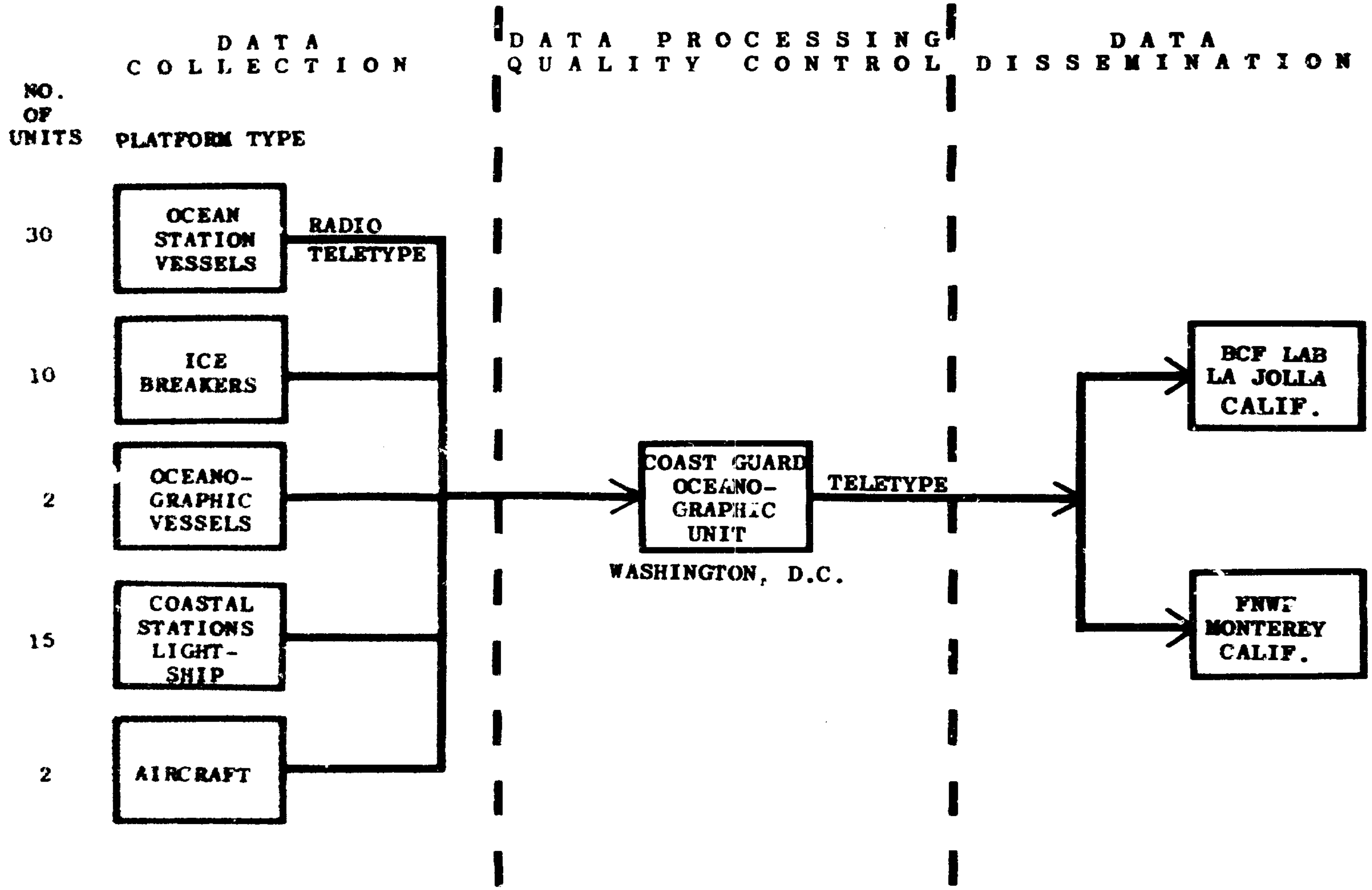
U.S. Geological Survey		Grab Sample	Specimen	180/year	
NAVOCEANO		Grab Sample		90/year	
Weather Bureau	Radio	Weather Ship Meteorology	Digital	24/day	Sent every 6 hours
Coast Guard Oceanographic Unit	Radio	Weather Ship Temp-Depth Salinity Location	Digital	6/day	Sent once/ day
NAVOCEANO	TTY	Ice Reports	Digital	2/day	
Coast Guard Oceanographic Unit	Mail		Charts		

Data sent to the following from Coast Guard Oceanographic Unit:

NODC	Mail	XBT	Analog Strip Chart	6/day*	Taken every 4 hours
NODC	Mail	S-T-D	Analog Strip Chart and Digital	4/day	
NODC	Mail	Hydrographic Station Data	Report Form (21 observations/ station)	8/day	
Fleet Numerical Weather Facility & Bureau Commercial Fisheries	TTY	Real Time BT Data	Digital	80/day	Sent every 6 hours
Fleet Numerical Weather Facility & Bureau Commercial Fisheries	TTY	Real Time S-T-D	Digital	8/day	Sent once/ day

* As XBT's replace mechanical BT's on USCG vessels the total of XBT's will increase and mechanical BT's will decrease

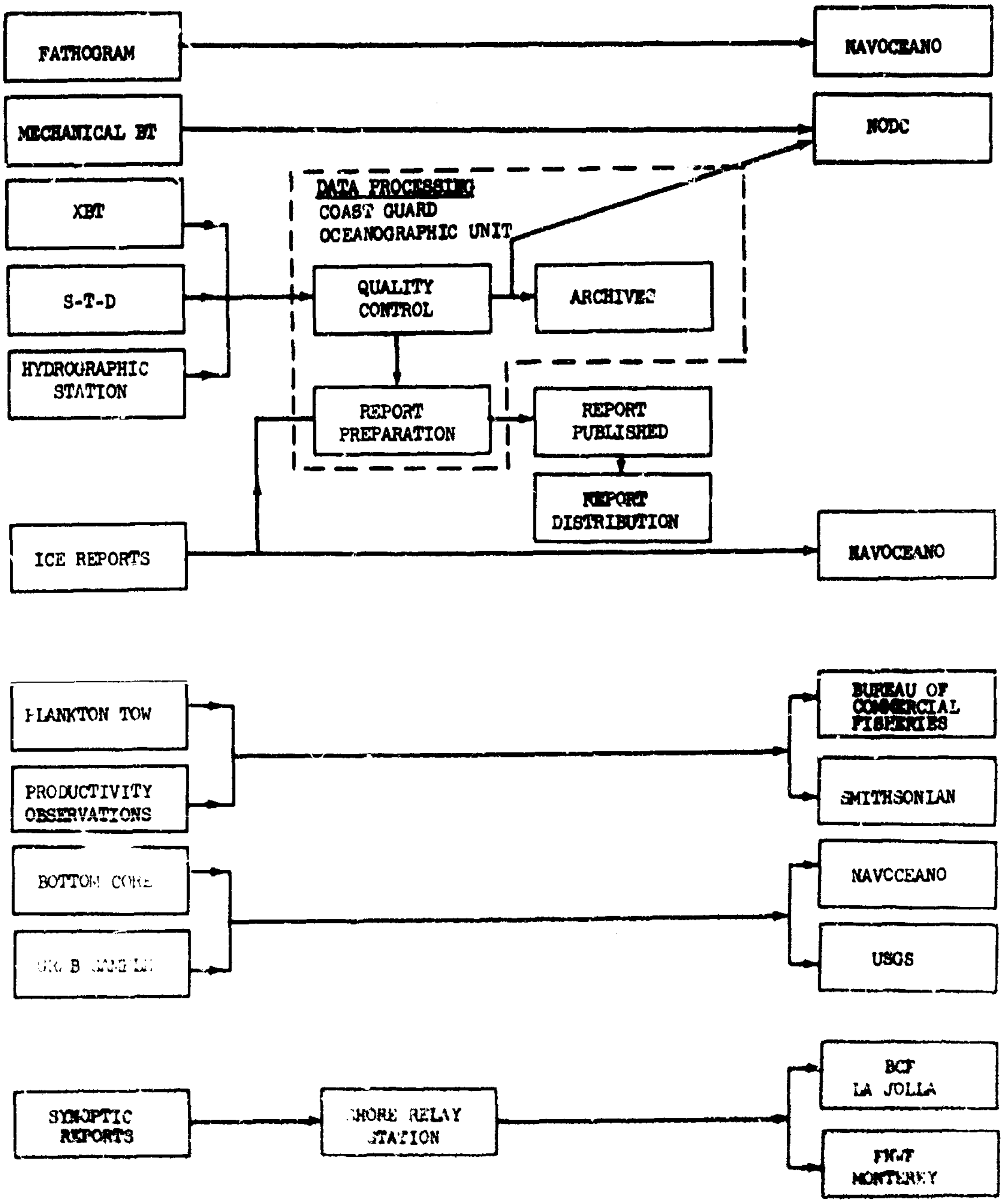
B



FLOW CHART FOR COAST GUARD OCEANOGRAPHIC SYNOPTIC DATA
BATHYTHERMOGRAPH AND HYDROGRAPHIC STATION DATA

SOURCE: CMDR. R. DINSMORE, CO, CGOU

FIGURE 16

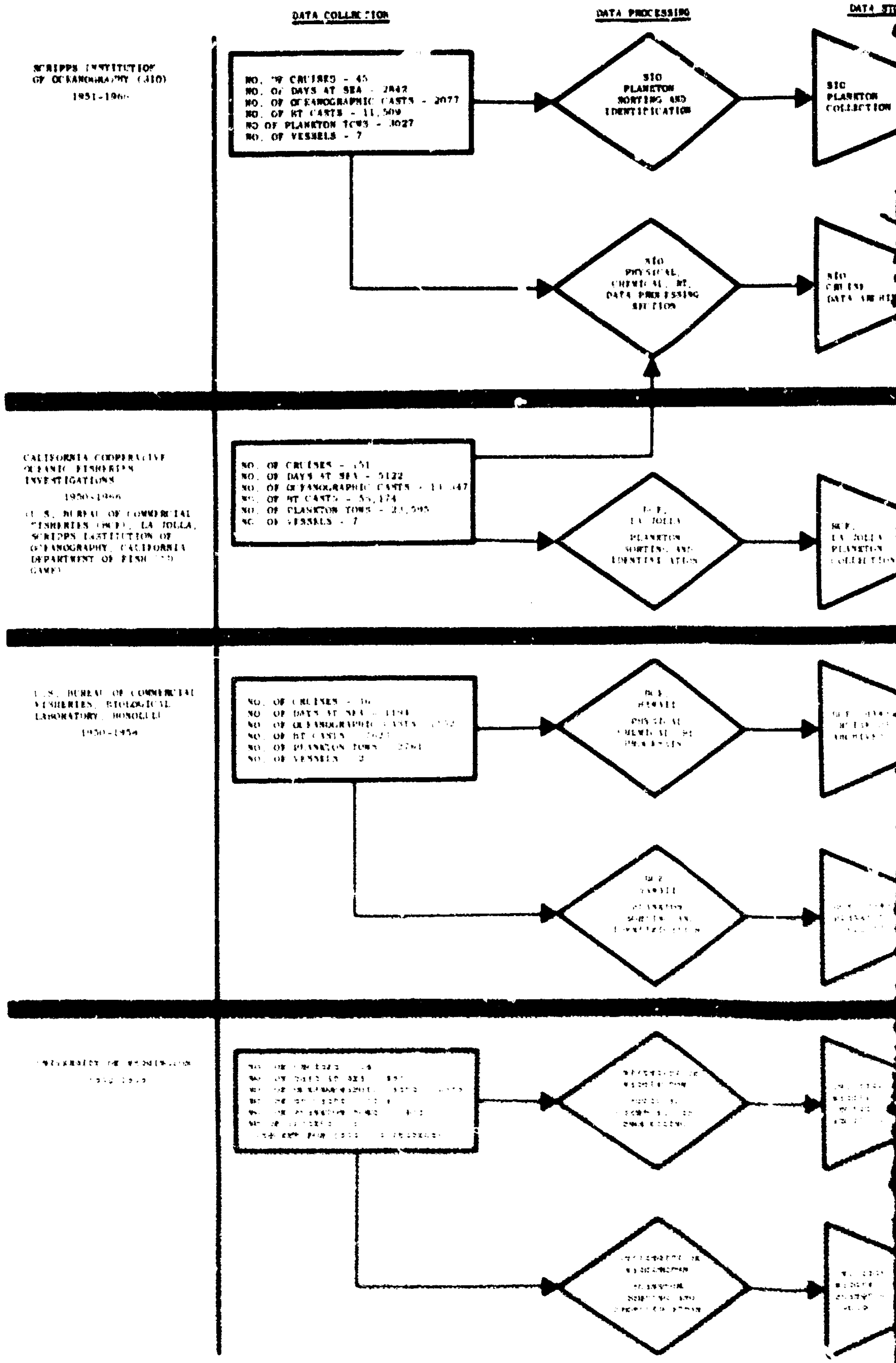


FLOW CHART

COAST GUARD OCEANOGRAPHIC DATA

SOURCE: Cmdr. R. Dinsmore, CO, CGOU

FIGURE 17



PARTIAL DATA FLOW DIAGRAM FOR

(L)-3705/003/00

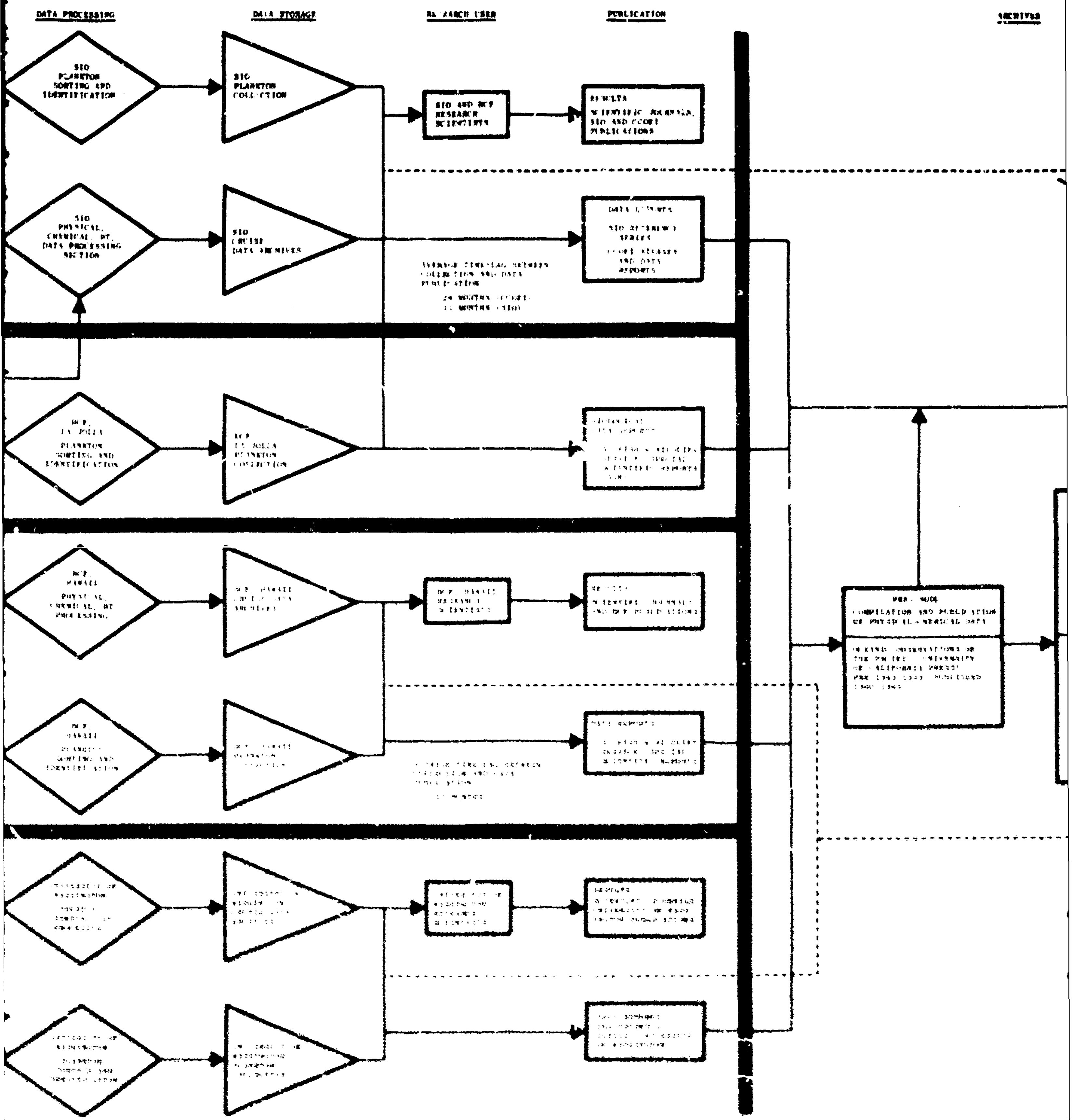
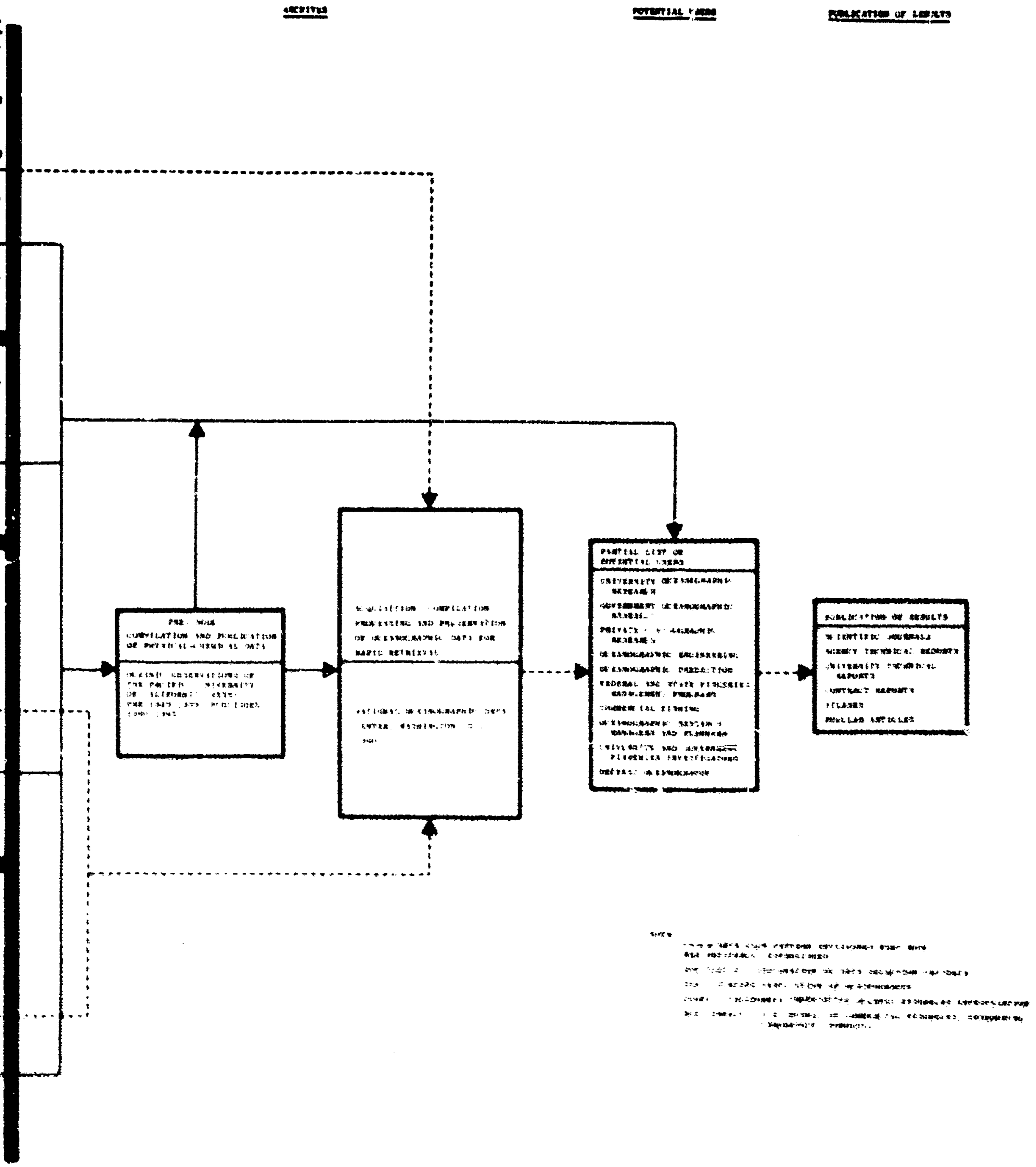


DIAGRAM FOR SELECTED OCEANOGRAPHIC COLLECTING, STORA

B.

FIGURE 18



COLLECTING, STORAGE AND USING ORGANIZATIONS

'E 18

During Phase II, the details of the data documentation formats, illustrated in Figure 19, will be expanded and modified to provide more information needed for the analyses of national marine data base requirements. A selection of the data gathered from NODC is exemplified in Figure 19. Preliminary evaluations of data characteristics and volumes for selected federal organizations, utilizing this format, appear in later parts of this section. Information from this data characteristics chart for items such as current input and output volumes, expected increases in volumes and existing purging activities will be important in locating bottlenecks and critical gaps in the National Marine Data Program.

2. Future Data Flow Requirements

The determination of National Marine Data Program requirements over time necessitates the conduct of a thorough analysis of anticipated changes in current data flows. Emphasis will be placed on evaluating the intensity and timing with which various technological, environmental, political, and legal developments will affect national marine data flows.

Certain of these anticipated future impacts have already been discussed (e.g., the impact of buoy-satellite systems on marine data collection and handling) in this Phase I report. However, a major effort must be devoted to such analyses during Phase II. In general, five (5) approaches will be used to assess future impacts on National Marine Data Program requirements.

- Analysis of long-range plans and problems

  This approach will be particularly fruitful for uncovering impacts of expected future marine activities. For example, Planning Research Corporation (DN 435) has completed the conceptualization studies for the Hydrography Office, NAVOCEANO, to develop an Ocean Survey Program. It has covered eight departments and has specified data and data management requirements for a data handling system which would be an integral part of the Intelligence Data Handling System (IDHS) (DN 338). Other federal organizations have long-range plans which must be given particular attention during Phase II.

DATA INPUTS						
NUMBER	TYPE	MEDIA	CURRENT ANNUAL VOLUME	EXPECTED INCREASE IN ANNUAL VOLUME	DATA RECEIVED FROM	TRANSM[illegible] MO[illegible]
1	c) BT DATA 1) ANALOG	LOGS GLASS SLIDES APERTURE CARDS GRIDS PRINTS PUBLICATIONS	 80,000 300 1,000 12,000	850,000 (UNPROCESSED BACKLOG)	NAVY INSTITUTIONS GOVERNMENT AGENCIES WDC-A FOREIGN EXCHANGE INDUSTRY	MA[illegible]

DATA STORAGE								
NUMBER	TYPE	MEDIA	CURRENT VOLUME	EXPECTED INCREASE IN ANNUAL VOLUME	EXPECTED DECREASE IN ANNUAL VOLUME (PURGING)	MAXIMUM VOLUME	WHAT DONE PURGED
1	BT 1) ANALOG	OZALID PRINTS PHOTOGRAPH NEGATIVES	1,000,000 22,000	30,000			

DATA OUTPUTS						
NUMBER	TYPE	MEDIA	CURRENT ANNUAL VOLUME	EXPECTED INCREASE IN ANNUAL VOLUME	RECIPIENT OF DATA	TRANSMISSIO[illegible] MODE
1	ATLASES INDEXES LISTINGS SUMMARIES BT REPRODUCTIONS	XEROX OZALID REPRODUCTION OF NEGATIVES	150,000		INSTITUTIONS FOREIGN AND DOMESTIC EXCHANGE NEL NAVOCEANO ESSA	MAIL

ORGANIZATION DATA CHARACTERISTICS
FIGURE 19

A

SOURCE: SEE FIGURE 29.

DATA INPUTS					
CURRENT ANNUAL VOLUME	EXPECTED INCREASE IN ANNUAL VOLUME	DATA RECEIVED FROM	TRANSMISSION MODE	FREQUENCY OF INPUT	USE
	850,000 (UNPROCESSED BACKLOG)	NAVY	MAIL		
80,000		INSTITUTIONS			
300		GOVERNMENT AGENCIES			
1,000		WDC-A			
		FOREIGN EXCHANGE			
12,000		INDUSTRY			

DATA STORAGE						
T E	EXPECTED INCREASE IN ANNUAL VOLUME	EXPECTED DECREASE IN ANNUAL VOLUME (PURGING)	MAXIMUM VOLUME	WHAT IS DONE WITH PURGED DATA?	FREQUENCY OF DATA PROCESSING	DATA PROCESSING FUNCTIONS
,000	30,000					CODING, FILING, PROOFING, EDITING
,000						

DATA OUTPUTS					
CURRENT ANNUAL VOLUME	EXPECTED INCREASE IN ANNUAL VOLUME	RECIPIENT OF DATA	TRANSMISSION MODE	FREQUENCY OF OUTPUT	REQUEST OR SCHEDULED ?
150,000		INSTITUTIONS	MAIL		
		FOREIGN AND DOMESTIC EXCHANGE			
		NRL			
		NAVOCEANO			
		ESSA			

ON DATA CHARACTERISTICS CHART

FIGURE 19

B

- Analysis of trends in data flows, volumes and characteristics

  Although information from historical trends will have important bearings on determining National Marine Data Program requirements, it is not considered wise to establish requirements solely on the basis of projecting historical data. This is especially important because of the dynamic nature of marine science activities. Quantitative extrapolation must be tempered with judgmental and planning information from the organizations and marine science experts.

- Predictions of marine science experts, both through personal interviews and the literature.

- Assessments of trends in marine sciences technology - instrumentation, platforms, changing data collection methods, etc.

- Assessment of the impact. of technological, economic, social, environmental, legal and political constraints over time.

These activities must not be limited to Phase II; they must be conducted in an ongoing fashion. Effective prediction of future conditions is required to ensure timely responses by organizations to changes in data program requirements.

Preliminary investigation of methods for performing the forecasting function suggests that the sporadic nature of most time-series of marine date volumes precludes their use as sole predictors of future conditions. It is anticipated, however, that the combination of predictions from historical data with information on anticipated occurrences will improve forecasting capabilities.

A good source of data is the published schedules of ships' cruises by the various organizations. These schedules are published with a lead time of one year (sometimes up to five years in long-range plans). Figure 20 presents a summary of the collection rates per day, based on a 365-day sampling period for a number of organizations. It may prove feasible to multiply the measurement units per day by scheduled ship days to obtain an estimated data volume by measurement type; although the sampling rates of the organizations in Figure 20 are not strictly comparable due to the fact that the method used to derive them discounts several variations between organizations. The technique shows significant promise, however, for Phase II use.

AVERAGE DATA COLLECTION RATES PER DAY (1)
FOR SELECTED ORGANIZATIONS*

		MEASUREMENTS					
DATA TYPE	UNITS	U. S. COAST GUARD (2)	NAVOCEANO (3)	SCRIPPS (4)	BCF HAWAII (5)	UNIV. OF WASH. (6)	CCOFI (7)
BOTTOM SAMPLES (CORE, GRAB, DREDGE)	PER-DAY	1.4	.98	-	-	-	-
BOTTOM PHOTO LOWERINGS	PER-DAY	-	0.04	-	-	-	-
MECHANICAL BT	PER-DAY	92.0	3.22	1.97	2.32	1.82	9.05
XBT		6.0	.82	-	-	-	-
FATHOGRAMS	MILES/DAY	1,000	712	-	-	-	-
CURRENT METER	HOURS/DAY		14.3	-	-	-	-
SOUND VELOCITY LOWERING	PER-DAY	-	.38	-	-	-	-
ACOUSTIC STATIONS	PER-DAY	-	0.02	-	-	-	-
NANSEN CASTS	PER-DAY	8.0	1.74	.36	.35	.37	2.15
S-T-D CASTS	PER-DAY	4.0	0.49	-	-	-	-
CONTINUOUS SEA SURFACE TEMPERATURE	HOURS/DAY	-	-	24	24	-	24
SEISMIC PROFILE	MILES/DAY	-	475	-	-	-	-
MAGNETIC PROFILE	MILES/DAY	-	535	-	-	-	-
PLANKTON TOW	PER-DAY	4.0	0.20	.52	.84	.48	3.8
MIDWATER TRAWL	PER-DAY	-	-	-	-	-	-
PRODUCTIVITY OBSERVATION	PER-DAY	2.0	-	-	-	-	-

(1) BASED ON A 365 DAY SAMPLING PERIOD.

ORGANIZATION	SOURCE OF INFORMATION	SAMPLING PERIOD COVERED
(2) U.S. COAST GUARD	PERSONAL COMMUNICATION, COMMANDER R. P. DINSMORE, OCT. 1967	1967
(3) NAVOCEANO	INTERVIEWS WITH HYDROGRAPHIC AND OCEANOGRAPHIC SURVEYS DEPTS., NAVOCEANO	1949-1967
(4) SCRIPPS INSTITUTION OF OCEANOGRAPHY		1951-1966
(5) U.S. BUREAU OF COMMERCIAL FISHERIES, BIOLOGICAL LABORATORY, HONOLULU	OCEANIC OBSERVATIONS OF THE PACIFIC. (UNIV. OF CALIF. PRESS.), SIO DATA PROCESSING SECTION	1950-1958
(6) UNIVERSITY OF WASHINGTON, OCEANOGRAPHY DEPARTMENT	OCEANIC OBSERVATIONS OF THE PACIFIC (UNIV. OF CALIF. PRESS)	1952-1959
	OCEANIC OBSERVATIONS OF THE PACIFIC (UNIV. OF CALIF. PRESS)	
(7) CALIFORNIA COOPERATIVE OCEANIC FISHERIES INVESTIGATIONS	OCEANIC OBSERVATIONS OF THE PACIFIC (UNIV. OF CALIF. PRESS) SIO DATA PROCESSING SECTION	1950-1966

*FOR SMALL SAMPLE SIZES

FIGURE 20

In addition to extrapolative techniques, considerable attention must be devoted to defining future functions that organizations might perform in support of the National Marine Science Programs which they do not now perform. In response to this requirement, SDC has conducted, in a preliminary fashion, an analysis of the functions and related data programs of selected federal agencies. Figures 21 and 22 present the results of an aggregation of information concerning the National Marine Science Programs and the current support provided these programs by NODC and NAVOCEANO.* These two organizations were selected to illustrate the approach that will be applied to all pertinent organizations during Phase II. The charts describe a number of factors:

- The horizontal axis headings depict the National Marine Science Programs and the New Initiatives of the Marine Resources and Engineering Development Act of 1966. These programs have been listed from left to right in order of FY 1968 Federal funding. Also included are:

  Dollar change in funding of each program FY 1966 to FY 1968.

  The principle federal agencies, in order of total funding, that are contributing to the specified programs.

- The vertical axis headings describe current NODC and NOSP data collections and functions, or those to be established shortly. The FY 1969 anticipated NODC processing costs associated with each data collection are also presented.

- The right-hand column contains comments about collection size, input, backlog and cost.

The hatched areas on the charts indicate that on a preliminary basis, it appears that the organization is providing reasonable support to National Marine Science programs in terms of the extent of its collections and processing activity. An asterisk (*) on the chart suggests that somewhat concentrated study effort is required in Phase II to substantiate or refute the preliminary inference that potentially desirable benefits could be derived from increased support to the particular national program.

*The evaluation is for the Navy Ocean Science Program (NOSP) of which NAVOCEANO is a major part.

NATIONAL PROGRAMS AND NEW INITIATIVES / NODC DATA COLLECTION	FY '69 ANTICIPATED PROCESSING COSTS (THOUSANDS)	NATIONAL SECURITY DOD	OCEANOGRAPHIC RESEARCH DOD NSF COMMERCE SMITHSONIAN TRANSPORTATION	FISHERIES DEVELOPMENT AND SEAFOOD TECHNOLOGY INTERIOR	MAPPING AND CHARTING DOD COMMERCE	TRANSPORTATION TRANSPORTATION COMMERCE DOD	OCEAN ENVIRONMENT OBSERVATION & PREDICTION DOD TRANSPORTATION COMMERCE AEC NASA
		+86.2	+ 1.6	+10.5	+6.8	+17.4	+7.4
		$191.6	$73.2	$49.2	$39.1	$27.8	$21.1
BATHYTHERMOGRAPH	$200	////	////	////		////	////
OCEANOGRAPHIC STATION	$170	////	////	////		////	////
BIOLOGICAL	$100	*	*	*		*	
GEOLOGICAL ENGINEERING	$100	*	*		*		
COASTAL AND ESTUARINE	$50	*					*
SURFACE AND SUBSURFACE CURRENTS	$35	////	////	////	////	////	////
CHEMICAL	$25	*	*	*			*
CLIMATOLOGICAL	**	*	*	*		*	*

LEGEND:

//// AREAS IN WHICH USE OF NODC DATA MAY BE ADEQUATE BUT NEEDS FURTHER INVESTIGATION

* AREAS IN WHICH INCREASED USE OF NODC DATA APPEAR BENEFICIAL.

A

RELATIONSHIP OF NODC

'05/003/00

* OCEAN ENVIRONMENT OBSERVATION & PREDICTION DOD TRANSPORTATION COMMERCE AEC NASA	RECREATION INTERIOR DOD TRANSPORTATION	* DEEP OCEAN RECOVERY AND SUBMERGENCE NAVY	POLLUTION INTERIOR AEC DOD	INTERNATIONAL COOPERATION AND COLLABORATION STATE AID	RESOURCES INTERIOR	EDUCATION NSF DOD HEW INTERIOR COMMERCE TRANSPORTATION	DEEP OCEAN TECHNOLOGY NAVY	HEALTH HEW	* FOOD FROM THE SEA BCF AID
+7.4	+3.3		+1.1	+2.3	+ 2.0	+3.3		-.9	
$21.1	$13.6	($10.9)	$9.5	$7.4	$5.8	$5.5	($5.5)	$4.2	($3.9)
			*						
			*						
			*				*	*	
		*			*		*		
*			*						
		*	*				*		
*			*					*	
*									

F NODC DATA PROCESSING ACTIVITIES TO THE

B

FIGURE

P AN OLOGY Y	HEALTH HEW	* FOOD FROM THE SEA BCF AID	* SEA GRANT PROGRAMS NSF	* ENVIRON-MENTAL PRE-DICTION COMMERCE	SHORE STABILIZA-TION DOD	* ASSESSMENT OF CONTINENTAL SHELF INTERIOR	* ESTUARY STUDY DOD	
	-.9				+.5			DOLLAR DIFFERENCE OF FY'68 OV
.5)	$4.2	($3.9)	($4.0)	($2.5)	$1.7	($.6)	($.4)	PRESIDENT'S BUDGET FY'68. (M
								500,000 DIGITIZED OBSERVATI OBSERVATIONS RECEIVED PER A PROCESSING COST $6 PER OBSE
								375,000 DIGITIZED STATIONS (55,000 STATIONS TO BE DIGIT
*	*						* *	8,000 CODED STATIONS. 15,00 IN UNPROCESSED BACKLOG; 30,(PHYTOPLANKTON, PHYTOPLANKTO
*					*	*	*	18,000 GRAB, CORE AND DREDG TO BE PROCESSED IN FY'68.
				*	*	*	*	60,000 DIGITIZED STATIONS I IN FY'68.
*							*	100,000 DRIFT BOTTLE OBSERV BOTTLE DATA RECEIVED PER AN
	*			*			*	NO CHEMISTRY DATA CURRENTLY BE PROCESSED IN FY'68.
				*				250,000 HISTORICAL SURFACE LA JOLLA SYNOPTIC TEMPERATU

S TO THE NEEDS OF NATIONAL PROGRAMS AND

FIGURE 21 C

DOLLAR DIFFERENCE OF FY'68 OVER FY'66. (MILLIONS)	PRESIDENT'S BUDGET FY'68. (MILLIONS)	CURRENT STATUS OF NODC DATA COLLECTION
		500,000 DIGITIZED OBSERVATIONS, 600,000 OZALID PRINTS ON HAND: 500,000 UNPROCESSED BACKLOG: 100,000 OBSERVATIONS RECEIVED PER ANNUM: 95,000 OBSERVATIONS TO BE DIGITIZED IN FY'68. PRESENT AVERAGE PROCESSING COST $6 PER OBSERVATION.
		375,000 DIGITIZED STATIONS ON HAND: 20,000 UNPROCESSED BACKLOG: 40,000 STATIONS RECEIVED PER ANNUM: 55,000 STATIONS TO BE DIGITIZED IN FY'68. PRESENT AVERAGE PROCESSING COST $5.00 PER STATION.
		8,000 CODED STATIONS, 15,000 SOURCE DOCUMENTS, 5,000 BIBLIOGRAPHIC REFERENCES ON HAND: 10,000 STATIONS IN UNPROCESSED BACKLOG: 30,000 OBSERVATIONS TO BE PROCESSED IN FY'68. TYPE OF DATA INCLUDE ZOOPLANKTON, PHYTOPLANKTON, PHYTOPLANKTON PIGMENTS, PRIMARY PRODUCTIVITY AND BENTHOS.
		18,000 GRAB, CORE AND DREDGE STATIONS ON CARDS: 65,000 STATIONS IN UNPROCESSED BACKLOG: 50,000 STATIONS TO BE PROCESSED IN FY'68.
		60,000 DIGITIZED STATIONS INCLUDED IN OCEANOGRAPHIC STATION FILE: 75,000 STATIONS TO BE PROCESSED IN FY'68.
		100,000 DRIFT BOTTLE OBSERVATIONS ON CARDS: 2,500,000 TOTAL CURRENT OBSERVATIONS ON HAND: 20,000 DRIFT BOTTLE DATA RECEIVED PER ANNUM: 180,000 DRIFT BOTTLE DATA TO BE PROCESSED IN FY'68.
		NO CHEMISTRY DATA CURRENTLY ON HAND: PROCESSING SYSTEM IN PREPARATION: 10,000 CHEMICAL OBSERVATIONS TO BE PROCESSED IN FY'68.
		250,000 HISTORICAL SURFACE OBSERVATIONS ON FILE: NAVOCEANO DATA ON FILE: COMPUTED DATA FOR THE BCF, LA JOLLA SYNOPTIC TEMPERATURE CHARTS IN PASSIVE STORAGE.

* NEW INITIATIVES FUNDS ( ) INCLUDED IN BUDGETS OF OTHER PROGRAMS.

** NO SPECIFIC FUNDING PLANS FOR THIS ACTIVITY

GRAMS AND NEW INITIATIVES

D

NATIONAL PROGRAMS AND NEW INITIATIVES / NAVY OCEAN SCIENCE PROGRAM	NATIONAL SECURITY DOD	OCEANOGRAPHIC RESEARCH DOD NSF COMMERCE SMITHSONIAN TRANSPORTATION	FISHERIES DEVELOPMENT AND SEAFOOD TECHNOLOGY INTERIOR	MAPPING AND CHARTING DOD COMMERCE	TRANSPORTATION TRANSPORTATION COMMERCE DOD	OCEAN ENVIRONMENT OBSERVATION & PREDICTION DOD TRANSPORTATION COMMERCE AEC NASA	RECREATION INTERIOR DOD TRANSPORTATION	DEEP OCEAN RECOVERY AND SUBMERGENCE NAVY	POLLUTION INTERIOR DOD TRANSPORTATION
	+30.2	+1.6	+10.5	+6.8	+17.4	+7.4	+3.3		+1.1
	$191.6	$73.2	$49.2	$39.1	$27.6	$21.1	$13.6	($10.9)	[illegible]
PHYSICAL OCEANOGRAPHY TEMPERATURE, CURRENT, HEAT TRANSFER, SURFACE WAVE, TIDE			*	*					
CHEMICAL OCEANOGRAPHY SURFACE ORGANIC FILM, ISOTOPE RATIO, SALINITY, DISSOLVED GAS, RATE OF MINERAL ALTERATION, INDUSTRIAL POLLUTANT, NUCLIDE DISTRIBUTION, H_2S CONTENT							*		
GEOLOGY AND GEOPHYSICS BATHYMETRY, BOTTOM SAMPLES, SEISMIC PROFILES, SEDIMENT THICKNESS, SEDIMENT TRANSPORT, SUB-SURFACE STRUCTURE, CRUSTAL THICKNESS, MAGNETIC PROFILES, GRAVITY STATIONS, HEAT FLOW-BENTHIC BOUNDARY				*	*				
BIOLOGICAL OCEANOGRAPHY BIOLOGICAL FOULING, BIOTA LOCATION, BIOTA SOUNDS, SOUND SCATTER, LIGHT SCATTER, LUMINESCENCE, POISONOUS ORGANISMS, PREDATORY ANIMALS									
UNDERWATER SOUND ACOUSTIC ENERGY PATH, REFLECTION, ACOUSTIC VELOCITY, ACOUSTIC ENERGY ABSORPTION, ACOUSTIC ENERGY SCATTER, INDUSTRIAL NOISE, NATURAL NOISE									
ENVIRONMENTAL PREDICTION SURFACE WAVE SPECTRA, OCEAN CURRENTS, ESTIMATED BOTTOM CONDITIONS, WEATHER			*		*				*
ENGINEERING RESEARCH DEEP WATER MAPPING, DEEP WATER NAVIGATION, DEEP WATER PHOTOGRAPHY, DEEP WATER COMMUNICATIONS, BOTTOM SOIL PENETRATION, OCEAN BOTTOM CONSTRUCTION					*		*		
MAN IN THE SEA PHYSIOLOGY, LIFE SUPPORT SYSTEMS, DIVING TECHNIQUES, UNDERWATER MANIPULATORS									
INSTRUMENTATION TOWED INSTRUMENTS, HYDROPHONE ARRAYS, SEA SURFACE SLOPE, NAVIGATION, HIGH SPEED DATA HANDLING, BUOY DATA ACQUISITION SYSTEMS			*						
SPECIAL-PURPOSE PLATFORMS RESEARCH SHIP, DEEP SUBMERGENCE									
OCEAN DATA SYSTEMS MONSTER BUOY, SEA SPIDER, FIXED TOWERS							*		

RELATIONSHIP OF NAVY OCEAN SCIENC

ON	RECREATION INTERIOR. DOD TRANSPORTATION	• DEEP OCEAN RECOVERY AND SUBMERGENCE NAVY	POLLUTION INTERIOR DOD TRANSPORTATION	INTERNATIONAL COOPERATION AND COLLABORATION STATE AID	RESOURCES INTERIOR	EDUCATION NSF DOD HEW INTERIOR COMMERCE TRANSPORTATION	DEEP OCEAN TECHNOLOGY NAVY	HEALTH HEW	• FOOD FROM THE SEA ICF AID	• SEA GRANT PROGRAMS NSF	• ENVIRONMENTAL PREDICTION COMMERCE	SHORE STABILIZATION DOD	• ASSESSMENT OF CONTINENTAL SHELF INTERIOR	• ESTUARY STUDY DOD	
	+3.3		+1.1	+2.3	+7.0	+3.3		-.9				+.5			DOL
	$13.6	($10.9)	$9.5	$7.4	$5.8	$5.5	($5.5)	$4.2	($[illegible].9)	($4.0)	($2.5)	$1.7	($.[illegible])	($.4)	P
														*	NAN MEI CUR SEA NGT SEA S-T
	*							*						*	SAL
					*							*		*	BOT TOT TOT FAT GRA SEI
															PLA BIO API
															ACC ACC VEI
			*												
	*														
				*											

OCEAN SCIENCE PROGRAMS TO THE NEEDS OF NATIONAL PROGRAM

b

FIGURE 22

• ASSESSMENT OF CONTINENTAL SHELF INTERIOR	• ESTUARY STUDY DOD	PRESIDENT'S BUDGET FY'68, (MILLIONS) / DOLLAR DIFFERENCE OF FY'68 OVER FY'66, (MILLIONS) CURRENT STATUS OF NAVOCEANO DATA COLLECTION (APPROXIMATE) DATA TYPE AND TOTAL ACQUIRED THROUGH FY 1967	ESTIMATED VOLUME TO BE ACQUIRED IN FY 1968
($,·)	($.·)		
	✱	NANSEN CASTS 15,000 MECHANICAL BT 60,000 CURRENT METER 88,000 HOURS SEA SURFACE TEMPERATURE 557,000 MILES XBT 300 SEA SURFACE TEMPERATURE (ART) 50,000 DATA POINTS S-T-D 180	NANSEN CASTS 1,200 MECHANICAL BT 6,200 CURRENT METER 30,000 HOURS SEA SURFACE TEMPERATURE 320,000 MILES XBT 120,000 SEA SURFACE TEMPERATURE (ART) 50,000 DATA POINTS S-T-D 5,000
	✱	SALINITY SAMPLES 2,700	SALINITY SAMPLES 200
(shaded)	✱	BOTTOM SAMPLES AND CORES 5,700 TOTAL MAGNETIC INTENSITY - SHIP 2,300,000 MILES TOTAL MAGNETIC INTENSITY - AIR 1,200,000 MILES FATHOMETER SOUNDINGS 2,300,000 MILES GRAVITY PROFILE - SHIP 1,600,000 MILES SEISMIC PROFILE - SHIP 350,000 MILES	BOTTOM SAMPLES AND CORES 700 TOTAL MAGNETIC INTENSITY - SHIP 530,000 MILES TOTAL MAGNETIC INTENSITY - AIR 200,000 MILES FATHOMETER SOUNDINGS 555,000 MILES GRAVITY PROFILE - SHIP 225,000 MILES SEISMIC PROFILE - SHIP 310,000 MILES
		PLANKTON TOW 1,400 BIOLOGICAL STATIONS 130 AMBIENT NOISE 75	PLANKTON TOW 141 BIOLOGICAL STATIONS 20 AMBIENT NOISE 25
		ACOUSTIC STATIONS 150 ACOUSTIC RUNS 350 VELOCIMETER 700	ACOUSTIC STATIONS 20 ACOUSTIC RUNS 50 VELOCIMETER 600

LEGEND:

(hatched) AREAS IN WHICH USE OF NAVY DATA MAY BE ADEQUATE BUT NEEDS FURTHER INVESTIGATION

✱ AREAS IN WHICH POTENTIAL USE OF NAVY DATA APPEAR BENEFICIAL.

• NEW INITIATIVES
FUNDS ( ) INCLUDED IN BUDGETS OF OTHER PROGRAMS.

SOURCE. (1) "THE OCEAN SCIENCE PROGRAM OF THE U.S. NAVY, ACCOMPLISHMENTS AND PROSPECTS", OFFICE OF THE OCEANOGRAPHER OF THE NAVY, JUNE 1967.

(2) "MARINE SCIENCE AFFAIRS - A YEAR OF TRANSITION," FIRST REPORT OF THE PRESIDENT TO CONGRESS ON MARINE RESOURCES AND ENGINEERING DEVELOPMENT, FEBRUARY, 1967.

'AL PROGRAMS AND NEW INITIATIVES

C

The appearance of a hatched area in any matrix cell does not suggest that analysis of this relationship and its data management requirements will be suspended. Rather, it indicates that substantial data activity is already occurring in these areas. Investigation of these areas must also be conducted in order to determine the effectiveness of the support being provided.

It should be noted that the symbolism on the charts merely represents an attempt to stratify Phase II study efforts in accordance with the identification of needs. Funding levels and changes in funding levels are shown in order to indicate the magnitude of national programs. Processing costs are shown for NODC to indicate the magnitude of processing activities in support of national programs.

Tables 3 and 4 list data collection parameters and functions which would provide benefits to National Marine Science Programs if corresponding data processing activities were accelerated in NODC and NAVOCEANO, respectively. Table 5 is a summarization of the two foregoing tables and indicates data bases which, if available and accessible, would provide benefits to the marine science community if maintained at NODC and NAVOCEANO. These and other potential data collections will be investigated during Phase II.

TABLE 3

Potential Support Areas - NODC	
National Program	Data Collection Parameters
Estuary Study	All
Assessment of Continental Shelf	Imbalance except for current data
Shore Stabilization	Imbalance except for current data
Environmental Prediction	Coastal and Estuary Chemical Climatological
Health	All
Deep Ocean Technology	All
Resources	All
Pollution	All
Deep Ocean Recovery	All
Ocean Environmental Observation and Prediction	Coastal and Estuaries Chemical Climatological
Transportation	Biological Climatological
Mapping and Charting	Geological and Engineering
Fisheries Development and Seafood Technology	Biological Chemical Climatological
Ocean Research	Biological Geological and Engineering Chemical Climatological
National Security	Biological Geological and Engineering Coastal and Estuaries Chemical Climatological

TABLE 4

Potential Support Areas - NAVOCEANO	
National Program	Functions on Data Collections
Fisheries Development and Seafood Technology	Physical Oceanographic Data
Transportation	Environmental Prediction Engineering Research Ocean Data Systems
Recreation	Engineering Research
Pollution	Environmental Prediction
International Cooperation and Collaboration	Ocean Data Systems
Resources	Geolcgical and Geophysical Data
Shore Stabilization	Geological and Geophysical Data
Estuary Study	Physical Oceanographic Data Chemical Oceanographic Data Geology and Geophysical Data

TABLE 5

Potential Data Bases Useful to the Marine Science Community	
NODC	NAVOCEANO
. Ice Data	. Sediment Data (Presently Classified)
. Bottom Photography	. Coastal Wave Data
. Bathymetry	. Seismic Data
. Engineering Parameters	. Geodetic Data
. Time Series Data	. Gravity Data

3. <u>Functional and Data Program Requirements of Selected Federal Agencies</u>

As mentioned in section III-B, preliminary functional and data program requirements analyses have been conducted during Phase I of the following selected federal agencies:

- NAVOCEANO
- NODC
- ESSA
- Smithsonian Oceanographic Sorting Center
- BCF
- Coast Guard

These organizations were selected on the basis of a number of factors including total funding, importance of National Marine Science Programs supported and relevance to the National Marine Data Program. These preliminary Phase I efforts served to refine and illustrate the analysis processes used, and to collect prime information for use in and for structuring the Phase II study.

In most cases, the organization's functions and the data program requirements derived therefrom are discussed in the following consecutive categories:

- Missions and benefits
- Functions and Data Requirements
- Data Program Priorities
- Impact of future marine activities
- Relevance for Phase II

The following sections then, describe briefly these aspects of the organizations listed above. The filling in of substantially greater detail remains as part of the work of Phase II.

a. Naval Oceanographic Office (NAVOCEANO)

1) Missions and Benefits. The primary mission of NAVOCEANO is to provide environmental oceanographic data for the National Security Program. In pursuit of this mission, NAVOCEANO is responsible for increasing the knowledge of the world's oceans which will be of use to the operational Navy and Navy Research and Development programs.

Obviously, since NAVOCEANO's mission is to support the Navy pursuant to National Security Program requirements, the direct benefits of its marine data collection programs must be evaluated in relation to Navy objectives. However, the key to determining NAVOCEANO's contribution to the National Marine Science Programs lies in its mission to increase knowledge of the world ocean. Many of the Navy Science Programs contribute substantial data collections and improved oceanic equipment which are directly applicable to National Marine Science Programs. During Phase II, a thorough evaluation of these derivative benefits must be conducted before a proper assessment of the value of NAVOCEANO's data collection programs to other organizations can be made.

2) Functions and Data Requirements. The functions performed by NAVOCEANO are:

- Data collection
- Processing and storage of data
- Chart and report generation
- Dissemination of information and data
- Research and development to support the preceding functions.

It is obvious, from this list of functions, that NAVOCEANO is concerned with functions that pervade all of the National Marine Science Programs. The data collected by the Navy, particularly NAVOCEANO, in support of its objectives finds many lines of transmission within NAVOCEANO, within the Navy, and to other organizations.

Virtually all oceanographic data types and users are represented within the NAVOCEANO operations. The users vary from NAVOCEANO vessels and ASW task forces to research scientists concerned with both defense and civilian oceanographic research. User requirements include surface charts; ocean bottom bathymetry; bottom conditions for acoustic work and anchorages; location of navigational aids; geophysical data such as magnetic, seismic and gravity; tides; synoptic reports and prediction of weather; sea surface and subsurface temperature; sea state; acoustic signal definition; and all the raw data requirements of the researcher; as listed in Appendix E.

Still, NAVOCEANO's primary goal in performance of its functions is to supply ocean environmental information to the Navy in as timely and accurate a manner as possible. During Phase II, the implications of this primary goal as it relates to the National Marine Data Program must be identified. Increased responsiveness to civilian requirements must be weighed against possible degradation of national defense capabilities. Currently, many of the results of NAVOCEANO's functional activities are made available to other organizations responsible for making major contributions to other National Marine Science Programs. Assistance to non-military programs includes:

- the distribution of synoptic sea surface temperatures to the U.S. fishing fleets;
- contributions of deep ocean charts to the merchant fleet;
- the distribution of documentation on worldwide navigation.

Because of the variety, complexity and volume of its data handling problems, NAVOCEANO should be studied in Phase II to gain insight into its organization, data management requirements and constraints which may be relevant for the design of a National Marine Data Program. NAVOCEANO is therefore considered to be a high priority activity for Phase II. The following discusses the functional and data requirements analyses of NAVOCEANO which are of importance to the Phase II study.

The functional requirements of NAVOCEANO described briefly above clearly suggest the extensiveness of the data parameters and volumes required by NAVOCEANO in fulfillment of its missions. This diversity of data needs is illustrated in Table 6 which represents a compilation of individual data elements required by the many functional organizations within NAVOCEANO (DN 308). Not all of the types are presently collected; rather they represent a combination of existing data and those which are not active but may be beneficial in performance of NAVOCEANO's functions.

TABLE 6

OCEANOGRAPHIC DATA PARAMETER REQUIREMENTS*

Established by NAVOCEANO

A. Water Motion	
Current Speed	Breakers and Surf
Current Direction	Bottom Pressure Fluctuation
Wave Height	Internal Wave Height
Wave Period	Sea Level Height
Wave Direction	
B. Physical and Chemical	
Temperature	Magnesium Sulphate
Salinity	Background Gamma Radiation
Density	Radioisotope Energy
Dissolved Oxygen	Cosmic Ray Energy
pH	Radioisotope Count
Reactive Silicate	Tracer Gamma Radiation
Nitrate	Energy
Nitrite	Count

* Source: Marine Sciences Department "Table of Proposed Oceanographic Measurement Requirements." U. S. Naval Oceanographic Office, May 1964.

TABLE 6 cont'd.

C. Sea Ice Features

- Concentration
- Water Openings
  - Length
  - Width
  - Orientation
- Development Stage
- Thickness
  - Level Ice
  - Pressure Ice
  - Draft
- Topography Surface Constructions
  - Vertical
  - Areal
- Flow Width
- Recent Fracture Patterns
  - Area
  - Orientation
- Drift Speed
- Drift Direction
- Iceberg
  - Height
  - Draft
  - Areal Coverage
- Mechanical Properties
  - Strength
- Temperature
- Porosity
- Salinity

D. Oceanographic Acoustic Properties

- In Sea Water
  - Sound Speed
  - Transmission Loss
    - Absorption
    - Reflections
  - Ambient Noise
  - Acoustic Paths
- In Sea Floor
  - Sound Speed
  - Transmission Loss
    - Absorption
    - Bottom Reflection

E. Electromagnetic Propagation

- Sea Water
  - Irradiance
  - Beam Attenuation
- Above Air-Sea Interface
  - Radiation Flux - Solar and Terrestrial

TABLE 6 cont'd.

F. Sea Floor and Sub-Bottom

Bottom Topography	Chemical
Microbathymetry	Organic Carbon
Bottom Composition	Chemical Composition
Engineering Properties	pH
Water Content	Eh
Bulk Density	Bottom and Sub-Bottom Temperatures
Shear Strength	

G. Marine Organisms

Volume Scattering Coefficient	Fouling Accumulation
Frequency	Marine Animal Sounds
Intensity	Frequency
Target Strength of Individual Scatters	Intensity
Frequency	Bioluminescence
Intensity	Intensity
Plankton and Nekton Sampling	Wave Length
Depth	
Size	
Volume	

H. Geomagnetism

Total Intensity	Declination
Inclination	Telluric Currents

I. Gravity

Areal	Shoreline and Coastal

NAVOCEANO is divided into two major organizations: the Hydrographic Office and the Oceanographic Office. Within these units a number of data requirements exist which are of primary importance to the present study.

a) Hydrographic Office. The data collection functions within the Hydrographic Office include acquisition of seismic data, gravity, bathymetric, magnetic profiles, bottom samples and core descriptions, and current measurements. The collection of these data through ocean surveys, ocean station measurements and research provide the fleet with information to assist them in ASW work, navigation, storm warnings, and in planning surface and submersible ship operations.

To provide these services, the Hydrographic Office prepares:

- Nautical charts
- Sea bottom profiles and charts from bathymetric measurements
- Magnetic field charts which help locate magnetic field anomalies
- Gravity charts
- Sub-bottom structural maps from seismic data
- Ocean bottom maps from bottom sediment grab samples and cores, which are useful in sonar and acoustic work.

All of these maps and charts require a substantial amount of data handling and processing prior to dissemination. An analysis of these requirements is needed during Phase II to account for both current and anticipated future volumes and uses of marine data flowing within NAVOCEANO.

From the preliminary analysis of NAVOCEANO conducted during Phase I there appears to be an increasing need for:

- Additional high speed, fast response processing of data as the data input and output frequencies and volumes continue to accelerate.
- Improved data base maintenance, updating, and purging to account for the voluminous flows of data throughout NAVOCEANO.

- Increased selectivity of data types for fast response user access to handle increased data loads effectively.

b) Oceanographic Office. The Oceanographic Office, comprises the Oceanographic Surveys Department, the Marine Sciences Department and the Instrumentation Department. The National Oceanographic Data Center is also administratively contained within this group.

Within the Marine Sciences Department exists the Anti-Submarine Warfare Environmental Prediction Service (ASWEPS) which has an extensive requirement for synoptic sea surface and subsurface temperatures usually obtained from BT reports, and Synoptic Marine Weather Reports from cooperating merchant vessels.

In general, hydrographic survey data is submitted to the Technical Production Department of the Hydrographic Office, while oceanographic survey data is submitted to the Marine Sciences Department. Data which are unclassified either normally or through sanitization, which involves the removal of the exact location of station data, are submitted to NODC.

NAVOCEANO has three operational libraries associated with nautical charts, bathymetry and magnetic data respectively. These libraries are administered by NAVOCEANO for the Department of Defense. A substantial portion of the Navy's data collections and those obtained from other organizations are contained therein. In defining data volumes and flows within NAVOCEANO, it should be recognized that substantial portions of the data are processed and used on-site by the ship or ships collecting the data.

Besides providing estimates for tactical operations (e.g., thermocline depths related to sound velocity and sonic paths), the Fleet must assimilate synoptic reports from the Fleet Numerical Weather Facility (FNWF) which provides the required wide area coverage. Once the data are processed by FNWF and NAVOCEANO they are used by others such as BCF to compile sea surface temperature charts and tables, by the oceanographic institutions to develop ocean climatology maps, and by the merchant marine for environmental prediction. Such complicated data flows from data acquisition through many users must be carefully documented during Phase II in order to ensure adequate definitions of data management requirements.

3) Data Program Priorities. Certain types of data have been attributed high priorities in relation to satisfying National Security requirements on ASW and submarine navigation. Primary among these high priority data collections are:

- Bottom topography
- Water temperature
- Bottom sediment conditions
- Magnetic and gravity fields
- Acoustic signal transmission

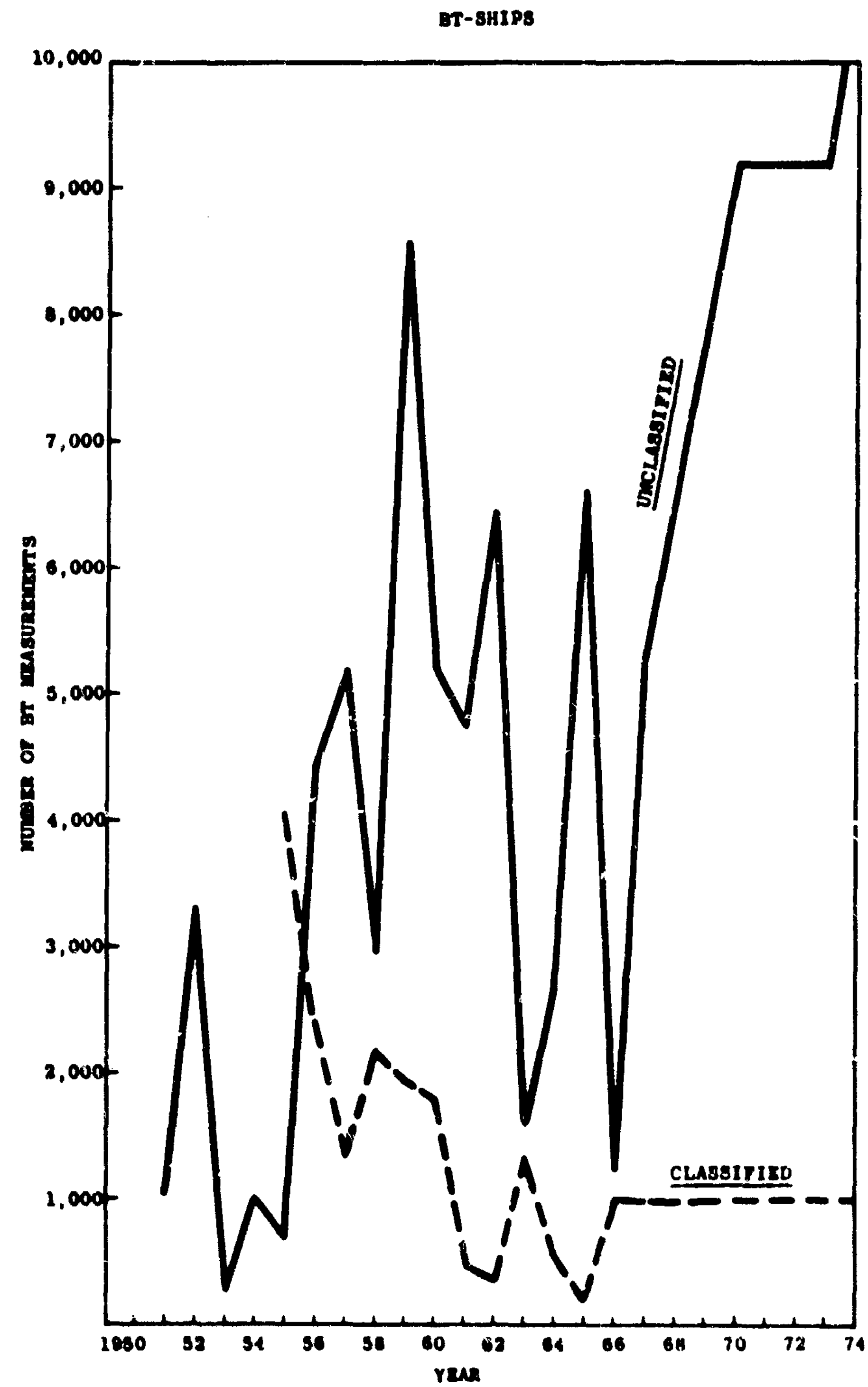
Figures 23 and 24 present data collected as a function of time for selected data types. The projected data volumes through 1974 are indicative of both the current and future importance of these data to NAVOCEANO. The data from which these graphs were derived are contained in Appendix E.

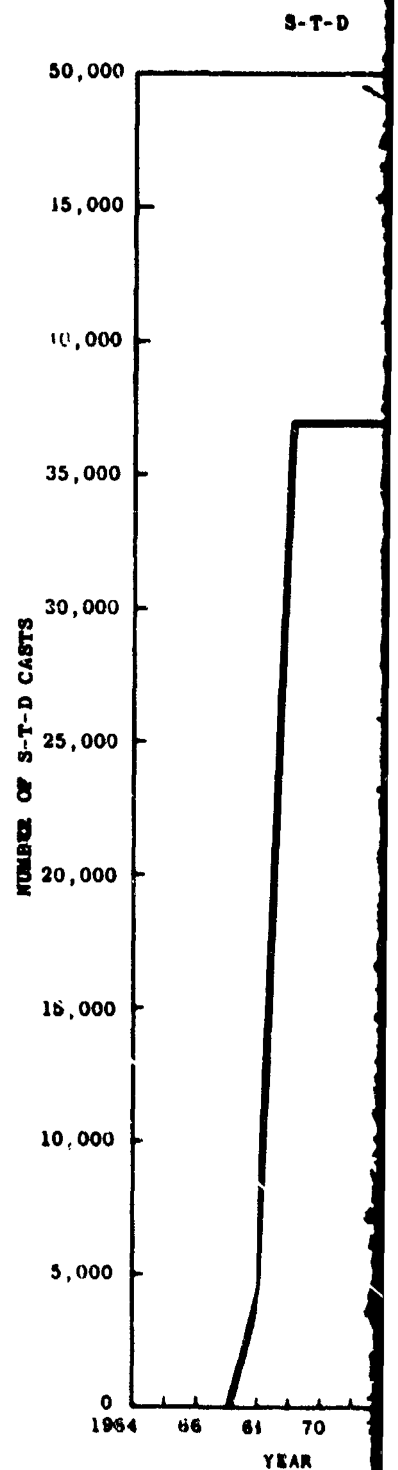
The priority requirements vary as research and development progresses and needs change. A continued evaluation must be made of new priorities and technological developments.

Important factors for consideration during the Phase II study effort are:

a) NAVOCEANO's intake of marine data is anticipated to expand rapidly. With the Navy presently accounting for a substantial portion of the national marine data collection, heavy emphasis should be placed on analyzing during Phase II the current and future marine data handling requirements and potential data flows to other organizations.

b) Classified data warrant investigation to determine the conditions under which portions of these data could be utilized by other sectors of the marine science community.





IN-SITU OCEANOGRAPHIC MEASUREMENT
MADE BY AND FOR THE U.S. NAVY OCEAN

SOURCE: SEE APPENDIX E

FIGURE 8

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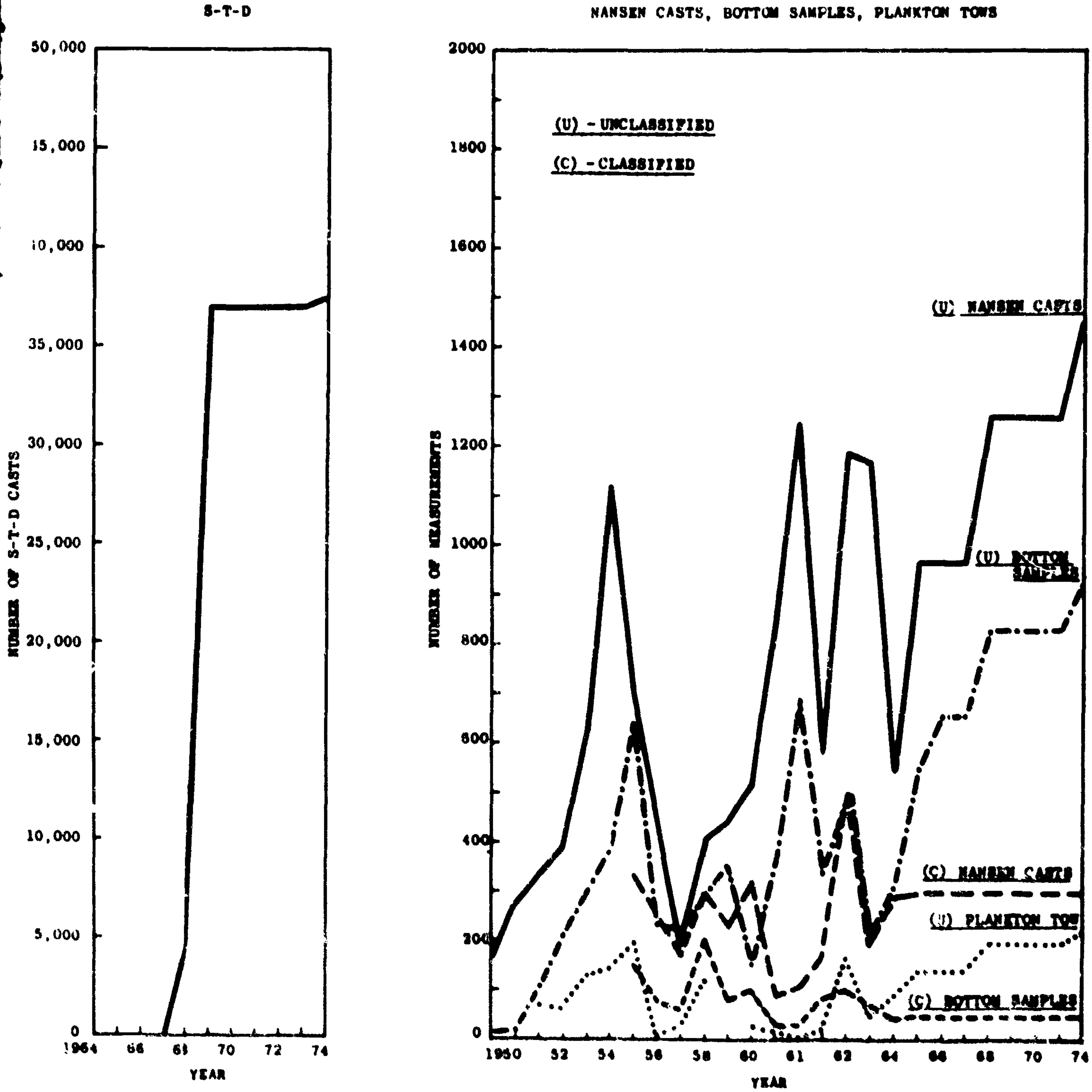
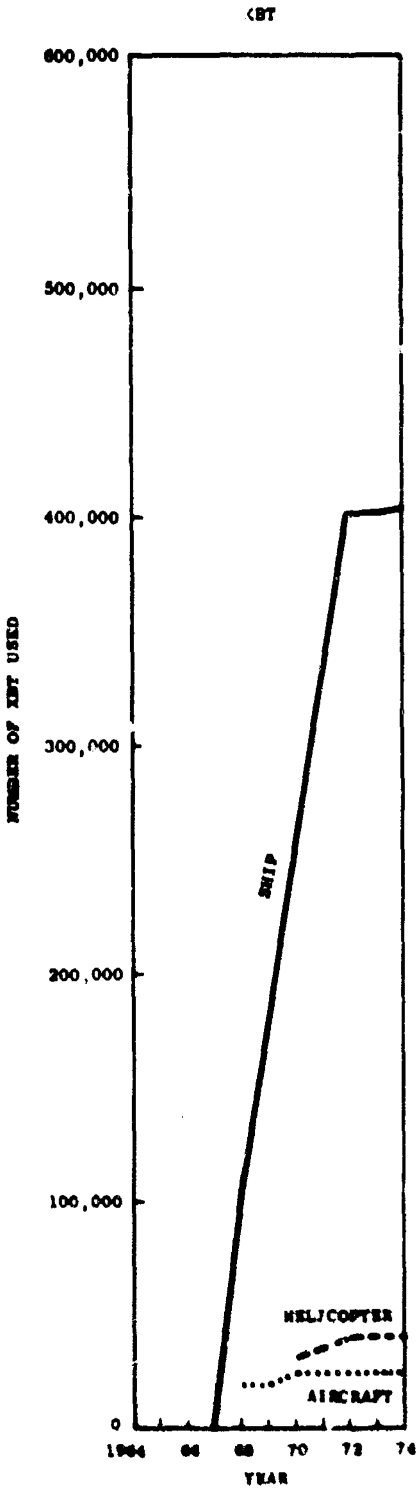
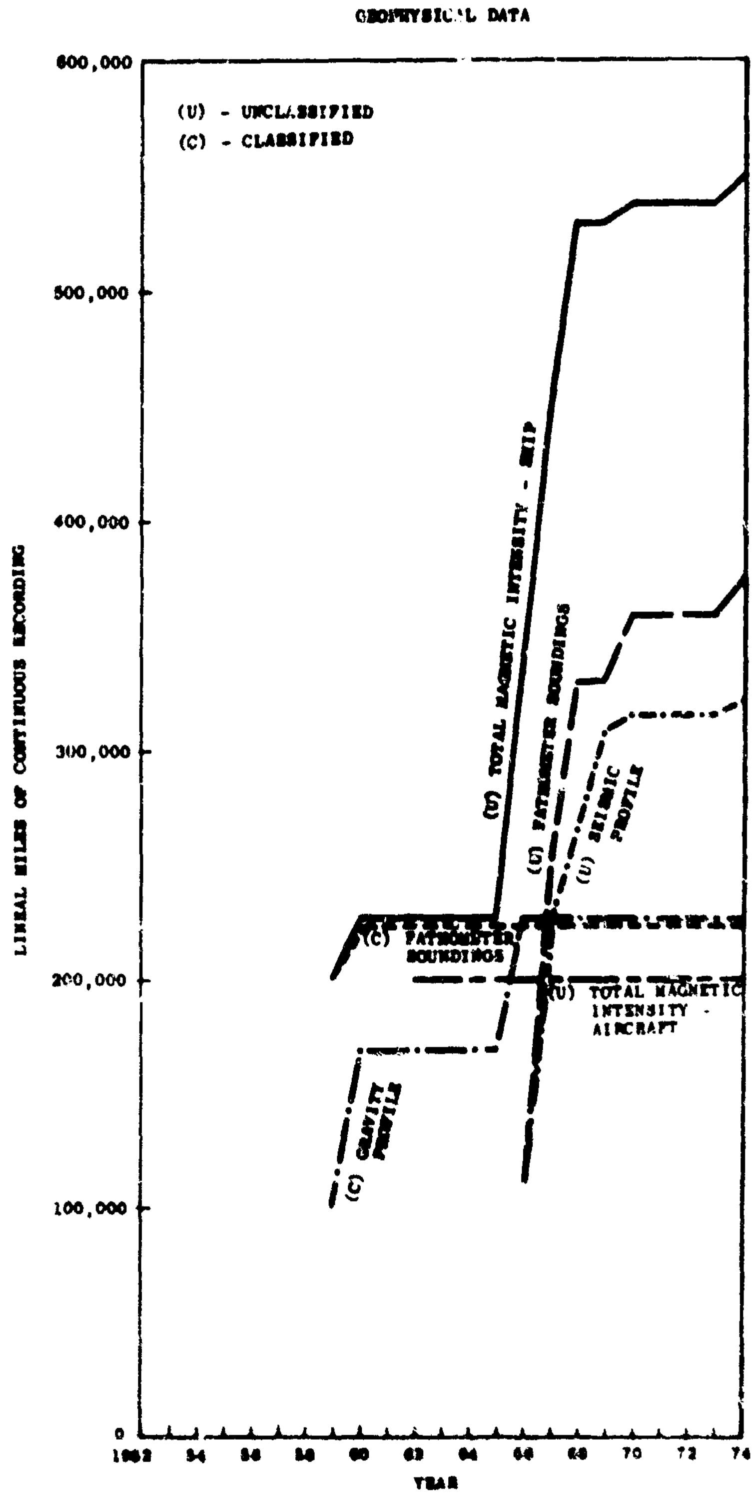


IC MEASUREMENTS, ESTIMATED AND PREDICTED,
U.S. NAVY OCEANOGRAPHIC OFFICE, 1949-1974
FIGURE 23

B





UNDERWAY OCEANOGRAPHIC MEASUREMENTS, ESTIMATED AND PREDICTED, MADE BY AND FOR THE U.S. NAVY OCEANOGRAPHIC OFFICE, 1949–1974

FIGURE 24

SOURCE SEE APPENDIX E

c) The immense data volumes that will be introduced by such technological advancements as the XBT and STD system could create almost insurmountable data management problems. It will be necessary to evaluate the data volumes and data flows of such voluminous data during Phase II.

4) Impact of Future Marine Activities. The following factors related to anticipated future conditions surrounding NAVOCEANO activities must be given careful consideration during Phase II in defining National Marine Data Program requirements. Some of these considerations are applicable to the entire National Marine Data Program rather than just NAVOCEANO.

a) Future data requirements are not expected to be appreciably affected by changes in Navy missions; however, technological developments are expected to have a major impact on NAVOCEANO's data program requirements. Given the size of the marine science budgets and programs, the Navy is expected to serve as a leader in the marine community in the adaption of technological advancements to their functional requirements. Administrators of the National Marine Data Program must maintain continual surveillance of Navy adaptations of new technology as somewhat advanced indicators of forthcoming applications within the entire marine community.

b) A change in current wartime requirements to more peaceful missions could lead to a revision in NAVOCEANO's data program priorities. Current urgency is directed to providing the Fleet with data on day-to-day operations, such as through the preparation of charts, maps, and general background information for the conduct of nuclear submarine and anti-submarine warfare group activities. These missions would continue to be emphasized even in the event that the orientation changed. However, priorities of data collections and functions are likely to change with corresponding effects on National Marine Data Program requirements. The effects of these potential changes should be identified.

c) Preliminary evaluations during Phase I suggest that emphasis will be placed on the collection of larger amounts of data within short periods of time by utilizing combinations of ships, aircraft, and satellites for general survey efforts and buoy networks for synoptic surveys. Coupled with this increased and more comprehensive data collection effort will be an increased user demand for such data. The impact on the data flow process is likely to be enormous and organizations must carefully plan their data management processes to handle such data volumes and flows. When users become convinced that other organizations can satisfactorily pre-process data before transfer, commensurate with a specified format, the requirement for transmission of raw data should be significantly reduced. The development and acceptance of standards should contribute greatly to this reduction. An example of NAVOCEANO's efforts toward achieving this end is the effort expended in ensuring that their gravity surveys are conducted with standardized meters and to a common datum (DN 101 p. 59).

d) Interviews with NAVOCEANO administrators have revealed the existence of data files that are kept by various users which duplicate archival files maintained by such central data storage facilities as NODC. A study for NAVOCEANO has been conducted by Planning Research Corporation (DN 435) in order to provide a system for consolidating such files into a ready access central data bank. The effect of such consolidation must be evaluated to assess the effect on National Marine Data Program requirements.

5) Relevance for Phase II. A number of implications of NAVOCEANO's functions and data requirements must be given consideration in Phase II. It is obvious from the pervasive nature of NAVOCEANO's functions that substantial overlap is likely to exist with other organizations. The most notable potential overlap exists between NAVOCEANO and ESSA. The primary difference between their functions lies in their respective orientation to military and civilian needs. This major overlap creates the need for substantial coordination in data collection between these two agencies. The effects of duplications in data collection on National Marine Data Program efficiency will be investigated during Phase II.

It will be necessary during Phase II to explore not only NAVOCEANO's current and future data requirements but also those of other organizations having a need for NAVOCEANO-collected data. National security requirements may preclude the transfer of much of this data, but with substantial increases in civilian user demands, it seems probable that decisions related to declassification or duplication of measurements will need to be made in identifying National Marine Data Program requirements.

b. Bureau of Commercial Fisheries (BCF)

1) Missions and Benefits. Both the urgency and the scope of the Bureau of Commercial Fisheries (BCF) responsibilities have been increased by the recent passage of the Marine Resources and Engineering Development Act of 1966. The interpretation of the act by the Department of Interior in relation to BCF activities is as follows: (1) The act broadens the scope of the Department of Interior responsibilities, and consequently, BCF's responsibilities, for the marine environment by requiring additional investigation and attention to an increased oceanic area of some one million square miles, and (2) it requires that the development of marine resources be greatly accelerated (DN 344, p 1).

BCF's mission is to satisfy a number of national and international needs. These needs are described below:

- The growing demand for fish products in the United States can be fulfilled by technological and productivity advancements perpetrated by BCF. The potential magnitude of the benefits is evidenced by the prediction by BCF that total fish consumption could increase by approximately 150 percent by the year 2000. In order to satisfy long-term food requirements, BCF must develop a comprehensive plan for aquiring increased knowledge regarding the availability of food-productive resources from the sea and methods for locating, harvesting, processing, marketing and distributing the resulting products of these resources.

- Some portion of the political and cultural unrest in the world is attributed to the underfed populations of the world. Through the development of fishery resources, BCF can contribute to the reduction in world food shortages. Therefore, the second national need is to use living marine resources to improve national security through the fulfillment of world food needs. To achieve even a portion of the total world fishery potential, BCF must increase the current efforts to facilitate widespread use of fish as food.

The effectiveness of future BCF efforts will depend heavily on the accumulation of knowledge, both biological and technological; upon its own research and development capacity; and upon a realistic understanding of the institutional factors inhibiting fishery resources utilization.

- The third national need involves the requirement for increased knowledge concerning the oceans and resources in them. With nations turning to the oceans to satisfy their food needs, fundamental research on ocean processes is becoming a critical requirement. BCF serves as the national focal point for contributing to this knowledge and must continue to pursue an active and farsighted research program.

2) Functions and Data Requirements. In the following paragraphs the functions and data requirements which BCF will be required to perform in satisfaction of the foregoing needs will be discussed with emphasis placed on their importance to the National Marine Data Program.

a) Resource Ecology. Data collection for the conduct of research to understand processes and environmental conditions affecting production and the complex interaction of the food chain in the sea.

In support of this function, physical, chemical, biological, and meteorological data of all types are required. Use of such data is made through field and laboratory studies which are conducted to gain an understanding of the processes in natural waters which convert nutrients into protein and other useful products.

Identification of National Marine Data Program requirements for this type of research effort will require an evaluation of the types and volumes of data collection as well as their compatibility to automatic machine processing. During Phase II, evaluation should be conducted to determine:

- the nature of past, present, and future data collection programs

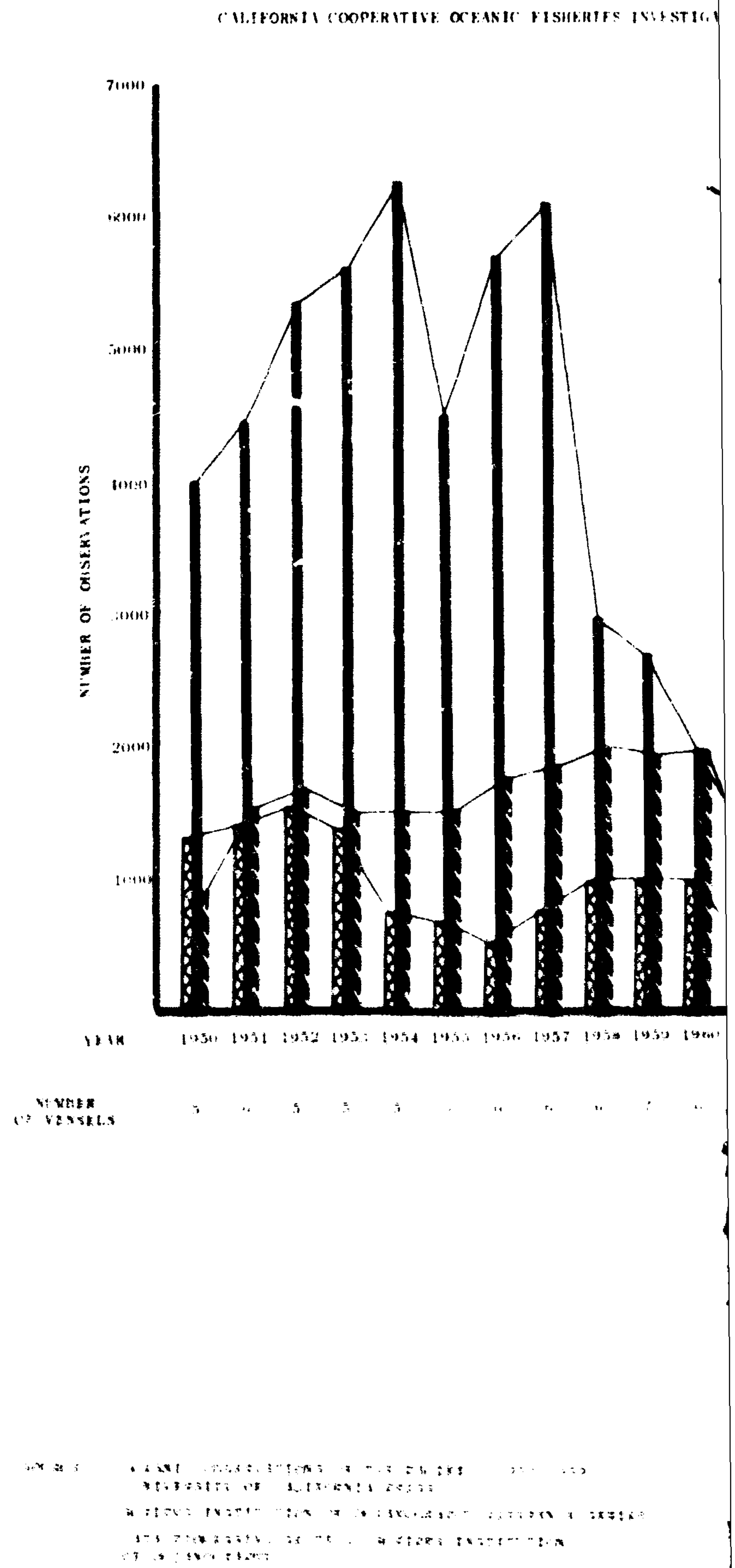
- the locations of past and present data collections

- the future data collection requirements of key researchers in this field

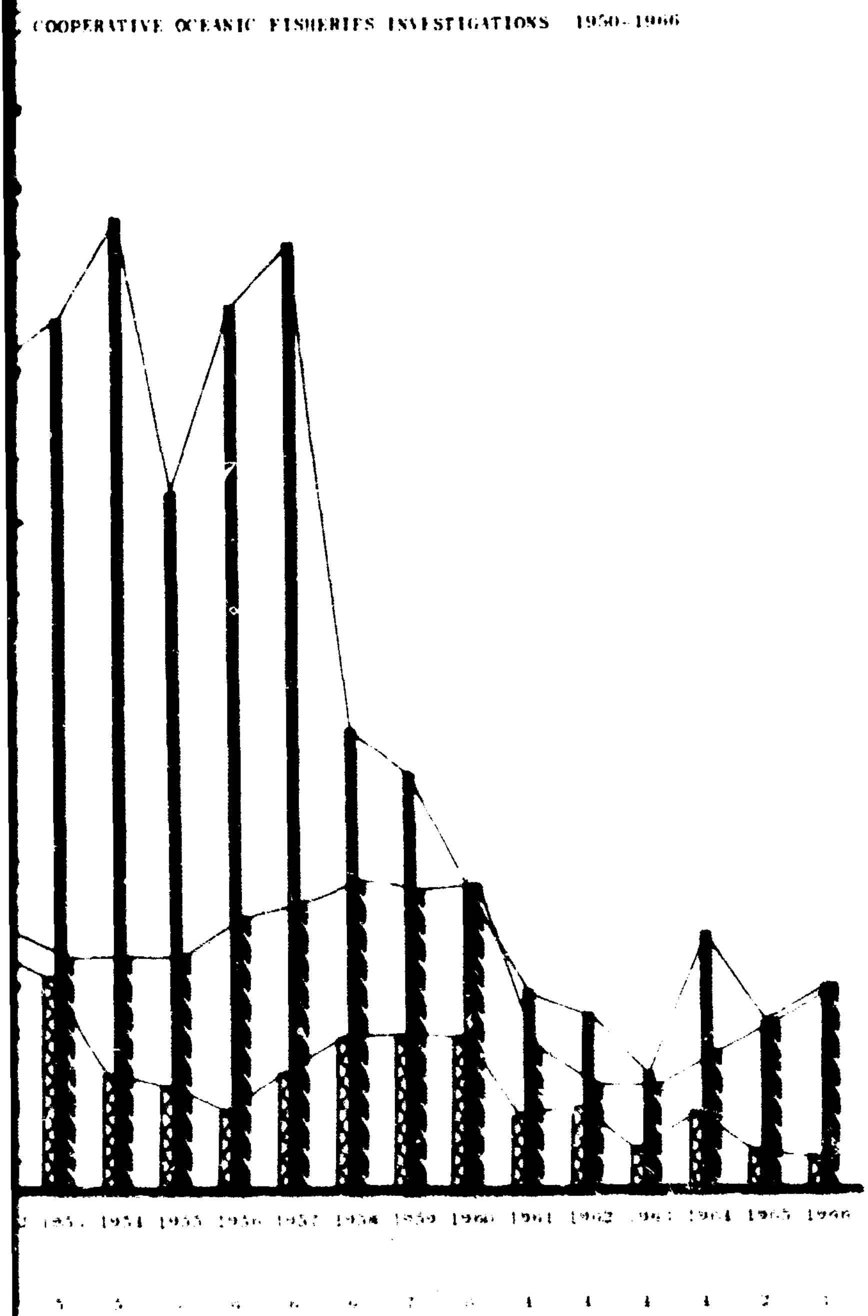
b) Propagating Commercial Species. Studies to reduce the damaging effects produced by man-made environmental changes on the propagation of fish and shell-fish, especially in estuaries and inshore waters.

Data requirements of this program cover the broad spectrum of physical and biological oceanography such as environmental data, fisheries data, physiological data, and ecological data. During Phase II, care must be taken to identify overlapping and duplicative data collection efforts conducted to support these various functional requirements. Preliminary analysis suggests that some duplication may exist in collecting marine data in support of the various BCF programs.

Figure 25 displays three types of data collected by the California Cooperative Oceanic Fisheries Investigations (CCOFI), a multiple ship, time-series fishery-oceanography program comprising Scripps Institute of Oceanography, BCF and the California Department of Fish and Game. The selection criteria for illustrating in Figure 25 the three basic types of oceanographic cruise data, namely oceanographic cast, bathythermograph cast and plankton tows were dictated by both the availability of the basic information from the data volumes of Oceanic Observations of the Pacific (OOP) (1950-1959, University of California Press) and the lack of time to pursue an exhaustive data search from the individual organizations. Only cruises that contained oceanographic casts along with either BT or plankton tows, or both, were utilized. Thus, the total number of BT's and plankton tows shown by the graphs are incomplete. For the period between 1950-1959, the oceanographic


7000
5000
2000
NUMBER OF OBSERVATIONS
YEAR
1950
1951
1952
1954
1956
1957
NUMBER OF VESSELS

A

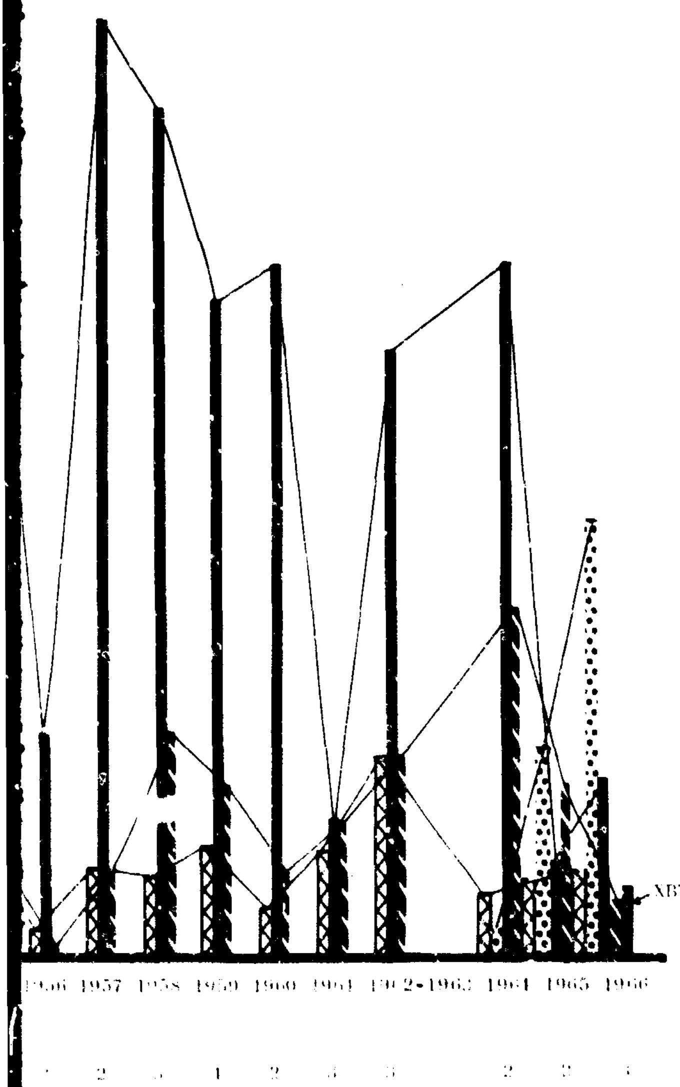


PARTIAL OCEANO
SELECTED ORGAN

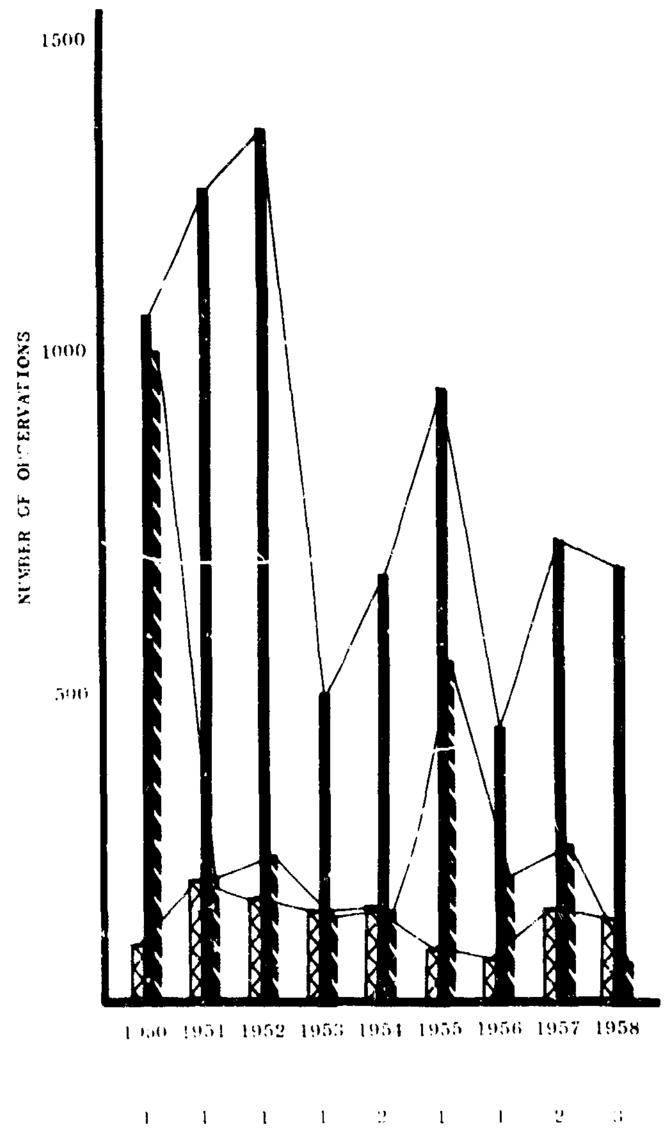
F

B

ITUTION OF OCEANOGRAPHY 1951-1966



U.S. BUREAU OF COMMERCIAL FISHERIES
BIOLOGICAL LABORATORY HONOLULU 1950-1959



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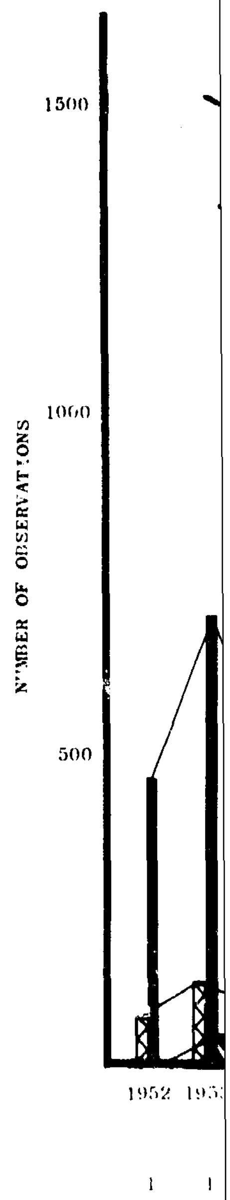
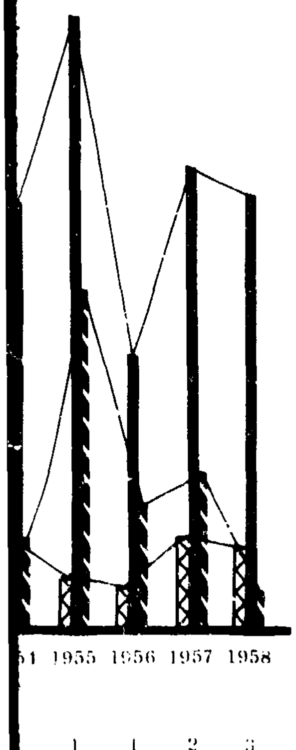


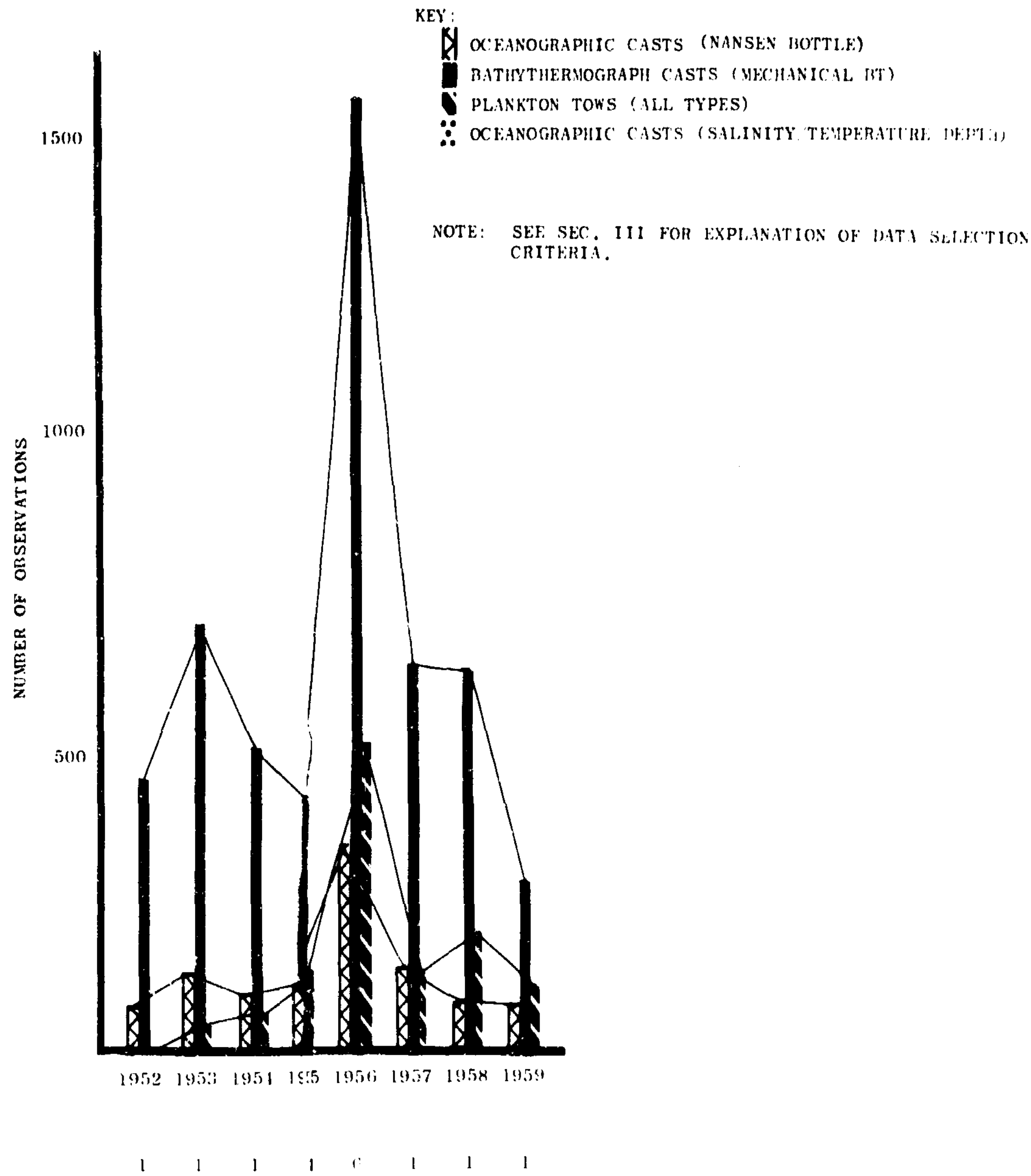
OCEANOGRAPHIC DATA COLLECTION BY
ED ORGANIZATIONS - VOLUME AND TYPE
FIGURE 25

C

MERCIAL FISHERIES
HONOLULU 1950-1959



UNIVERSITY OF WASHINGTON 1952-1959



ON BY
TYPE

D

stations and plankton tows shown, represent 77 percent and 91 percent respectively, of this type of data that is listed in the OOP data volumes.

It should be noted that CCOFI has experienced an overall decline in data collection volume since 1958, especially with the shift from monthly to quarterly cruises in 1961. CCOFI is at the crossroads as to the type of future sampling program that will suffice, from both a scientific and economic viewpoint, to satisfy the requirement to monitor the anchovy population in the California current. Other inter- and intra-organizational survey efforts are facing similar decisions and it will be important during Phase II to predict the outcomes for such programs pertinent to the National Marine Data Program.

c) Maintaining Fish Yield. Analyses of maximum sustainable yields for various species, critical to world food production, such as tuna, shrimp, and shellfish, and to provide data to regulatory agencies for maintaining this yield.

Creation of an optimum resource base requires that controls be exercised over fishing in order to provide high yields. To determine the maximum sustainable yield for given species, data on fishery resources such as catch per effort, year class, length-frequency, spawning, and survival are needed. Again the obvious inter-relationships between the various BCF functional requirements demand that a system analysis be conducted to reduce duplicative data collection efforts. For example, fisheries data such as scouting information collected as a byproduct of larger surveys could prove of great value in determining the seasonal distribution of fish populations, which in turn could be useful in understanding the nature of catch fluctuations.

d) Locating New Resources. Systematic fishery exploration, utilizing oceanographic, biological, and engineering data in an attempt to document the extent, density, and availability of resources.

Some of the data types and related volumes required to conduct exploratory fishery investigations by BCF in Hawaii from 1950-58 are illustrated in Figure 25 and their relationships to other types of research investigations are shown in Figure 26.

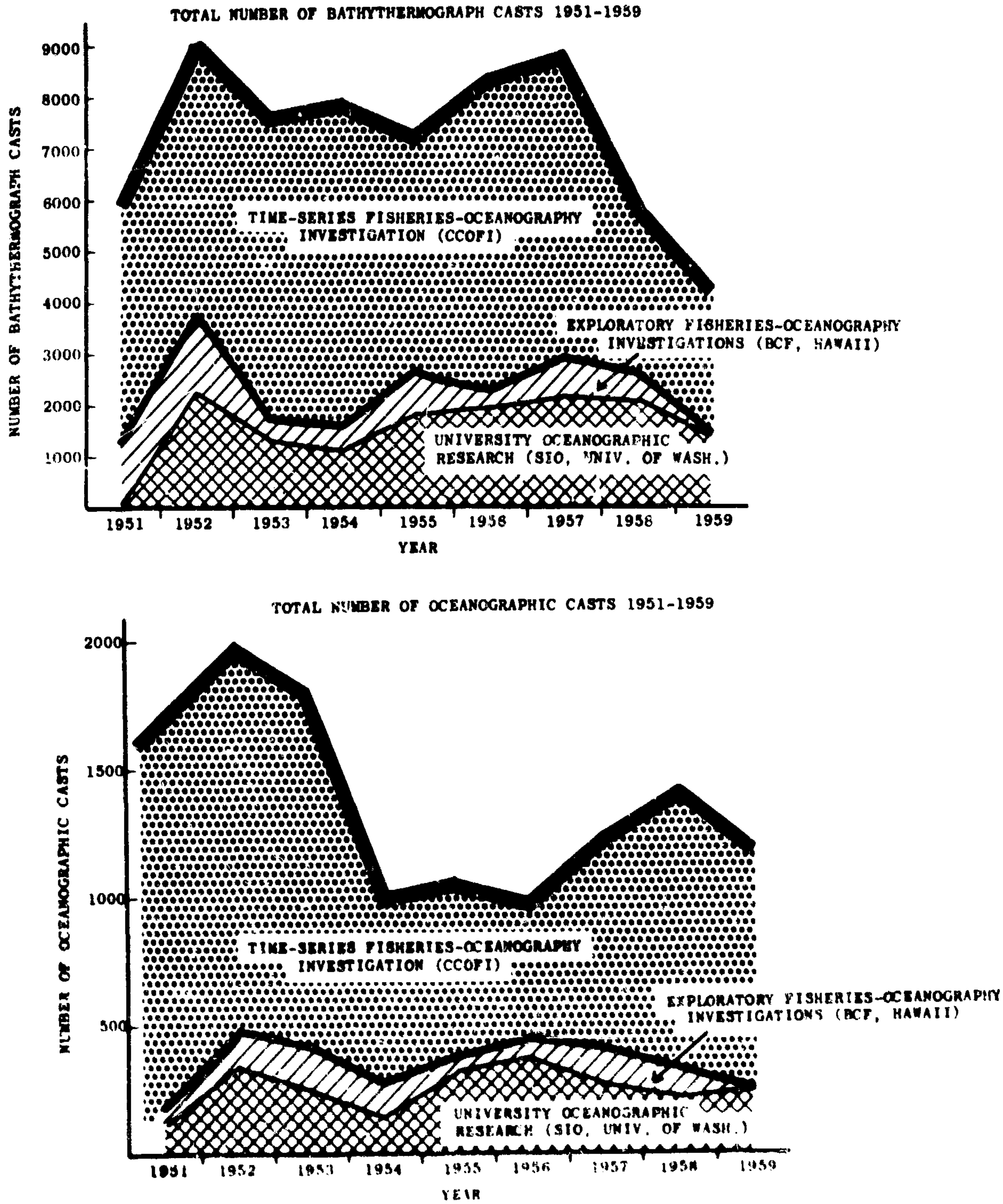
In addition to the physical and biological data shown in Figure 26, exploratory fishing requires information on gear development, fish schools, bird flock sightings and fisheries catch data. Collection of such data for this high priority functional requirement implies that an efficient data management system is needed which is responsive to the unique handling requirements of this type of data.

e) Protecting United States Fishing Rights. Statistical fishery research to provide a basis for negotiation regarding the division of yields of particular fisheries on the world ocean.

In order to establish the rationale for fishing rights negotiations, division of yield, and the establishment of related regulations, BCF must obtain data on the distribution (in time and space) and size of the fishery, catch per effort, population and subpopulation relationships, etc. During Phase II, it will be important to determine if the data requirements of this program are being fulfilled given the increased competition from foreign fisheries. The needs of researchers in this field in relation to data base requirements must be examined and methods for satisfying this means devised.

f) Harvesting. Studies in ocean engineering, gear development, and other means for upgrading and expanding the U.S. fishery.

In support of this important function, BCF requires data on the effectiveness of present fishing methods as well as ocean engineering data regarding the latest advances in equipment that could be utilized to reduce the present high costs of U.S. fishing operations.



MAGNITUDE OF DATA COLLECTIO
IN RELATION TO VARIOUS CATEGORIES OF OCEAN

FIGURE 26

A

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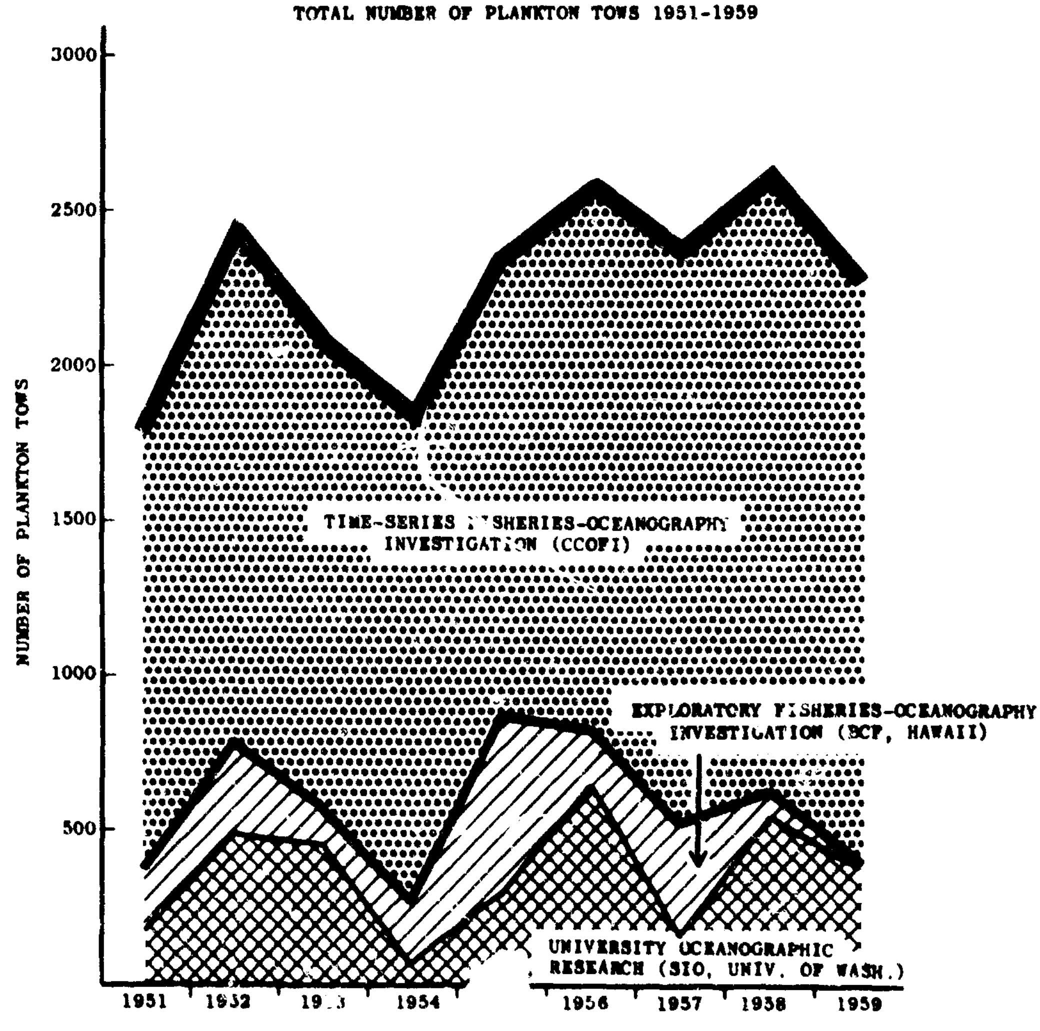
-OCEANOGRAPHY
CF, HAWAII)

TOTAL NUMBER OF PLANKTON TOWS 1951-1959



FISHERIES-OCEANOGRAPHY
TIONS (BCF, HAWAII)

CCOFI - CALIFORNIA COOPERATIVE OCEANIC FISHERIES INVESTIGATIONS
SIO - SCRIPPS INSTITUTION OF OCEANOGRAPHY

SOURCE OF INFORMATION
OCEANIC OBSERVATIONS OF THE PACIFIC
(1951-59, UNIVERSITY OF CALIFORNIA PRESS)

(SEE SEC. III FOR EXPLANATION OF DATA SELECTION CRITERIA)

OF DATA COLLECTION VOLUME BY TYPES
EGORIES OF OCEANOGRAPHIC RESEARCH INVESTIGATIONS

FIGURE 26

B

g) Processing. R&D expenditures and services for cost reduction and quality improvement of processing fishery raw materials.

The data needs of this program will be evaluated during Phase II in order to identify both the existing data bases and to locate other data bases that can provide valuable input into the successful prosecution of this program. The needs for document storage, listing and retrieval will also be investigated.

h) Distribution and Marketing. Investigations for improving the current methods of marketing and distribution of fish products.

In order to assist the U.S. fishing industry in providing maximum response to national needs BCF requires data on all phases of marketing. During Phase II the application of data management techniques to assist in performing this function will be investigated.

i) Information Dissemination. Effective dissemination of data collected, research results, and resources information for the educational needs of the fishing industry and the public.

Information distribution to industry and the public should be an integral part of any future data center operations in BCF. That is, when plans are laid for processing BCF collected data, mechanisims for distributing research results should be devised and implemented concurrently with traditional data processing procedures.

j) Economic Analyses. Functional requirement with particular relevance to the achievement of national marine science objectives.

Although there is evidence that some segments of the American fishery industry are experiencing serious economic difficulties, the industry *in toto* still remains an economic unknown in the U.S. economy because of the lack of data. Any meaningful study of the fishing industry must provide for a systematic measurement of the purchases of labor, materials, equipment, and all fisheries inputs, as well as a corresponding measure of total production and revenues.

During Phase II, it will be necessary to define the needs, data bases, data collection and handling processes and the interrelationships with other intra-and-inter-organizational elements in relation to the requirements for economic analyses. This is especially important to the national program of Food from the Sea in that the results of such economic studies will have substantial relevance to the determination of national policy and funding of this program.

3) Data Program Priorities. Future demands for ever increasing amounts of fish and fish products have caused BCF to set high priorities for research and development in five major areas: (DN 344 p. 25)

a) "Greater emphasis on modernization of U.S. fishing fleets by additional direct financial aid, on application of research results to increase fishing efficiency, on problems which arise from the unique international character of high-seas resources, on quality improvement and product diversification, and on mechanizing production and processing systems to aid in more efficient use of fishery resources."

b) "Increased emphasis on ocean engineering aspects of fishery development in addition to that already planned for FY '68. This will include greater use of submersibles in undersea exploration, use of remote sensors such as sonar, and multi-spectral devices from spacecraft, gear development for harvesting herring-like fishes and development of fleet fishing tactics;"

c) "Greater emphasis on providing extension services to insure that the results of research are applied when and where appropriate to solving problems of industry;"

d) "Expansion of economic studies at all levels of the production and marketing chain and acceleration of cost effectiveness studies to be used for guiding research as well as for policy decisions;"

e) "Increased cooperation between Federal and State governments in resources conservation and assistance to industry."

During Phase II it will be important to pay particular attention to these five key areas to determine their overall data management requirements and the effect that they will have on the National Marine Data Program.

4) Impact of Future Marine Activities. The research and development required and planned by BCF to insure that the future national demand for fishery products is met can be divided into two general programs, namely, (a) Creating an Optimum Resource Base, and (b) Utilization of the Resource.

A large portion of the Optimum Resources program is basic research devoted to investigations of the taxonomy, physiology, and behavior of fishes and marine invertebrates and of their environments. Increased emphasis can be expected to be placed on determining critical factors causing fish mortality; response of organisms to environmental features, such as upwelling; air-sea interaction studies; and oceanic circulation studies.

In addition, existing programs will continue to investigate the location and sizes of new high seas fish populations and how they vary with changes in the environment. The objective, ultimately, is to be able to determine what ocean conditions cause fish to aggregate and how these conditions can be predicted and utilized to improve fishing strategy.

Future studies will also continue with respect to the biology, ecology, and population dynamics of various continental shelf fisheries of the United States. Also, the biological research program on the Great Lakes, which includes studies of the coldwater fisheries, warmwater fisheries, lake trout and aquatic environmental conditions will be continued and expanded.

With respect to the utilization of the resource base, Ocean Engineering activities and Fish Protein Concentration (FPC) programs will receive the bulk of BCF's attention in the near future.

Present BCF programs in ocean engineering include the complete systems development started at the Seattle and Juneau Exploratory Fishing Bases in FY 1966. These programs have already conceived, developed, tested and demonstrated to the fishing industry total systems for harvesting, transporting and processing Pacific hake and shrimp. Present and future ocean engineering capabilities developed by BCF will be evaluated continually in order to attain optimum economic efficiency in the harvest of the fishing resource. Economic analyses are planned to determine problem areas that act as economic constraints on the best utilization of the resource. Additionally, cost-effectiveness and benefit-cost analyses are planned to seek alternatives and to determine maximum pay-off systems.

Economic analyses are also planned that will be aimed at all levels of U.S. fisheries. These, along with demand analyses, will be used to determine present and potential demand for all types of fishery products. This is a necessary step in order to guide the development of systems that will assure efficient production and marketing to fill national demands for fishery products.

The urgent need for accelerated development in the FPC program in response to the passage of the Marine Resources and Engineering Development Act will depend heavily on BCF's biological and technological knowledge. Owing to FY '68 budgetary problems, programs in other areas which should have been accelerated in FY '68, must be delayed in order to pursue the FPC development program.

A number of other bureaus or offices in the Department of Interior also have programs in progress or under development, which in cooperation with BCF could have considerable impact in planning for the National Marine Data Program. These are (DM 344 pp. F-5-6):

a) "Research and development by the Bureau of Sport Fisheries and Wildlife on fisheries for recreational use."

b) "Management of fisheries by the National Parks Service in marine national park regions."

c) "Research and development by the Office of Territories on fisheries in the Trust Territory."

d) "Improvement of water quality by the Federal Water Pollution Control Administration."

e) "Determination and amelioration of effects of marine mine waste effluent on living resources by the Bureau of Mines."

f) "Determination and amelioration of effects of effluent from saline water plants by the Office of Saline Water."

g) "Studies by the Geological Survey on the relation of living resources to bottom type and rates of sedimentation."

During Phase II it will be necessary to assess the relative importance of each of BCF's planned programs in terms of present and future data management needs. Only in this way can a realistic input to the National Marine Data Program be achieved.

5) Relevance for Phase II. The mission of the Bureau of Commercial Fisheries (BCF) exemplifies the complexity of marine science. Occupying vast areas of the world ocean, the living marine resources are comprised of the diversity of species, with differing abundances, distributions, environmental requirements, behaviors, growth rates and reproductive potentials. Effective development, management, and conservation of these species requires intimate knowledge of their biology and of their environment. The problems of harvesting, processing, transporting and marketing of fishery products are similarly complex. The data requirements for all this are obviously formidable and must receive primary attention during Phase II.

BCF carries out much of its research in cooperation with universities, industry, states and with various international fishery organizations and commissions. In the past, the Bureau has benefited greatly from the formal and informal exchange of information. For example, this cooperation has enabled international and national groups to solve mutual problems by developing and exchanging needed data as well as reducing the amount of duplication of costly marine research.

The Phase II study should establish areas in which approaches used successfully by BCF in gaining such cooperation can be adapted to similar needs of other marine science organizations. Similarly, methods must be identified for enhancing the cooperative efforts currently conducted by BCF. By approaching the problem of interorganizational cooperation in this fashion, implementation of the National Marine Data Program will be achieved more easily.

c. Environmental Science Services Administration (ESSA)

1) Mission and Benefits. Established in 1965, within the Department of Commerce, the Environmental Science Services Administration (ESSA) brought together the many functions of the Weather Bureau, Coast and Geodetic Survey, and the Central Radio Propagation Laboratory of the National Bureau of Standards. ESSA has a very broad mission "to describe and understand the physical environment, to predict the state of the oceans and atmosphere, and to determine precisely the size and shape of the earth." It is precisely in this broad mission that many of the implications for identifying National Marine Data Program requirements exist. Identification of these requirements becomes a primary task for Phase II because of ESSA's emergence as a major marine environment data collection agency within the civilian sphere of the National Marine Science Programs.

   The benefits for the National Marine Data Program functions derived from ESSA's functions, such as survey activities, will be identified during Phase II.

2) Functions and Data Requirements. In performance of the marine portion of its mission, ESSA devotes considerable effort to:

   - The conduct of marine charting surveys
   - The conduct of related oceanographic research and surveys
   - The supply of weather reporting and forecasting services

   a) Surveys. In pursuit of its survey function, ESSA utilizes the Coast and Geodetic Survey as its major survey support arm. This organization operates 20 survey ships, three of which are Class I vessels, approximately 300 feet in length with unlimited open ocean capability. Figure 27 indicates the data gathering capabilities of these vessels, the largest ever constructed by the U.S. solely for the conduct of environmental research. A slightly smaller (Class IA) vessel of comparable complex oceanographic capability is under construction.

VESSEL	MISSION	ASSIGNMENT	DATA COLLECTION CAPABILITIES
OCEANOGRAPHER	SCIENTIFIC EXPLORATION AND MAPPING PROGRAM (SEAMAP) OCEAN-WIDE SURVEYS	1967 SEAMAP OPERATIONS IN ATLANTIC 1968-72 DEEP SEA OCEANOGRAPHY IN PACIFIC	UNDERWAY: CONTINUOUS HYDROGRAPHIC MAGNETIC, GRAVITY AND SURFACE TEMPERATURE MEASUREMENT; BT, METEOROLOGICAL AND GEK OBSERVATIONS. ON STATION: WATER SAMPLING, LIGHT AND HEAVY CORING, ROCK DREDGING, BOTTOM PHOTOGRAPHY, BOTTOM HEAT FLOW MEASUREMENT, OTHER MEASUREMENTS REQUIRING ELECTRICAL CONDUCTING CABLE.
DISCOVERER	SUPPORT OF COASTAL NAUTICAL CHARTING SURVEYS, CURRENT SURVEYS AND TIDAL PROGRAMS OF ESSA	ATLANTIC OCEAN 1967 TRANSATLANTIC UNDERWAY SECTION FOR SEAMAP MANGANESE NODULE DISTRIBUTION STUDY TIDE AND CURRENT STUDIES 1968 GEOPHYSICAL AND GEOLOGICAL STUDIES 1969-72 SEA-AIR INTERACTION STUDIES GEOPHYSICAL AND GEOLOGICAL STUDIES PHYSICAL OCEANOGRAPHY	

EXAMPLE OF CLASS I OCEAN SURVEY SHI

FIGU

A

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DATA COLLECTION CAPABILITIES	DATA TYPES COLLECTED	DATA PROCESSING
NDERWAY: CONTINUOUS HYDROGRAPHIC MAGNETIC, GRAVITY AND SURFACE TEMPERATURE MEASUREMENT; BT, METEOROLOGICAL AND GEK OBSERVATIONS. N STATION WATER SAMPLING, LIGHT AND HEAVY CORING, ROCK DREDGING, BOTTOM PHOTOGRAPHY, BOTTOM HEAT FLOW MEASUREMENT, OTHER MEASUREMENTS REQUIRING ELECTRICAL CONDUCTING CABLE.	SALINITY, TEMPERATURE, DEPTH (STD) BATHYTHERMOGRAPH (BT, XBT) BOTTOM SAMPLES CURRENT DATA MAGNETIC DATA GRAVITY DATA SUBBOTTOM PROFILES SURFACE AND UPPER ATMOSPHERE METEOROLOGICAL DATA HEAT PROBE DATA PLANKTON TIDE GAGE DATA GEOMAGNETIC ELECTROKINETOGRAPH (GEK) CURRENT DATA NANSEN CAST BOTTOM PHOTOGRAPHY ECHOSOUNDER RECORDING	DATA ACQUISITION SYSTEM (DAS) ABOARD WILL (WHEN OPERATIONAL) PROCESS AND RECORD ON MAGNETIC TAPE GEOPHYSICAL, OCEANOGRAPHIC, HYDROGRAPHIC, AND METEOROLOGICAL DATA. THE ENVIRONMENTAL DATA SERVICE WILL SUBSEQUENTLY (AT ASHEVILLE, N.C.) PROCESS THE TAPES AND SEPARATE THE DATA TYPES FOR TRANSMISSION TO USERS. EVENTUAL STORAGE, AS PER DATA TYPE, AT NATIONAL WEATHER RECORDS CENTER (NWRC), NATIONAL OCEANOGRAPHIC DATA CENTER (NODC) AND THE COAST AND GEODETIC SURVEY CENTERS.

AN SURVEY SHIP DATA GENERATION CAPABILITIES
FIGURE 27

B

The Coast and Geodetic Survey divides its survey support among a number of important survey efforts. Foremost among these, in terms of response to national missions and objectives, is the assignment of its vessels to the part-time support of the SEAMAP programs. This commitment represents 20 percent of ESSA's survey effort (DN 90, pp 47).

The SEAMAP program is a partial implementation of the world ocean survey program recommended by the National Academy of Sciences Committee on Oceanography (NASCO). It is being conducted through international cooperation and is intended eventually to encompass all the world's oceans. It is concerned with systematically and comprehensively mapping the characteristics and distribution in time and space of oceanographic phenomenon and of the properties and content of the water column, the sea floor and its bottom substructure (DN 192, pp iv). It is recommended that the U.S. portion of the survey be 30 percent of the ocean area. The regions to be surveyed by the U.S. are the Northern Pacific and Atlantic, both areas of particular interest to the U.S. Of the potentially usable United States ships for this program, the Coast Guard's are almost fully committed to the Coast Guard missions. Likewise, the Navy survey ships are assigned primarily to classified mission-oriented tasks. The Coast and Geodetic Survey accordingly is the only remaining U.S. agency appropriate to handle the non-military program for the United States. Its contribution, however, is severely restricted in quantity by the number of suitable ships at its disposal. Planning models indicate that the fulfillment of the NASCO survey plan will require approximately 90 to 100 Class I ship-years over a ten-year period (DN 192, p xi). Recent budget trends suggest that the ESSA ship acquisition and operation programs are in a contracting rather than expanding phase. Accordingly, the pace of the U.S SEAMAP effort can be expected to fall below initial expectations unless alternative methods are extensively and successfully employed to fill the gap.

The foregoing trends will have a substantial effect on the identification of National Marine Data Program needs. On the one hand, the predictions of marine data type and volume emanating from the SEAMAP program may be seriously overstated if the apparent lack of facilities and equipment materializes. The incorporation of such faulty predictions into National Marine Data Program requirements could have serious repercussions on the program's cost/effectiveness.

On the other hand, efforts to fill equipment and facilities requirements will have definite effects on the design of data management systems. The deployment of a system of buoys to help fill a part of this gap, for example, would induce different data management requirements than the deployment of newly built or acquired ships.

These alternative situations must be thoroughly analyzed during Phase II in order to establish the most likely occurrence. The National Marine Data Program can then be designed in accordance with the most probable events, while still maintaining the necessary flexibility to handle the less probable situations if they should occur. The early identification of probable major program shifts will enable the creation of alternative strategies for implementation, as needed.

The preponderance of ESSA's survey effort, and that of the Coast and Geodetic Survey, is devoted to data collection within the confines of the continental shelf. Roughly 65 percent of its total FY 68 budget is devoted to Marine Science Continental Shelf activities (DN 125, p 78). Projects include the seaward extension of the Upper Mantle Project Transcontinental Geophysical Survey; a long-term systematic study of the Gulf Stream in cooperation with Navy, Bureau of Sport Fisheries and Wildlife, the Coast Guard and five oceanographic institutions; and new surveys of the shelf for the revision of various chart services. The Coast and Geodetic Survey is responsible for coastal charts and NAVOCEANO for the deep ocean. In some geographic areas, there is extensive overlap of coverage by several agencies. Each survey unit has its own resources for data collection and use. These conditions of overlapping functions must be carefully examined during Phase II

b) Research. The conduct of ESSA's oceanographic research function is the primary responsibility of the Institute of Oceanography. Activities include tidal and tsunami investigations, air-sea and land-sea interaction studies, and projects in marine geology and geophysics and physical oceanography. In the land-sea interaction area study, projects are currently underway to develop prediction equations for the behavior of all types of sediments under natural and artificial loads. The work is supportive to the development of a computerized data acquisition and analysis system for the processing of 24-hour forecasts of wind, wave, tide current and storm surge effects on beaches and on estuarine and continental shelf sediments (DN 90, pp 32). Of particular note in the air-sea interaction area is ESSA's participation i the Barbados Oceanographic and Meteorological Experiment (BOMEX), scheduled for July and August 1968, which was discussed previously in this report.

Implemented systems arising from such research activities will induce stringent data management requirements. For example, computerized environmental prediction systems will impose requirements for fast response and continuous data collection and transmission systems for the pertinent oceanic variables.

c) Weather. In pursuit of its weather functions, ESSA utilizes the support of the Weather Bureau which reports and forecasts the weather of the United States. In addition to those basic services, the Weather Bureau also provides specialized forecasts in support of the needs of agriculture, maritime, space and military operations. Weather data are stored in the National Weather Records Center (NWRC) situated in Asheville, North Carolina, which is an arm of the Environmental Data Service (EDS) of ESSA. NWRC is the largest of several ESSA data centers and is the principal data processor of ESSA. The NWRC houses and provides administration support for ESSA's National Geophysical Data Center which is made up of the Seismological Data Branch and the Geodetic Data Branch. The

Air Force and Navy share climatological data resources with NWRC, but remain as separate units of their own in the same facility at Asheville.

The NWRC supports the international cooperative efforts of the United States through various working groups of the technical commission of the World Meterological Organization (WMO), especially in the field of Marine Meteorology and Climatology. One result of this type of cooperation through WMO is the effective exchange and standard summarization of Marine Weather observation from ships at sea. Future plans for international cooperation include a proposed system for a World Weather Watch incorporating weather data from buoys, satellites and ships that was discussed previously. Three principal data centers have been proposed: Moscow, Washington, and Melbourne. The Washington Center began operations in 1965 and combines the U.S Weather Bureau's numerical prediction and satellite facilities with the National Weather Records Center's data storage and recall capabilities.

3) Data Program Priorities

a) Surveys, Mapping, Charting and Geodesy. It is important first to note that over half of ESSA's total FY 1968 marine budget is devoted to surveys, mapping, charting and geodesy (DN 125, pp 108-113). These activities are pursued primarily by the Coast and Geodetic Survey and the Institute for Oceanography. These two units compliment one another, with the Institute laying the foundation for future routine operations of the Coast Survey and the Coast Survey providing geophysical, oceanographic, and marine geological data for study by Institute scientists

Substantial support is provided to the traditional Coast and Geodetic missions of bathymetric surveys, measurement of tides and currents, and nautical charting. A considerable portion of the existing data is applied to this mission requirement, although there will be a continued accelerated expansion in the collection of physical, tidal, bathymetric, magnetic, and gravitational data. Some of the results of SDC's preliminary survey of ESSA's data requirements are expressed in

Figure 28, the format of which is based on the Organizational Data Characteristic Chart of Figure 19 discussed earlier. The extensive storage volumes and the expected yearly increases in these volumes which appear are indicative of the importance that must be attached to ESSA as an integral part of the envisioned National Marine Data Program. The preliminary estimates and descriptions of data volumes and characteristics documented in the figure will receive further study during Phase II, especially in relation to the description of data flow channels and user requirements, both within and outside of ESSA. The critical need for effective data management activities in ESSA is an important element in these studies.

b) Research. Extensive data is also required to support ESSA's research program that is conducted by the Weather Bureau, the Coast and Geodetic Survey and primarily by the Institute for Oceanography. This important research effort will consume approximately one-third of the total ESSA oceanographic budget and requires substantial marine data input, much of which is provided by survey efforts. The high priority data program requirements include: physical, chemical, magnetic, seismic, gravitational, and geologic marine data.

c) Environmental Prediction. A high priority requirement of ESSA, which has been established by the Marine Council, is that of improving environmental prediction. Towards this end, the present tornado, hurricane, flood, severe storm and tsunami warning systems are being modified and enhanced. The primary information for the development and operation of these systems include meteorologic, physical, and geologic data.

Certain other comments can be made which have particular relevance to the Phase II study of functional data requirements.

- ESSA is presently a major recipient of requests for synoptic marine data mainly because of the support provided by the data center activities of the Weather Bureau. In response to these requests, ESSA expects

DATA INPUTS						DATA STORA[GE]		
TYPE	MEDIA	CURRENT ANNUAL VOLUME	EXPECTED INCREASE IN ANNUAL VOLUME	DATA RECEIVED FROM	TRANSMISSION MODE	MEDIA	CURRENT VOLUME	EXPECT[ED] ANNU[AL] VOLU[ME] 1967-19[..]
OCEANOGRAPHIC CRUISE DATA								
a) HANSEN CASTS	DIGITAL PRINTOUT	3,000		ESSA VESSELS	MAIL			
b) STD CASTS	DIGITAL PRINTOUT, ANALOG RECORD	100		ESSA VESSELS				
c) BT DATA 1) MECHANICAL 2) XBT	ANALOG, DIGITAL	2,200		ESSA VESSELS		DIGITAL, ANALOG (NODC)	38,350	6,3
d) SEA SURFACE TEMPERATURE 1) BUCKET (SURFACE SALINITY ALSO)	HANDWRITTEN REPORTS	400		ESSA VESSELS			[illegible],350	6,7
2) INJECTION	HANDWRITTEN REPORTS MAGNETIC TAPE & PUNCH CARDS	1,200,000 1,296,000		COOPERATING MERCHANT SHIPS AND OTHER RESEARCH AGENCIES		HANDWRITTEN REPORTS (NWRC)	19,200,000	1,200,0
e) WAVE DATA 1) PERIOD 2) HEIGHT 3) DIRECTION 4) LENGTH	HANDWRITTEN REPORTS MAGNETIC TAPE & PUNCH CARDS	1,200,000 1,296,000		COOPERATING MERCHANT SHIPS AND OTHER RESEARCH AGENCIES		HANDWRITTEN REPORTS (NWRC) PUNCH CARDS (NWRC) MAGNETIC TAPE (NWRC)	19,200,000 35,300,000 22,000,000	1,200,0 1,300,0 1,300,0

[illegible] ENVIRONMENTAL SCIENCE SERVICES ADMINISTRATION

[illegible] OBSERVE AND PREDICT METEOROLOGICAL ACTIVITIES CONDUCT INVESTIGATIONS, ANALYSES, RESEARCH, SURVEYS AND DISSEMINATE DATA IN FIELDS OF HYDROGRAPHY, OCEANOGRAPHY, SEISMOLOGY, GRAVITY, MAGNETISM

ANNUAL BUDGET FY 67 - 30.6 MILLION

COLLECTION $

[illegible] $

[illegible] $

[illegible] $

AGENCY DATA CHA[RT]

FIGUR[E]

03/00

	DATA STORAGE			DATA OUTPUTS					
	CURRENT VOLUME	EXPECTED ANNUAL VOLUME 1967-1968	DATA PROCESSING FUNCTIONS	TYPE	MEDIA	CURRENT ANNUAL VOLUME	EXPECTED INCREASE IN ANNUAL VOLUME	RECIPIENT OF DATA	TRANS-MISSION MODE
			CODING MACHINE PROCESSING KEYPUNCHING COMPUTING INDEXING ABSTRACTING REPRODUCING MICROFILMING PHOTOGRAPHING CONVERTING QUALITY CONTROL PROOFING VERIPUNCHING EDITING		HANDWRITTEN OR PRINTED FORMS MAGNETIC TAPE PAPER TAPE PUNCH CARDS DIGITAL PRINT-OUT ANALOG RECORD CHARTS OR MAPS IMAGE PUBLICATION			ESSA GOVERNMENT AGENCIES PRIVATE ORGANIZATIONS FOREIGN COUNTRIES (WMO MEMBERS)	MAIL ORALLY TELETYPE
,	38,350	6,300							
  TEN	46,350 19,200,000	6,700 1,200,000		OCEAN STATIONS VESSEL SUMMARY WMO 1960 - ATLAS NORTHERN HEMISPHERE DATA TABULATION	TABLES (MONTHLY) CHARTS TABLES	400 PAGES (1500 COPIES) 2000 PP/10 YEARS 365			
TEN RDS 	19,200,000 35,300,000 22,000,000	1,200,000 1,300,000 1,300,000		OCEAN STATION VESSEL SUMMARY WMO 1960 - ATLAS NORTHERN HEMISPHERE: SURFACE CHARTS (WB) MARINERS WEATHER LOG NORTHERN HEMISPHERE DATA TABULATION	TABLES (MONTHLY) CHARTS DIGITAL PRINTOUT CHARTS GALE TABLE TABLES	400 PAGES (1500 COPIES) 2000 PP/10 YEARS 80,000 CHARACTERS 1480 12 365			

DATA CHARACTERISTICS - ESSA

FIGURE 28

B

DATA INPUTS						DATA STORA		
TYPE	MEDIA	CURRENT ANNUAL VOLUME	EXPECTED INCREASE IN ANNUAL VOLUME	DATA RECEIVED FROM	TRANS-MISSION MODE	MEDIA	CURRENT VOLUME	EXPECT ANNUA VOLU 1967-1
METEOROLOGICAL DATA a) WIND DIRECTION b) WIND VELOCITY	MAGNETIC & PAPER TAPE HANDWRITTEN REPORTS MAGNETIC TAPE & PUNCH CARDS	87,600 1,200,000 1,296,000		ESSA CURRENT BUOY COOPERATING MERCHANT SHIPS AND OTHER RESEARCH AGENCIES		HANDWRITTEN REPORTS (NWRC) PUNCH CARDS (NWRC) MAGNETIC TAPE (NWRC) DIGITAL PRINT-OUT (NWRC)	19,200,000 35,300,000 22,000,000 96,000,000	1,200,0 1,300,0 1,300,0 9,600,0
c) AIR TEMPERATURE d) AIR PRESSURE	HANDWRITTEN REPORTS MAGNETIC TAPE & PUNCH CARDS	1,200,000 1,296,000		ESSA CURRENT BUOY COOPERATING MERCHANT SHIPS AND OTHER RESEARCH AGENCIES		HANDWRITTEN REPORTS (NWRC) PUNCH CARDS (NWRC) MAGNETIC TAPE (NWRC) DIGITAL PRINT-OUT (NWRC)	19,200,000 35,300,000 22,000,000 96,000,000	1,200,0 1,300,0 1,300,0 9,600,0
TIDAL DATA a) PERIOD b) HEIGHT	PAPER TAPE & ANALOG RECORDS	1,600 STATIONS		ESSA TIDE GAUGE		HANDWRITTEN & PUNCH CARD		
MAGNETIC DATA	ANALOG, DIGITAL, MAGNETIC & PAPER TAPE	1-10 READINGS PER MIN. WHILE SHIP IS UNDER-WAY		TOWED PROTON MAGNETOMETER				
SEISMIC DATA a) SHIPS b) LAND	MAGNETIC TAPE SEISMOGRAMS	2,000 263,000		SHIP & LAND STATIONS		MAGNETIC TAPE CHARTS (FILE CABINET) SEISMOGRAMS	 2,000 1,300,000	12,000 (SHIPS) 2,000 (SHIPS) 263,000 (LAND)
CHEMICAL [illegible]	HANDWRITTEN REPORTS					MAGNETIC TAPE (NODC)	3,200	

AGENCY ENVIRONMENTAL SCIENCE SERVICES ADMINISTRATION

FUNCTIONS OBSERVE AND PREDICT METEOROLOGICAL ACTIVITIES CONDUCT INVESTIGATIONS, ANALYSES, RESEARCH, SURVEYS AND DISSEMINATE DATA IN FIELDS OF HYDROGRAPHY, OCEANOGRAPHY, SEISMOLOGY, GRAVITY, MAGNETISM.

ANNUAL BUDGET FY 67 - [illegible] BILLION

COLLECTOR X

PROCESSOR X

DISSEMINATOR X

USER X

AGENCY DATA CHAR

FIGU

3/00

	DATA STORAGE			DATA OUTPUTS					
	CURRENT VOLUME	EXPECTED ANNUAL VOLUME 1967-1969	DATA PROCESSING FUNCTIONS	TYPE	MEDIA	CURRENT ANNUAL VOLUME	EXPECTED INCREASE IN ANNUAL VOLUME	RECIPIENT OF DATA	TRANS-MISSION MODE
RC) RE NT-	19,200,000 35,300,000 22,000,000 94,000,000	1,200,000 1,300,000 1,300,000 9,000,000		OCEAN STATION VESSEL SUMMARY WMO 1960 - NORTHERN HEMISPHERE SURFACE CHARTS (WB) MARINERS WEATHER LOG NORTHERN HEMISPHERE DATA TABULATION	TABLES (MONTHLY) CHARTS GALE TABLES & OSV SUMMARIES TABLES	400 pp. (1500 COPIES) 1480 12 365			
RC) RE NT-	19,200,000 35,300,000 22,000,000 94,000,000	1,200,000 1,300,000 1,300,000 9,000,000		OCEAN STATION VESSEL SUMMARY WMO 1960 - ORIGINAL RECORDS NORTHERN HEMISPHERE SURFACE CHARTS (WB) MARINERS WEATHER LOG NORTHERN HEMISPHERE DATA TABULATION	TABLES (MONTHLY) PHOTO COPIES CHARTS GALE TABLES & OSV SUMMARIES TABLES	400 pp. (1500 COPIES) 3000 COPIES 1480 12 365			
S				SUMMARY LISTING	TABLES	6,000 STATIONS			
				POSITION AND TIME MAGNETOGRAMS MAGNETIC FIELD	MAGNETIC TAPE ANALOG RECORDS CHARTS	1-4 REELS 10-100 ROLLS 1-8			
ARE LS [illegible]	 2,000 1,500,000	13,000 ([illegible]) 2,000 ([illegible]) 182,000 ([illegible])		CHARTS VERTICAL SECTIONS SEISMOGRAMS		300 3000 13,000 (ANALOG)			
APE	3,500								

DATA CHARACTERISTICS – ESSA (CONT.)
FIGURE 28

P.

to acquire fast access data systems within five years. The effect of this development on ESSA's data management function and that of the National Marine Data Program must be carefully evaluated

- A substantial Phase II problem will be to determine whether oceanographic data should be separated from non-oceanographic data according to some predefined criteria. ESSA data collection efforts represent a prime case in point. For example, should the Synoptic Marine Weather Reports received by the Weather Bureau be diverted into a separate data base? If so, should these same data be duplicated at the NWRC in Asheville, N.C.? Care must be taken to prevent any isolation of the sciences and their related data types if the objectives of the National Marine Science Programs are to be achieved. Such coordination will be especially critical to the achievement of cooperative ventures between complementing sciences (e.g., joint marine-meteorological buoy network program).

- The effect of the satellite data collection effort performed by ESSA's National Environmental Satellite Center, that is now in its formative stage, will receive attention during Phase II. The advent of serially digitized camera images and transmission of satellite-collected in situ sensor data to ESSA data centers presents new data handling problems.

4) Impact of Future Marine Activities. Based on the preliminary analyses of ESSA operations, certain potential effects that changing future conditions may have on ESSA operations were noted as follows:

   1) In the immediate future, the outlook is for a decreasing number of operational survey ships due to reduced budgets. In that survey efforts are continuous, the effect could be to merely reduce the volumes of data capture and resultant output publications. On the other hand, the situation would seem to call for a critical

evaluation of present data collection activities to select and maintain those that best support the National Marine Science Programs. Careful attention must be given to the changes in data program requirements that might arise from the modification of priorities under these conditions.

b) With ESSA evolving as a major civilian-oriented marine data acquisition and handling organization, some centralized coordination of marine data activities within ESSA seems logical. Alternative mechanisms for this coordination will be investigated during Phase II.

5) Relevance for Phase II. ESSA is an important facet of the National Marine Data Program. Effort will be devoted to evaluating ESSA's current and future data system requirements in relation to the National Marine Data Programs. A Phase II study effort to define these requirements is summarized below:

a) Analysis of ESSA research and survey projects.

b) Definition of priorities of requirements in relation to national marine goals.

c) Characterization of present and future data needs in terms of defined priorities.

d. National Oceanographic Data Center (NODC)

1) Missions and Benefits. The National Oceanographic Data Center (NODC) was established to function as a service activity for the nation's scientific and technical community for the storage, processing and dissemination of marine data. It is managed and guided in its scientific operations in accordance with the policies and procedures determined by the NODC Advisory Board which consists of representatives from each of the supporting departmental agencies plus two representatives selected by the National Academy of Sciences. As the primary general purpose national marine environment data acquisition and handling center, NODC has a particularly important role to play in the development of a National Marine Data Program.

The missions of NODC are generally defined as follows:

- The National Oceanographic Data Center was organized for the purpose of acquiring, compiling, processing and preserving marine data for ready retrieval.

- The Center is responsible for establishing procedures for ensuring that the accuracy and general quality of its stored data meet the criteria established by the NODC Advisory Board and for undertaking analytic studies necessary for that purpose.

- The Center is also responsible for acquiring by exchange, gift or purchase, oceanographic data of scientific value from domestic or foreign sources.

- In 1964, NODC was designated as one of the twenty-two information analysis centers serving the Department of Defense. The centers are under instruction to gather data; analyze, evaluate and condense the data; disseminate the data upon request for information.

It should also be noted that in the performance of its missions, NODC is not to duplicate the functions of other official repositories but shall be cognizant of other sources of relatable information for referral purposes.

There has always been a requirement for better descriptive information about the world's oceans. There is a need for greater precision and uniformity of geographic coverage. The recent developments in buoy technology, satellite data collection, expendable BT's, and synoptic data collection, offer to NODC the opportunity for developing greatly improved data services. In order to realize this potential, some rather substantial current problems need to be overcome and new procedures developed in anticipation of future developments. Some of the benefits within the context of the National Marine Science Program that will evolve through the achievement of effective support services by NODC are:

- International Cooperation and Collaboration. The data exchange program of World Data Center A will be enhanced by an expanded range of user services.

- National Security. Increased size and accuracy of physical and geologic data collections together with improved methods for accessing the collections, will be of general use to the Navy in their submarine and deep ocean technology programs.

- Fishery Development and Seafood Technology. Rapid accessing and transmission of temperature versus depth information could be of great use to the fishing industry and could improve fishery productivity if the proper fast response prediction system based on temperature profiles could be established to locate fishing areas.

- Transportation and Coastal Engineering. The intended development of a near-shore data base will be of substantial use for channel and harbor development and protection as well as for shore stabilization and protection programs.

- Marine Pollution Abatement and Control. Operations in this area could expect to benefit from enlargements and improvements across almost the full range of NODC data collections: physical, chemical and biological.

- <u>Health.</u> Access to an improved biologic data handling system would be of considerable benefit.

- <u>Minerals, Chemicals, Water and Energy Resources.</u> The Department of Interior's near-shore investigations would benefit greatly from use of the intended near-shore data base as would the recreation program.

2) <u>Functions and Data Requirements.</u> NODC, in order to satisfy its given mission as a repository of marine information, performs the following functions:

- Discovers and develops sources of information.
- Encourages submission of captured oceanographic data to the Center.
- Develops or participates in the development of reporting forms, formats, standards.
- Indexes, catalogs, files and archives received data.
- Uses stored data to develop charts, standard reports and special reports which show annual and seasonal oceanographic conditions.
- Prepares and makes available to requesters, indexes of its holdings and other information necessary for requesting data or services.
- Promotes and encourages the routine collection of time-series and ocean-wide survey data.
- Satisfies requests for information from the public, the academic community and the federal agencies.

As mentioned previously, NODC is presently the principal national data acquisition and storage center for marine data. However, numerous constraints, primarily budgetary, have forced NODC to be extremely selective in providing service to the marine community. The nature and implications of current data program requirements in relation to expected future user requirements will be discussed in succeeding paragraphs.

3) Data Program Priorities. NODC functions primarily as a repository of marine data; it performs no collection activities. In this role it is required to establish and maintain substantial collections of Nansen cast data, BT data, biological data, geological data, data on currents, and recently, special collections on near-shore and chemical data.

During Phase I, SDC personnel conducted a preliminary survey of NODC data handling activities to ascertain current volumes, processing techniques, problem areas, and major requirements arising from future marine activities. Figure 29 presents a compilation of information received on NODC marine data inputs, storage efforts, and outputs. These data illustrate broadly the data flow processes that exist between NODC and the marine community. This information and the subsequent analysis uncovered a number of factors related to current data flows which must be given attention during the Phase II effort as follows:

a) Current Usage and Potential Demand. Of the several data collections maintained by NODC, only two, Nansen cast and BT data, are employed to any degree in satisfying user requests. These two collections are the only ones that are, to any extent, in machinable form, and, thus, due to their known availability, are in greater demand by the users.

Requests for data provide poor indicators of the actual demand for data. The requests reflect only an awareness that these data are retrievable at NODC. An example of latent demand is the eighty requests for data from a small microfilm collection of seismic surveys since its availability was announced in the NODC Bulletin (ciculation 1600). The latent demands for marine data and their relative importance will be assessed during Phase II.

Requirements for new improved data bases are evident. Engineering data (fouling, corrosion, strength of materials, etc.), bottom photographs, time series data, ice data, and chemical data are in demand.

DATA INPUTS						DATA STORAGE		
TYPE	MEDIA	CURRENT ANNUAL VOLUME	EXPECTED INCREASE IN ANNUAL VOLUME	DATA RECEIVED FROM	TRANS-MISSION MODE	MEDIA	CURRENT VOLUME	EXPECTED ANNUAL VOLUME 1967-1968
OCEANOGRAPHIC CRUISE DATA a) NANSEN CASTS	PUBLICATIONS CODING FORMS MACHINE LISTINGS PUNCH CARDS (NODC) PUNCH CARDS (NON-NODC) MAGNETIC TAPE (NON-NODC) ANALOG RECORDS	8,000^{E} 5,000^{E} 1,000^{E} 2,000 20,000 2,000^{E}	FY66 50,000 (34,000 NEW STATIONS; 4,000 RE-PROCESSED; 12,000 CON-VERTED FROM OTHER FORMATS)	FOREIGN EXCHANGE WDC-A INSTITUTIONS GOVERNMENT AGENCIES EXPEDITIONS	MAIL	PUNCH CARDS LISTINGS MAGNETIC TAPE	350,000	55,000 (FROM BACKLOG)
b) STD CASTS	ANALOG STRIP CHART RECORDS	500		GOVERNMENT AGENCIES INSTITUTIONS	MAIL	ANALOG RECORDS CODED FORMS LISTINGS MAGNETIC TAPE	500	
c) BT DATA 1) ANALOG	LOGS GLASS SLIDES APERTURE CARDS GRIDS PRINTS PUBLICATIONS	 80,000 300 1,000 12,000	850,000 (UNPROCESSED BACKLOG)	NAVY INSTITUTIONS GOVERNMENT AGENCIES WDC-A FOREIGN EXCHANGE INDUSTRY	MAIL	OZALID PRINTS PHOTOGRAPH NEGATIVES	1,000,000 22,000	30,000
2) DIGITAL	INHOUSE FILE OF ANALOG PRINTS	80,000 (SLIDES) 300 (APERTURE) 12,000 (PRINTS)	850,000 (UNPROCESSED ANALOG BT)	EXCEPT FOR DATA SUBMITTED DURING ICITA NO DIGI-TIZED BT'S ARE BEING SUBMITTED TO NODC (CONTRACT DIGI-TATION RECENTLY STARTED BY WHOI, SIO, AND TEXAS A&M)	MAIL	LISTINGS PUNCH CARDS MAGNETIC TAPE	280,000 250,000	90,000
3) XBT	ANALOG STRIP CHARTS	2,700	1968-300,000 1969-400,000 1970-1972-2,750,000 BASED ON NODC ESTIMATES	NAVY INSTITUTIONS GOVERNMENT AGENCIES	MAIL	LISTINGS PUNCH CARDS MAGNETIC TAPE (DIGITAL BT FORMAT)	2,700	1968-300,00 1969-400,00 1970-1972-2,750,000 BASED ON NO ESTIMATES

AGENCY NATIONAL OCEANOGRAPHIC DATA CENTER (NODC)
FUNCTIONS RECEIVES, COMPILES, PROCESSES, AND PRESERVES OCEANOGRAPHIC DATA FOR RAPID RETRIEVAL
ANNUAL BUDGET FY 67 - 1.4 MILLION
COLLECTOR
PROCESSOR X
DISSEMINATOR X
USER

E - ESTIMATE

AGENCY DATA CHARACTER

FIGURE 29

	DATA STORAGE				DATA OUTPUTS					
	CURRENT VOLUME	EXPECTED ANNUAL VOLUME 1967-1968	DATA PROCESSING FUNCTIONS	TYPE	MEDIA	CURRENT ANNUAL VOLUME	EXPECTED INCREASE IN ANNUAL VOLUME	RECIPIENT OF DATA	TRANS-MISSION MODE
RDS)	350,000	55,000 (FROM BACKLOG)	CODING KEYPUNCHING CONVERTING MACHINE PROCESSING COMPUTING CORRECTING AND RECOMPUTING PROOFING VERIPUNCHING PLAUSIBILITY EDITING SORTING	INDEXES ATLASES LISTINGS PUBLICATION LISTINGS SPECIAL SORTING REPRODUCTION PLOTTING SUMMARIES DATA SEARCHES GRAPHS	PUBLICATIONS MAGNETIC TAPE MACHINE LISTING PUNCH CARDS REPORTS GRAPHS AND PLOTS	1,200,000 STATIONS		NAVY INDUSTRY INSTITUTIONS GOVERNMENT AGENCIES FOREIGN EXCHANGE PRIVATE	MAIL
	500		CODING AND DIGITIZING						
PH ES	1,000,000 22,000	3[illegible],000	CODING, FILING, PROOFING, EDITING	ATLASES INDEXES LISTINGS SUMMARIES BT REPRODUCTIONS	XEROX OZALID REPRODUCTION OF NEGATIVES	150,000		INSTITUTIONS FOREIGN AND DOMESTIC EXCHANGE NEL NAVOCEANO ESSA	MAIL
RDS	280,000 250,000	90,000	PRE-SCREENING CODING AND DIGITIZING KEYPUNCHING MACHINE PROCESSING COMPUTING CONVERSION TO STANDARD UNITS PROOFING, EDITING, VERIPUNCHING COMPUTER EVALUATOR	INDEXES ATLASES COUNTS BY 1° SQ/MONTH	MAGNETIC TAPE	480,000		NAVY NEL NAVOCEANO INDUSTRY ORL INSTITUTIONS SIO WHOI TEXAS A&M	MAIL
RDS L. AT)	2,700	1968-300,000 1969-400,000 1970-1972-2,750,000 BASED ON NODC ESTIMATES	SAME AS FOR DIGITAL BT'S						

CHARACTERISTICS – NODC
GURE 29

B

DATA INPUTS						DATA STORAGE		
TYPE	MEDIA	CURRENT ANNUAL VOLUME	EXPECTED INCREASE IN ANNUAL VOLUME	DATA RECEIVED FROM	TRANS-MISSION MODE	MEDIA	CURRENT VOLUME	EXPECTED ANNUAL VOLUME 1967-196
GEOLOGICAL (INFORMATION ON CORE, GRAB & DREDGE SAMPLES)	MACHINE LISTINGS PUBLICATIONS SHIPS LOGS MANUSCRIPTS UNREDUCED LABORATORY REPORTS CODING FORMS (NODC) MAGNETIC TAPE (NON-NODC)			INSTITUTIONS DOD WDC-A INDUSTRY PRIVATE PARTIES	MAIL	PUNCH CARDS LISTINGS (IN CRUISE SEQUENCE)	16,000	[illegible]0,000 (FROM BACKLOG OF 65,0 STATION
BIOLOGICAL a) STATION DATA (ZOOPLANKTON, PHYTOPLANKTON, PRIMARY PRODUCTION, PHYTOPLANKTON PIGMENTS, BENTHOS)	PUBLICATIONS MACHINE LISTINGS			WDC-A EXPEDITIONS GOVERNMENT AGENCIES INSTITUTIONS STATE AGENCIES	MAIL	SOURCE DOCUMENTS (PREPARATION OF PUNCH CARDS & LISTING OF CODED DATA IS IN PROGRESS)	8,000 (PHYTO-PLANKTON PIGMENTS, PHYTO-PLANKTON, ZOOPLANKTON, PRIMARY PRODUCTIVITY, BENTHOS)	30,000
b) MARINE BIOLOGY DOCUMENTS	DOCUMENTS PUBLICATIONS REPRINTS, ETC.	1[illegible],000	2,000	JOURNALS INSTITUTIONS GOVERNMENT AGENCIES STATE AGENCIES UNIVERSITIES	MAIL	DOCUMENTS PUBLICATIONS REPRINTS INDEX CARD FILES	6,000 (3,000 COMPLETELY INDEXED & RETRIEVABLE)	3,000 (BASED ON NODC FY 67 ANNUAL REPORT

AGENCY NATIONAL OCEANOGRAPHIC DATA CENTER (NODC)
FUNCTIONS RECEIVES, COMPILES, PROCESSES, AND PRESERVES OCEANOGRAPHIC DATA FOR RAPID RETRIEVAL
ANNUAL BUDGET FY 67 - 1.4 MILLION
COLLECTOR
PROCESSOR X
DISSEMINATOR X
USER:

X - ESTIMATE

AGENCY DATA CHARACTERIST

FIGURE 29

/003/00

	DATA STORAGE				DATA OUTPUTS					
...EDIA	CURRENT VOLUME	EXPECTED ANNUAL VOLUME 1967-1968	DATA PROCESSING FUNCTIONS	TYPE	MEDIA	CURRENT ANNUAL VOLUME	EXPECTED INCREASE IN ANNUAL VOLUME	RECIPIENT OF DATA	TRANS-MISSION MODE
...CH CARDS ...TINGS (IN ...VISE ...QUENCE)	18,000	50,000 (FROM BACKLOG OF 65,000 STATIONS)	CODING KEYPUNCHING MACHINE PROCESSING TAPE LISTING	INDEXES CALCOMPLOT OF STATION DISTRIBUTION (ATLANTIC SHELF) SUMMARIES DATA SEARCH	PUBLICATION MAGNETIC TAPE MACHINE LISTING REPORTS			ESSA ISRAEL	MAIL
...E ...MENTS ...PARATION ...NCH CARDS ...STING OF ...D DATA IS ...ROGRESS)	8,000 (PHYTO-PLANKTON PIGMENTS, PHYTO-PLANKTON, ZOOPLANKTON, PRIMARY PRODUCTIVITY, BENTHOS)	30,000	CODING PROOFING KEYPUNCHING VERIFYING LISTING	NONE	NONE		NONE	NONE	
...MENTS ...LICATIONS ...RINTS ...EX CARD ...LES	4,000 (3,000 COMPLETELY INDEXED & RETRIEVABLE)	3,000 (BASED ON NODC FY 67 ANNUAL REPORT)	CATALOGING INDEXING CODING PUNCHING	SOURCE DOCUMENTS BIBLIOGRAPHIES	LISTINGS REPRODUCTIONS			INSTITUTIONS NAVY INDUSTRY GOVERNMENT AGENCIES	

...ERVAL

...HARACTERISTICS - NODC (CONT.)

FIGURE 29

B

These data collection requirements are currently receiving varying degrees of attention.

b) <u>Backlogs</u>. As is indicated for BT data in Figure 29 substantial backlogs of unprocessed data exist at NODC. With the advent of expendable instrumentation, buoy networks, world ocean surveys and instrument systems transmitting digital data, the incoming data volumes and, thus, the backlogs are likely to increase at multiplicative rates.

Substantial differences in quality between measurement types and collection methods must be understood, if any national organization of data is to be attempted. For example:

- Substantial portions of data collected are from Ships of Opportunity and are thus of irregular quality and format.
- With the quality of BT's ranging from fair to good, there is concern that semi-automated techniques applied to reduce the BT backlog will result in a collection of lower quality than present manual techniques can provide.
- The collection of XBT data, which will be extensive over time, is expected to be of distinctly high quality and accuracy.

c) <u>New Demands for Services</u>. NODC users will be expecting better satisfaction of their information requirements and will probably require more extractions and more summaries than has been the case in the past. NODC will be required to do more data processing as opposed to merely retrieving data. Four important inferences can be drawn from the above:

- NODC's data flow function is not peripheral, but instead is its principal function; that is, NODC's main responsibility is to provide and enhance the flow of marine information between the government, academic, and industrial contributors and users of marine data.
- As a national data center, NODC must be concerned with acquiring data, in any form, which has prime importance to the accomplishment of

national marine objectives. Users of the acquired data require such data to be disseminated in tapes, cards, analog traces, machine listing, bibliographical formats, etc. User satisfaction will require the development of highly flexible acquisition, storage, retrieval, and dissemination systems which are, at present, nonexistent.

- To provide users with the diversity and complexity of services required, NODC must bolster its research support capabilities. Information dissemination in particular formats, preliminary statistical analyses, evaluations of data quality, etc., are necessary in order to gain marine community acceptance of NODC as a provider of useful services.

- NODC's suppliers of physical/chemical data usually capture their data on cruises. Accordingly the input of data is usually in cruise order. The users of such data, however, are often interested in learning about a specific area during a specific season. Accordingly it is required that NODC be able to accept data as it is supplied, but structure and store it geographically and by time, or alternatively, store it as received but employ a retrieval logic which will extract in response to geo-time parameters.

d) Overlapping Collections. Although NODC is by charter constrained from maintaining overlapping collections, certain overlap conditions have varied implications.

- Operational and research marine data users often collect their own data and, thus, make considerable use of such information before it is submitted to NODC for further processing and dissemination. Long delays between collection and NODC acquisition, duplicating data handling functions and data bases, etc., must be given careful considerations during Phase II.

- Useful duplications may exist in order to provide the most efficient multiple use as in the case of BCF's La Jolla file of weather and sea state data obtained from the Fleet Numerical Weather Facility in Monterey. An analysis of data centers must be conducted during Phase II to identify data flows into and out of these centers and the existing and potential overlaps involved.

4) Impact of Future Marine Activities. With the recent developments in buoy technology, satellite sampling and readout systems, synoptic data capture devices, and expendable BT's greater volumes of information will shortly be captured.

NODC expects to accommodate and process a significant part of these tremendously increased data volumes. The data acquisition, processing, storing, and disseminating functions within the NODC organization must consequently be expanded extensively. The following factors are pertinent:

a) Data volumes now present within the marine community, which are appropriate for inclusion in NODC, far exceed the data actually stored there. In addition, volumes to become available within three to five years will dwarf present collections. Examples of significant future data requirements include:

- NODC presently maintains in various forms and states of processing, two million BT measurements. Based on conservative estimates, the use of XBT's could generate an increase of three million measurements by 1972.

- The widespread use of the STD system could result in the accumulation of 50,000 station measurements per year by 1970. NODC has a current backlog of some 20,000 ocean station observations.

- Buoy systems, could, within five years, be generating in excess of one billion items of information per annum.

- The acquisition of biological data will increase at a sustantial rate, only to experience extreme bottlenecks resulting from inadequate data handling techniques to satisfy its unique requirements.

b) Marine data collection has been characterized by a wide variety of methods for capturing and documenting descriptive information. With the increased feasibility of aggregating individualized sources of marine data for national useage, brought about by technological advances, the problem of incompatible data formats is highlighted. The task of translating like information into a common format is a difficult, but solvable, problem; correlating similar information acquired by different methods is much more difficult, and often impossible. A primary task during Phase II will be to identify and categorize marine measurement types by collection methods in order to determine approaches for achieving commonality of format.

c) NODC is currently pursuing a vigorous exchange program through the World Data Center A, from which is received information from all principal oceanographic nations including Russia and East Germany. Since international cooperation represents a high priority in the Marine Science Programs, substantial emphasis must be placed on defining the international data program requirements of NODC.

d) NODC currently attempts to maintain up to twenty separate programs, supported by a comparable number of data bases, as well as handling special requests, routing requests, Atlas publication, newspaper publication, and special studies. These extensive operations are supported by a distressingly small number of personnel (128), and limited funds. Indicative of this meager funding and support is NODC's lack of its own computer facility and the resultant need to buy non-priority computer time from remote government facilities. Such limitations represent the major reason for NODC's required selectivity in servicing the marine community. Until efforts are made to broaden NODC's perspective through adequate funding and support, it will continue to operate suboptimally.

5) Relevance for Phase II. Some areas which are relevant to Phase II are as follows:

a) Substantial inequities exist between NODC funding and its broad responsibilities. NODC's obvious inability to perform its functions effectively is becoming more pronounced as user data requirements continue to accelerate. This substantial handicap to effective performance by this keeper of the nations' existing marine data base must be adequately considered in planning the National Marine Data Program system.

b) The form of policy guidance within NODC conducted by its interagency advisory board has desirable and undesirable effects on NODC performance. Every board member has a legitimate concern that his agency obtain an equitable share of the services. This tends to direct NODC activities into a host of special-purpose projects with attendant diffusion and compartmentalization of staff capabilities. Accordingly, the emphasis tends to focus on specific problem solution rather than on the development of general-purpose retrieval programs which would be more cost-effective in the long run than the existing special-purpose format transformation routines.

On the other hand, it should be noted that there are definite advantages to interagency advisory boards. NODC is thereby kept aware of marine activities across the range of pertinent federal agencies. This source of information is of extreme value in the long-range planning of NODC activities.

c) A. V. Ochinero, in an unpublished NODC manuscript entitled, "The Data Backlog Problem," describes the worsening communication in the marine science community as due primarily to the increasing number of workers in the field. Data collections are often widely dispersed and growing at high rates. The tasks facing NODC, if it is to attain and maintain currency in its collections, is to discover the existence of significant collections, establish rapport with those responsible for the collections, and subsequently to arrange for acquisition of the collections. If the data owner is indifferent to the possible interest of the marine science community in his data, and unwilling to invest the effort to prepare and supply the data to NODC, important information may be lost. NODC has revealed the intent to embark on an extensive user liaison program entailing extended visits of senior technical personnel to marine science institutions. The results of this liaison effort should provide valuable inputs for the establishment of a National Marine Data Program.

d) As the current primary national marine data handling, storage, and dissemination center, NODC must be carefully evaluated in relation to National Marine Data Program requirements. The following statement of Phase II activities illustrates the approach to this analysis. Some of these tasks have received preliminary coverage in Phase I.

- Determine the potential demand for NODC services if improvements are made in the usefulness of NODC collections.

- Evaluate the completeness, accuracy, and ease of access and use, of existing data collections in support of National Marine Science Program requirements.

- Characterize for each of the National Marine Science Programs the support that NODC could provide and, conversely, the potential for NODC to receive and store data from the programs.

- Evaluate the effects of current and future data backlogs and input rates on NODC's capability to support the National Marine Science Programs, taking into account technological developments, such as new types of platforms and sensors.

- Study and characterize:

  the practicality of developing and employing data capture and transmission standards.

the potential applications of data quality control methodologies.

the potential applications of automatic data processing for handling the NODC data collections.

alternative methods for handling non-machinable collections.

alternatives for purging and archival safety.

e. Smithsonian Institution

1) Missions and Benefits. The primary mission of the Smithsonian Institution in marine science is to carry out basic investigations of marine populations, of the distributions of organisms and sediments in the ocean, and of the taxonomy of marine organisms. It provides assistance and support to international programs such as the International Indian Ocean Expedition, as well as to national programs such as the U.S Antarctic Research Program and other expeditionary efforts. Its 50 marine scientists carry out and participate in the planning and field operations of biological and geological expeditions, and report upon the results of their studies of collections obtained on these expeditions (IN 90, p 44).

The primary mission of the Smithsonian Oceanographic Sorting Center is to support the mission of the Smithsonian Institution through the processing of specimens and sediments collected by and for oceanographic institutions, other government agencies and the research staff of the U.S. National Museum.

In relation to its various internal missions, the Smithsonian's fundamental goals are to operate as a research organization performing basic research in natural history which is defined to include systematics, ecology, geology and anthropology; to support education in natural history from preschool to post-doctoral activities; and to care for and to increase the national collections in zoology, botany, anthropology and geology. The research program of the Smithsonian is focused upon the physical specimens of its collections, and the specimens to which it has access through a museum exchange program.

The National Marine Science Programs derive a number of benefits from the Smithsonian's pursuit of its basic mission. The Phase I analysis suggests the following benefits to be derived from the pursuit of Smithsonian's missions:

a) Fisheries Development and Seafood Technology. The Smithsonian participates in Bureau of Commercial Fisheries cruises, processes BCF data at the sorting center and provides BCF with extensive biologic information. The

Bureau maintains an overlapping collection of fish specimens with the Smithsonian, although the latter is substantially larger. Excellent liaison is maintained between BCF and the Smithsonian.

b) Pollution. The extensive historic specimen collection available at the Smithsonian is of great value in supporting studies of environmental and ecological changes which are important to pollution studies.

c) International Cooperation and Collaboration. The Smithsonian participates in and supports international scientific surveys; and its sorting center serves customers from 26 countries. It participates in extensive international specimen exchange and loan programs and sends its staff members to perform field research throughout the world as well as at foreign museums. The research of many scientists from other nations is also supported at the Smithsonian.

d) Education. The Smithsonian serves as a major educational resource in oceanography and the other natural sciences. It is in communication with virtually all the educational establishments of the nation and many overseas establishments that are concerned with oceanography. It participates in a number of scientific endeavors together with various universities. An example is the consortium of academic institutions which is now developing scientific research programs for the Chesapeake Bay Center for Field Biology.

2) Functions and Data Program Requirements. In the pursuit of its mission requirements, the Smithsonian Institution must perform a number of marine-related functions. The primary activities are:

a) Perform all activities by which it can maintain an awareness of the magnitude of world wide oceanographic specimen collection activities.

b) Participate in the collection, exchange, and specimen exchange activities on a worldwide basis.

c) Maintain a specimen receiving and processing, categorizing, and storing system appropriate to keep up with the input data generated.

d) Manage in an orderly fashion the ingestion of volumes of written information describing specimens, charts, maps, and documentary formats.

e) Care for and increase the national specimen collections in satisfaction of its curatorial requirements.

f) Make such collections usefully available to students and researchers in satisfaction of its educational responsibilities.

g) Maintain a qualified staff of people working in the oceanographic disciplines in satisfaction of its research requirements.

2) Data Program Priorities. Basically, the Smithsonian's data program mission is to acquire and maintain a complete and representative specimen collection in marine zoology, botany, and, to a lesser degree, marine sedimentology. The individual specimen types comprising these collections need to be gathered continuously to provide the necessary historical record. The specimens need to be preserved, identified, described, indexed, catalogued, and stored. In like fashion, scientific documents, studies, and papers which have relevance to marine biology and zoology must be acquired and catalogued.

In handling specimen inputs, the Smithsonian is required to physically sort the material and retain together with the material whatever descriptive information is received. There are several levels of information beyond the individual physical specimen that need to be captured or developed. Since the specimen may represent an object of particular ecological, nutritional, toxicological, or pharmacological interest, various identification parameters must be cross-indexed with specimen contents. As new information about the specimen is acquired, it must be properly retained in the aggregation of information which has evolved about the specimens.

The information requirements for physical specimens is a unique data management problem which must be considered in the design of a National Marine Data Program.

Through the cross-classification of descriptive variables and physical specimens, the proper marine biology index and inventory systems can be maintained to ensure ready retrieval of relevant information or specimen type commensurate with specialized user requirements. The critical need for such systems is obvious from a number of authoritative statements on the subject. For example, Dr. D. F. Squires of the Smithsonian suggests that there is the danger that Smithsonian and other museums may lose much of the specimen-associated data because of the inability to cope with the problems of recording it (DN 405). It is apparent that ecological, serological, biomedical, biochemical, genetic, and morphologic data are not being effectively recorded with specimens. Given the importance of such data to the National Marine Science Programs (i.e., Fisheries Development, Pollution Control, International Cooperation), particular effort during Phase II should be devoted to the alleviation of these problems.

4) <u>Impact on Future Marine Activities</u>. The Smithsonian specimen collections are extensively used by scientific investigators and researchers, by the museum itself in developing displays and exhibits, and in support of the extensive specimen loan and exchange program. Beyond this, the world scientific community constitutes its user/customer group. The requirements for serving this group will include care in specimen preservation, accuracy of specimen identification, usefulness and meaningfulness of labelling systems, catalog and descriptive information and, most importantly, ease of access.

The following comments are intended as preliminary observations on some factors which must be given additional attention during Phase II:

a) With the Smithsonian concentrating its efforts on bolstering its senior staff, manpower voids exist in those areas concerned with filling specimen requests for outside researchers. The files, to a major degree, are handwritten and often clumsily described. Accordingly, the current non-automated retrieval system has all but collapsed under the burden imposed by inadequate files, personnel shortage, and burgeoning specimen requests. Again, as in most other organizations, the system development of a National Marine Data Program must start with the alleviation of problems within elements of the existing system.

b) As with other organizations comprising the bulk of the marine community, the Smithsonian is developing a number of systems which, although in their formative stages, must be effectively tied into the data management systems of the National Marine Data Program. For example, a project is now underway to develop a procedure for generating the ledger entry, the file cards and the specimen labels at a single typing and to derive therefrom an input suitable for automatic data processing. From these inputs, a specimen file is to be prepared which will initially comprise three collections: marine crustacea, sea birds, and marine rocks. Approximately 50,000 of the 60 million specimens are contained in those collections. Further analysis of this evolving system should be conducted during Phase II.

5) Relevance for Phase II. Each of the above mentioned activities will have an effect on the definition of National Marine Data Program requirements. Some of the more important implications drawn from these requirements are described below:

a) The Smithsonian's need to maintain an awareness of the scope and magnitude of the world-wide oceanographic specimen collection activities necessitates the inclusion of at least a bibligraphical retrieval mechanisms. The prestige enjoyed by the institute in international marine affairs, education, and general science suggests the importance of providing such a service, if feasible.

b) The multi-input sources of specimens, the unique requirements for processing such materials, and the increased volumes of specimens received by the Smithsonian suggest the need for extremely effective data management tools to provide the proper service to the national and international marine communities. Preliminary evidence during this Phase I effort has suggested that the most underrated facet of marine science data requirements is in marine biology. Analysis will be conducted during Phase II to substantiate this inference and to specify the data management systems that need to be provided to satisfy these requirements. Such an objective will require the detailed study of the needs of the users of Smithsonian marine specimen collections. A major facet of this analysis will entail the evaluation of the adequacy of the existing and planned indexing and accounting system to satisfy information retrieval and inventory management requirements.

c) An investigation during Phase II should also be conducted to determine the similarities and differences between the Smithsonian Sorting Center and the National History Museum in relation to specimen inventories. For purposes of expediting the activities of the Smithsonian and those of the National Marine Data Program, some considerations should be given to the possibility of introducing a common data management system.

f. U. S. Coast Guard

The requirements of the U. S. Coast Guard (USCG) are mentioned here only briefly to exemplify the substantial effect that its long-range activites may have on data management. Other data on USCG are included elsewhere in this report.

1) Missions and Functions. The USCG performs varied marine functions. In 1949 Congress identified the following ten missions:

- Port Security
- Military Readiness
- Aids to Navigation
- Oceanography
- Law Enforcement
- Search and Rescue
- Ocean Stations
- Merchant Marine Safety
- Reserve Training
- Icebreaking

Its transfer in October 1966 from the Treasury Department to the newly formed Department of Transportation will undoubtedly have profound long-range influence on broadening and increasing the roles, missions and activities of the USCG to encompass those aspects of the National Marine Science Program which relate to marine transportation.

2) Relevance for Phase II. USCG's primary missions both draw from and contribute to the support of the National Marine Science Programs. This support of the National Programs takes the form of ocean wide surveys, inshore surveys, ocean wave and swell studies, studies of radioactivity in the ocean, studies of oil pollution in navigable waters, and military oceanography.

The implications of this support are likely to be far reaching in terms of the data management problems. Figure 20, included earlier, summarizes the sampling rates per day for several agencies and organizations. The sampling rates of the organizations listed are not completely comparable owing to the fact that the method used to derive them discounts the variations between organizations in: (1) the total number of days at sea, (2) the number of vessels used, and (3) the unequal sampling periods. Nevertheless for a preliminary analysis, the derived sampling rates serve a purpose for generalized comparison.

It can be seen from Figure 20, that in every case where comparable data collection rates are shown for all six organizations, the Coast Guard rate is by far the highest. Its present activities plus the current expansion of its oceanographic capability and the further increases contemplated in its long-range plans will make the Coast Guard a major agent in ocean data acquisition.

One specific example of expanded Coast Guard activity is its involvement with data-buoys. The Marine Science Council, on 17 November 1967, delegated to the USCG, the responsibility for development of National Data Buoy Systems as conceptualized in the reports of The Study of the Feasibility of National Data Buoy System by The Travelers Research Center Inc. (TRC) (DN 83, Vol I-III). The Department of Transportation considers USCG involvement with data-buoy systems as a natural extension of its aids to navigation buoyage operations and is therefore sponsoring a budget request to start the development program in FY 69.

USCG has established a Project Management Office to effect the further planning and studies preparatory to actual development of a National Data Buoy System. This office will serve as the focal point for coordination, planning, and development activities of a potential national system of data buoys designed to satisfy the common requirements of all major federal marine oriented agencies.

Table 7 illustrates some facets of the TRC suggested development plans which are serving as a "frame of reference" for planning by the USCG Project Office.

If the TRC suggested schedule of development and implementation were initiated starting in FY 69, it would have substantial effects on marine data volume by 1974. The potential deployment of over 1200 data buoys producing data on over 18 different physical parameters on synoptic schedule, and the transmission and dissemination of this data for multi-agency operational use within one hour of measurement, adds new dimensions to an already potentially staggering problem in data management.

TABLE 7

NATIONAL DATA-BUOY SYSTEM

PLANNED INSTALLATION SCHEDULE

	INSTALLATION SCHEDULE (PROJECT YEAR)					
	1	2	3	4	5	6
Mod 0 Buoy System (1)	-	10	35	-	-	-
Mod 1 Buoy System (2)	-	-	-	-	(3) 280/620	275/615
Mod 0 Communications hub	-	-	2 *	-	-	-
Mod 0 Buoy Depot	-	-	2	-	-	-
Mod 1 Buoy Depot	-	-	-	-	2/5 #	2/4 #
Mod 0 Buoy-tending ship	-	-	2	-	-	-
Mod 1 Buoy-tending ship	-	-	-	-	2/5	1/5

NOTES: (1) Mod 0 System involves use of current state-of-the-art hardware

(2) Mod 1 System uses 5 year state-of-the-art hardware developed from 5-year program of RTD&E

(3) Implementation numbers are for 10-year funding levels of 500/1000 million dollars

* Mobile communications hub

Two Mod 0 depots are upgraded to Mod 1

If a preliminary analysis of Coast Guard functions were confined to near-term activities as exemplified by their funding in Figure 13, it is possible that a low priority would be attached to their contributions. This situation suggests the deficiencies that could arise from neglecting to investigate the long-range plans of organizations. The Phase II effort must include a thorough search for and evaluation of such plans so as not to overlook important considerations in developing the National Marine Data Program.

4. General Implications to the National Marine Data Program

The previous parts of this section have been concerned with structuring the approach by which data program requirements can be considered in detail during Phase II in relation to the functions that they support and, thereby, determine their importance to the accomplishment of national marine science objectives. Considerable effort has also been devoted to gathering detailed information on selected organizations which is pertinent to this effort. The following discussion is intended to summarize some important general implications that have been derived from the discussion in preceding pages.

a. Data Management Concepts

It must be recognized that to this point in the analysis, the importance of various functions and data programs have been developed through considerations other than detailed data management considerations. Questions such as the following need be answered to determine the data management requirements of the various functional data programs:

- What are the characteristics of the user requests for information in terms of:

  Number of users

  Frequency type and volume of user requests

  Processing required per request type

  Storage and storage level requirements for requests

  Response time of requests

- What are the requirements for analysis?
- What are the requirements for developing models to study ocean characteristics?
- What data should be in the data bases to effectively service requests and provide analytical services in accordance with their importance to National Marine Science Program objectives?
- What are the data security/privacy requirements associated with the data base elements?
- What data processing capabilities exist to provide the required processing and where will improved system or expanded facilities be needed?

- What are the file content, updating requirements, and data file purging needed to effectively service user requests and provide analytical services?

b. Marine Data Inventory

The foregoing comments highlight the need for the development during Phase II of a National Marine Data Inventory. During Phase II marine data bases of national interest will be identified. For each such data base, it will be necessary to learn and catalog the following: the type of data, how data is captured, by whom, at what rate, how much (in terms of logical entries) is on hand, how the data are processed, and by whom, who uses the data and for what mission. An inventory will be made to contain for each logged data base the information already named plus indications of the coverage as to geographical area, physical area, and subject/topic area. Information will be noted as to the media of storage, where obtainable and other descriptive parameters thought to be useful. This derived knowledge will serve as an important basic input in the development planning of the National Marine Data Program.

c. The Importance of Data Service Centers

Important activities are performed by existing data service centers, such as NODC, and will be performed in the future by planned data service centers. Coordination of these centers in relation to a national effort represents a key to the successful implementation of the National Marine Data Program. Evaluation is planned of the operations of these centers during Phase II in relation to National Marine Data Program requirements. Plans will be recommended by which these centers can be directed to a common national purpose. As a step in this direction, Table 8 presents SDC's preliminary efforts to identify existing data bases, their pertinent functional components, and the organizations maintaining them.

d. Impact of Greater Data Volumes

Constant reference has been made in previous sections to the accelerated increase in marine data volumes that have and will continue to accompany technological progress and increased national emphasis on marine affairs. Numerous implications can be derived from these occurrences which have relevance to National Marine Data Program requirements. A few of these are as follows:

TABLE 8

PARTIAL INVENTORY OF MAJOR DATA FILES MAINTAINED BY ORGANIZATIONS CONTACTED DURING PHASE I.

ORGANIZATION: DEPARTMENT	ORGANIZATION: DIVISION OR BRANCH	DATA FILES OPERATIONAL OR BEING IMPLEMENTED	LOCATION	COMPUTER HARDWARE	REMARKS
DEPARTMENT OF DEFENSE OFFICE OF THE OCEANOGRAPHER OF THE NAVY	[illegible] CENTER	OCEANOGRAPHIC AND MARINE SCIENCE INFORMATION TECHNICAL STAFF-GENERATED ADMINISTRATIVE NON-DOCUMENTARY	ALEXANDRIA, VA.	FILE SEARCH FLEXOWRITER REMOTE QUERY CONSOLE	ON MICROFILM WITH AUTOMATED RETRIEVAL SYSTEM AND AUDIO-VISUAL DISPLAY CAPABILITY.
[illegible]	NATIONAL OCEANOGRAPHIC DATA CENTER	BT, OCEANOGRAPHIC CARDS	WASHINGTON D.C.	NONE IN HOUSE. PLAN TO ACQUIRE MEDIUM SIZE SYSTEM (IBM 360/40, RCA SPECTRA 70/35 CLASS)	
	HYDROGRAPHIC OFFICE	TOTAL MAGNETIC INTENSITY LIBRARY	WASHINGTON, D.C.	IBM 1401-7074, 7090 SYSTEM TO BE REPLACED BY IBM 360/65 CLASS WITH REMOTE TERMINALS.	AUTOMATED [illegible] ASSISTING IN DESIGN OF SYSTEM FOR HYDROGRAPHY
		BATHYMETRIC LIBRARY			AUTOMATED
		NAUTICAL CHART LIBRARY			AUTOMATED
		GRAVITY			
		SEISMIC			
	OCEANOGRAPHIC OFFICE	BATHYMETRY MAGNETIC SEISMIC RANDOM CARDS BT, TST, S-T-D BOTTOM SAMPLES CURRENT DATA PLANKTON TOW SEA SURFACE TEMPERATURE BOTTOM PHOTOGRAPHY	WASHINGTON, D.C.		
	SPACECRAFT OCEANOGRAPHY PROJECT	PHOTOGRAPHS INFRARED IMAGES RADIOMETER SCATTEROMETER MICROWAVE	MANNED SPACECRAFT CENTER HOUSTON, TEXAS		DATA RESERVED 3 MONTHS FOR PRINCIPAL INVESTIGATOR.

TABLE 8

PARTIAL INVENTORY OF MAJOR DATA FILES MAINTAINED BY ORGANIZATIONS CONTACTED DURING PHASE I. (CONT.)

ORGANIZATION		DATA FILES OPERATIONAL OR BEING IMPLEMENTED	LOCATION	COMPUTER HARDWARE	REMARKS
DEPARTMENT	DIVISION OR BRANCH				
NAVAL WEATHER SERVICE	FLEET NUMERICAL WEATHER FACILITY	SEA SURFACE TEMPERATURE DIGITIZED BT DATA METEOROLOGICAL DATA	MONTEREY, CALIF.	2 CDC 3200 1 CDC 3100 1 CDC 1604A 1 CDC 8090	ALL DATA ON MAGNETIC TAPE. PROVIDE SYNOPTIC REPORTS ON PREDICTIONS. (SOURCE: DOC. 344, P. 3)
NAVY SHIPS	AUTEC RANGE NAVAL SHIPS, RESEARCH AND DEVELOPMENT CENTER (NSRDC)	ACOUSTIC DATA ACOUSTIC DATA	AUTEC RANGE EACH RANGE AND SHIPYARD	2 CDC 3400	FEW MAGNETIC TAPES CONTAINING SUMMARY DATA KEPT AT RANGE. PLANNING TO DEVELOP AUTOMATED STORAGE AND RETRIEVAL SYSTEM - MOST OF DATA IS CLASSIFIED.
ARMY CORPS OF ENGINEERS	U. S. LAKE SURVEY	BATHYMETRIC TEMPERATURE	DETROIT, MICH.	GE 225	INFORMATION CENTER FOR MOST ORGANIZATIONS CONCERNED WITH GREAT LAKES RESEARCH. SOME DATA STORED ALSO.
	COASTAL ENGINEERING RESEARCH CENTER	WAVE DATA SEISMOGRAMS VISUAL REPORTS SAND DEPOSIT INVENTORIES	WASHINGTON, D. C.	USE BUREAU OF STANDARDS UNIVAC 1108	PLAN TO INSTALL A DIGITIZER AND A UNIVAC 1004 TERMINAL AT THEIR FACILITY. ACQUIRING A LEEDS-NORTHRUP PLOTTER. DO NOT SUPPLY DATA TO NODC.
DEPARTMENT OF COMMERCE ESSA	NATIONAL WEATHER RECORDS CENTER	WEATHER REPORTS CLIMATOLOGY	ASHEVILLE, NORTH CAROLINA	H-2200 BEING REPLACED BY AN RCA SPECTRA 70/45 SYSTEM	PLAN TO ACQUIRE RCA 70/25. JOINT OPERATION WITH AIR WEATHER SERVICE.
	SEISMOLOGICAL DATA CENTER	OBSERVATORY SEISMOGRAMS	ASHEVILLE, NORTH CAROLINA		NO ON-LINE OPERATION. WILL CONTINUE TO BATCH PROCESS. INTERESTED IN LONG TERM TRENDS, SERVICE REQUESTS FROM PUBLIC, RESEARCHERS, ETC.
	GEOMAGNETIC DATA CENTER	OBSERVATORY MAGNETOGRAMS			
SMITHSONIAN INSTITUTION	SMITHSONIAN OCEANOGRAPHIC SORTING CENTER	MARINE BIOTA SPECIMENS SEA BIRDS SUBMARINE ROCKS	WASHINGTON, D. C.	PLAN TO ACQUIRE A HONEYWELL 1200 SYSTEM, SUBSEQUENTLY EXPAND TO A 1250 HAVE FLEXOWRITER	

TABLE 8

PARTIAL INVENTORY OF MAJOR DATA FILES MAINTAINED BY ORGANIZATIONS CONTACTED DURING PHASE I. (CONT.)

ORGANIZATION		DATA FILES OPERATIONAL OR BEING IMPLEMENTED	LOCATION	COMPUTER HARDWARE	REMARKS
DEPARTMENT	DIVISION OR BRANCH				
DEPARTMENT OF TRANSPORTATION	COAST GUARD OCEANOGRAPHIC UNIT	ICE INFORMATION, BT, OCEANOGRAPHIC CASTS	WASHINGTON, D. C.	PDP-5	COMPUTER USED PRIMARILY FOR DATA QUALITY CONTROL AND RESEARCH.
DEPARTMENT OF THE INTERIOR	BUREAU OF COMMERCIAL FISHERIES, LA JOLLA BIOLOGICAL LABORATORY	SEA SURFACE TEMPERATURE, FISH CATCH, METEOROLOGICAL HEAT BUDGET, SYNOPTIC CHARTS, FISH EGGS AND LARVAE	LA JOLLA, CALIF.	CAL COMP PLOTTER ON LOAN BASIS	DATA USED FOR RESEARCH AND STATISTICAL INFORMATION FOR COMMERCIAL FISHERIES REPORTS.
	BUREAU OF COMMERCIAL FISHERIES, STANFORD BIOLOGICAL LABORATORY	NORTH PACIFIC SEA SURFACE TEMPERATURES BT	STANFORD, CALIF.		PREPARING SURFACE TEMPERATURE ATLAS AND INVESTIGATING LARGE SCALE OCEANIC CHANGES. OTHER LABORATORIES HAVE SIMILAR DATA FILES.
	U. S. GEOLOGICAL SURVEY COMPUTER CENTER DIVISION	PHYSICAL, CHEMICAL, AND ENGINEERING DATA ON ROCKS GEOLOGICAL AND GEOPHYSICAL ABSTRACTS WATER DATA	WASHINGTON, D. C., DENVER, COLO., MENLO PARK, CALIF.	IBM 360/65 AND THREE 360/30 AND ONE 360/50 AT OTHER LOCATIONS FORMING A SYSTEM NETWORK	INSTALLING AND CHECKING OUT SYSTEM.
	FEDERAL WATER POLLUTION CONTROL ADMINISTRATION	WATER DATA CHEMICAL, VOLUMES, POLLUTION	WASHINGTON, D. C. AND REGIONAL OFFICES		STORET SYSTEM DEVELOPED FOR STANDARDIZING WATER QUALITY DATA (USE B-5 400 COMPUTER).
WOODS HOLE OCEANOGRAPHIC INSTITUTION	INFORMATION PROCESSING CENTER	MANY TYPES OF OCEANOGRAPHIC DATA	WOODS HOLE, MASS.	GE 225 SHIPBOARD IBM 1710, PDP-5	HAVE DATA STORED ON MAGNETIC TAPE, PUNCH CARDS, APERTURE CARDS, SPECIMENS.
SCRIPPS INSTITUTION OF OCEANOGRAPHY		MANY TYPES OF OCEANOGRAPHIC DATA	LA JOLLA, CALIF.	USE UNIV. OF CALIF. COMPUTER. SHIPBOARD IBM 1800	HAVE DATA ON MAGNETIC TAPE, PUNCH CARDS, APERTURE CARDS, SPECIMENS.

PAGE 3 of 4

TABLE 8

PARTIAL INVENTORY OF MAJOR DATA FILES MAINTAINED BY ORGANIZATIONS CONTACTED DURING PHASE I. (CONT.)

ORGANIZATION		DATA FILES OPERATIONAL OR BEING IMPLEMENTED	LOCATION	COMPUTER HARDWARE	REMARKS
DEPARTMENT	DIVISION OR BRANCH				
COLUMBIA UNIVERSITY	LAMONT GEOLOGICAL OBSERVATORY	GEOLOGIC CORES, GRAVITY, SEISMIC, AND MAGNETIC PHYSICAL, CHEMICAL AND BIOLOGICAL DATA	PALISADES, N. Y.	IBM 1130, 1627 AUTOMATIC PLOTTER	USE COMPUTER TO REDUCE AND PLOT SEISMIC PROFILES AND FOR OTHER DATA PROCESSING
UNIVERSITY OF MICHIGAN	GREAT LAKES RESEARCH DIVISION	MANY TYPES OF GREAT LAKES AND LIMNOLOGY DATA	ANN ARBOR, MICH.		MANY DATA FILES, GENERALLY STORED BY INDIVIDUAL RESEARCH SCIENTISTS.
UNIVERSITY OF RHODE ISLAND	NARRAGANSETT MARINE LABORATORY AQUATIC SCIENCES INFORMATION RETRIEVAL CENTER (ASIRC)	BIOLOGICAL, PHYSICAL AND CHEMICAL DATA BIOLOGICAL DOCUMENT INFORMATION	KINGSTON, R. I.	1050 REMOTE TERMINAL CONNECTED TO IBM 360/50 ON MAIN CAMPUS IBM 407, 1620, 104	HAVE 20,000 DOCUMENTS ON AQUATIC SCIENCE ON PUNCHED CARDS. NO ADDITIONS CURRENTLY BEING MADE.
JOHNS HOPKINS UNIVERSITY	DEPARTMENT OF OCEANOGRAPHY, CHESAPEAKE BAY INSTITUTE	BIOLOGICAL, PHYSICAL AND CHEMICAL DATA	BALTIMORE, MD.		EMPHASIS ON CHESAPEAKE BAY AND ESTUARIES. MOST DATA ON MAGNETIC TAPE, PUNCH CARDS AND PRINTED FORMS
AMERICAN GEOLOGICAL INSTITUTE		GEOLOGICAL ABSTRACTS EXCLUSIVE OF NORTH AMERICA	WASHINGTON, D. C.	CONTRACT ALL COMPUTER WORK. HAVE OWN FLEXOWRITERS.	PUBLISH ABSTRACTS USING AUTOMATED SYSTEM. STORE DATA ON MAGNETIC TAPE.
CALIFORNIA	STATE FISHERIES LABORATORY	FISH CATCH INFORMATION	TERMINAL ISLAND, CALIF.	CONTRACT FOR COMPUTER TIME	DATA PROPRIETARY - SUMMARIZED IN ORDER TO PUBLISH

- With the substantial increases in marine data volume and the coverage of the world ocean, there will be greater requirements from both research and operational personnel for data in a format which is amenable to high speed data reduction techniques. Although analog recording will remain important to the marine community, more data in digital format will be required to satisfy these user requirements. The necessary analog data will often result from separate conversion or playback of digitized data, e.g., this will be a necessity in the control of data content and quality while the bulk of the data is being captured in a digital format.

- Closely related to the foregoing comment is the phenomenon that user demand for high speed data reduction will feed upon itself. As the data reduction systems are improved and researchers become aware of the merits of such high speed data reduction, demand for such services is likely to increase at an exponential rate.

- A critical implication of increased data volumes is the potential bottle-necks in the data flow system resulting from the deluge of raw marine data. Substantial effort during Phase II must be devoted to detecting and effectively channeling data traffic.

e. Organizational Participation Requirements

As mentioned previously, the National Marine Data Program is composed of two major components. These are: (1) the National Marine Data Planning System, which provides guidelines for agencies in supporting national programs, and (2) the implementation and improvement in individual organizations of data management systems in that combination which will provide maximum support to national programs, given available resources and implementation schedules. Therefore, it is clear that it will be necessary to develop those data management systems at the agency and organizational level which will be coordinated and in harmony with national needs before a National Marine Data Program can be realized. Since this task involves a formidable effort, it seems reasonable to develop such systems within the various organizations commensurate with their relative importance to national marine science objectives.

5. Data Collection Requirements

The preceding parts in this section have discussed organizational functions required to pursue National Marine Science Program objectives and data programs needed to support these functions. The next step is to analyze the effect on data programs of current and future data collection methods. The results of such an analysis will provide important information for evaluating:

- The feasibility of capturing data to fulfill data program requirements.
- The costs associated with acquiring the necessary data to fulfill the data program requirements.
- The effects of technological advancements in data collection methods and instrumentation.

The following discussion is divided into a number of topics which appear to be most pertinent to providing information on the above factors. These topics in order of discussion are as follows:

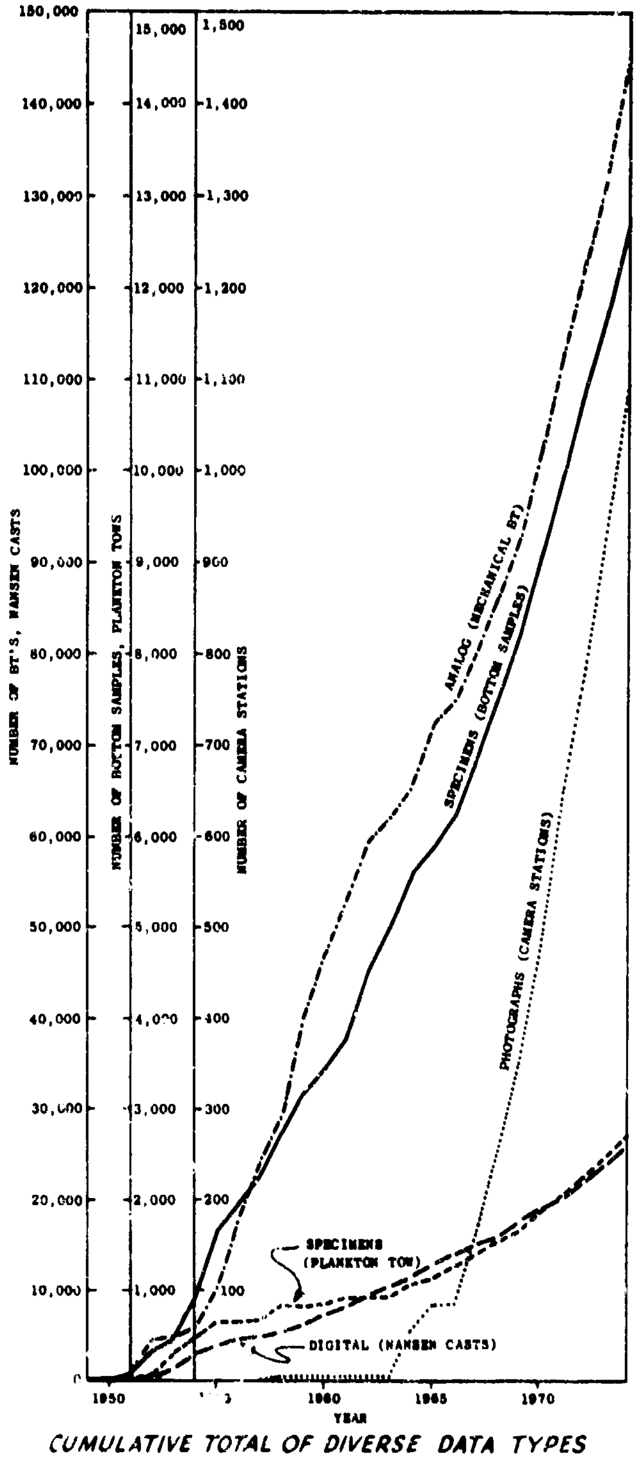
- Collection Systems

    Diversity of Data Needs
    Trends in Recording Needs
    Recording Systems
    Recording Platforms

- Data Transmission
- Modes of Data Collection for Various Response Time Requirements
- Data Standards

a. Collection Systems

1) Diversity of Data Needs. It is evident from the preceding discussions on data programs that the variety of data measurements required is very large. This diversity of data needs is closely correlated with the substantial variations in recording needs which are of primary concern to the development of a National Marine Data Program. Figure 30, Parts (a-f), depicts some of this diversity of recording needs. It is obvious that substantial portions of marine data will be in analog and/or non-machinable forms which are not conducive to digital conversion,

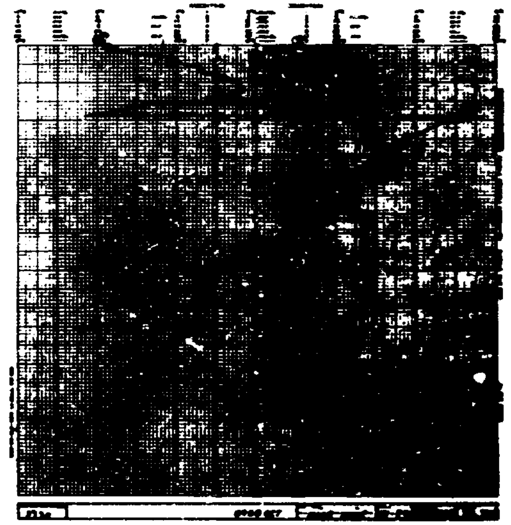


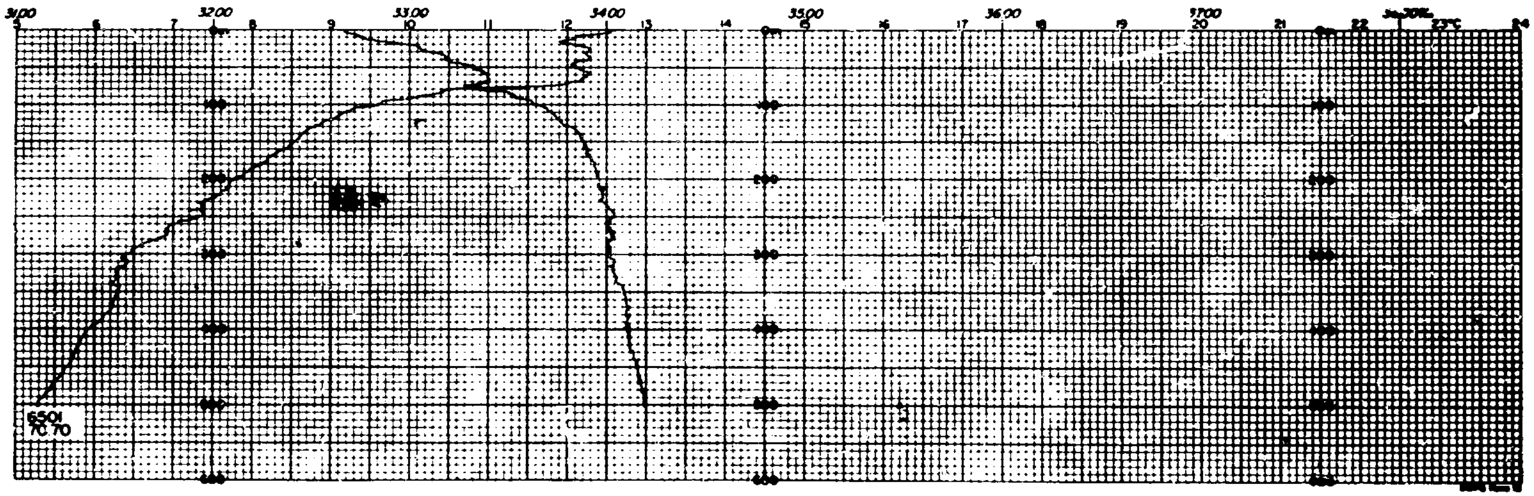
CUMULATIVE TOTAL OF DIVERSE DATA TYPES COLLECTED BY NAVOCEANO

FIGURE 30

ALEXANDER AGASSIZ; January 17, 1965; 0847 CCT; 35°32'N 123°05.5'W; sounding, 2040 fm; wind, 350°, force 3; weather, overcast; sea, slight; wire angle, 04°.

BOTTLE SAMPLES						COMP	STD SELECTED DEPTHS			COMPUTED		
Z m	T °C	S ‰	O_2 ml/L	PO_4-P µg at/L	SiO_3-Si µg at/L	δ_T cl/ton	Z m	T °C	S ‰	σ_t g/L	δ_T cl/ton	ΔD dyn m
0	12.54	32.693	6.40	0.46	5	323	0	12.55	32.69	24.71	324	0.00
10	12.12	32.757	6.47	0.51	5	311	10	12.10	32.75	24.85	311	0.03
30	12.26	33.077	6.32	0.64	6	290	20	12.06	32.98	25.03	294	0.06
50	12.09	33.321	6.14	0.76	8	269	30	12.25	33.09	25.08	289	0.09
75	11.52	33.377	5.78	1.09	11	255	50	12.10	33.32	25.29	269	0.15
100	9.50	33.632	4.09	1.93	27	204	75	11.82	33.36	25.37	261	0.21
127	8.87	33.783	3.51	2.12	32	182	100	9.60	33.63	25.97	204	0.27
154	8.52	33.888	3.34	2.12	36	169	125	8.88	33.77	26.20	183	0.32
178	8.14	33.955	3.49	2.06	36	158	150	8.55	33.89	26.34	169	0.37
213	7.68	33.968	3.49	2.10	41	151	200	7.77	33.96	26.51	153	0.45
253	7.30	34.044	2.10	2.65	52	140	250	7.33	34.03	26.63	142	0.52
							300	6.40	34.02	26.75	130	0.59
							400	5.93	34.10	26.87	119	0.72
							500	5.28	34.19	27.02	105	0.84



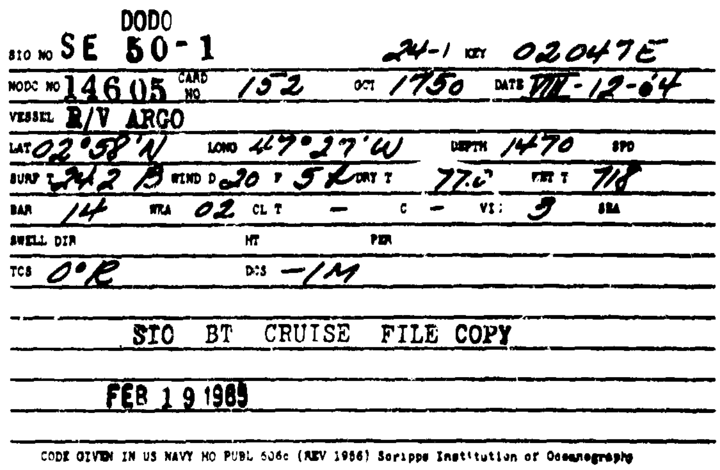


S/T/D AND NANSEN CAST DATA ON CCOFI CRUISE

Source: "Data Report," Physical & Chemical Data, CCOFI Cruise 6501, 6 January - 18 February 1965, SIO Reference 66-4, Scripps Institution of Oceanography.

DIGITAL AND ANALOG RECORDING

FIGURE 30a



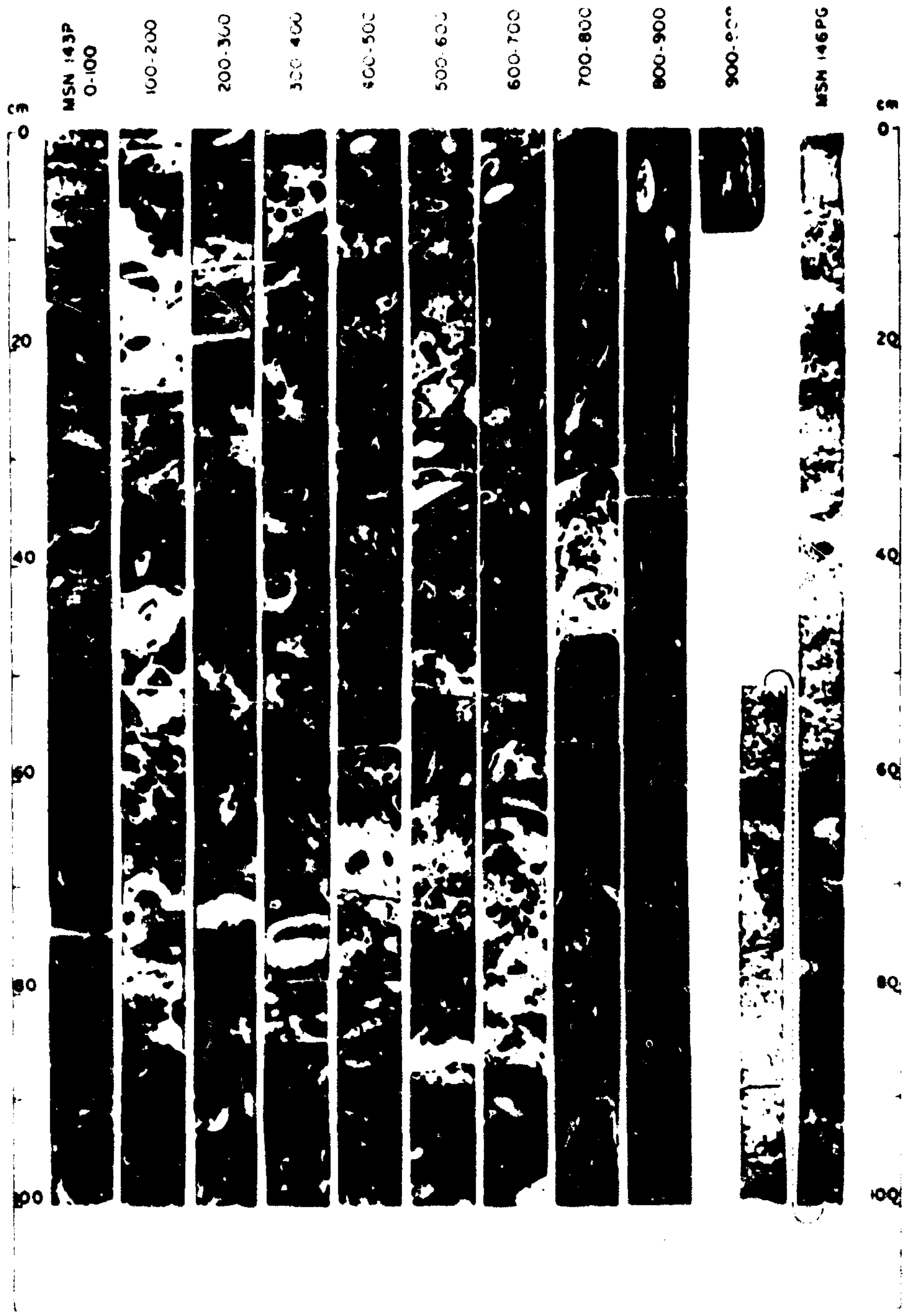
DODO
SIO NO SE 50-1 24-1 KEY 02047E
NODC NO 14605 CARD NO 152 GCT 1750 DATE VIII-12-64
VESSEL R/V ARGO
LAT 02°58'N LONG 47°27'W DEPTH 1470 SPD
SURF T 24.2 B WIND D 20 F 5 K DRY T 77.0 WET T 71.8
BAR 14 WEA 02 CL T — C — VIS 3 SEA
SWELL DIR HT PER
TCS 0°R DCS -1M
STO BT CRUISE FILE COPY
FEB 1 9 1965
CODE GIVEN IN US NAVY HO PUBL 606c (REV 1956) Scripps Institution of Oceanography

BOTH SIDES OF A PRINT MADE FROM A BATHYTHERMOGRAPH GLASS SLIDE

Source: University of California, Scripps Institution of Oceanography, Data Collection and Processing Group, December 1962.

ANALOG RECORDING

FIGURE 30b



TERTIARY SEDIMENT CORES TAKEN FROM THE PACIFIC OCEAN

Source: Quart. J. Geol. Soc. Lond., Vol. 120, 1964

GEOLOGICAL CORES

FIGURE 30c

MSN 143 P. 5° 32'N, 146° 09'W; depth 5100m; core length 909cm. Topography, Fig. 4. Photograph, Pl. 21.

0–34cm. Mottled light buff/brown, slightly manganiferous, clayey radiolarian ooze, somewhat greyish at 31–4cm.

34–99cm. Mottled light buff/grey-brown, clayey radiolarian ooze, with a black, highly manganiferous zone at 34–5cm.

(Marked transverse elongation of mottles in the upper 73cm probably indicates that the sediments of that interval have been compacted.)

99–377cm. Radiolarian ooze with large-scale 'marbled' light buff/grey-brown/dark brown mottles, predominantly lighter at 99–183cm and darker at 183–377cm.

377–574cm. Radiolarian ooze as in preceding interval (99–377cm), but more definitely greyish; predominantly, darker at 377–463cm and 477–574cm, and lighter at 463–72cm.

574–746cm. Radiolarian ooze: a sequence consisting of (*a*) a highly manganiferous zone at the top, followed by (*b*) a mottled buff/grey-brown zone in the middle, and (*c*) a mottled, predominantly lighter, light buff/grey-buff zone at the bottom, is repeated three times at 574–88cm, 588–687cm, and 687–746cm.

746–909cm. Radiolarian ooze: a sequence apparently incomplete but similar to the three above, consisting of (*a*) a lightly manganiferous zone at 746–9cm, and (*b*) a mottled buff/grey-brown zone below 749cm, becoming longitudinally streaked at approximately 800cm to the end of the core.

Levels examined microscopically: 0–2, 8–10, 60–2, 76–8, 116–18, 160–2, 231–3, 293–5, 353–5, 396–8, 432–4, 457–9, 465–7, 566–8, 648–50, 683–5, 690–2, 786–8, 796–8, 902–4cm.

Micropalaeontology. Radiolaria in the samples above 10cm appear to be Quaternary with Pliocene and a little Miocene admixture; those in the samples below 60cm are Pliocene with a little Miocene admixture. The Pliocene section is characterized by the occurrence of *Pterocanium prismatium* in all samples examined below 60cm and of *Eucyrtidium elongatum peregrinum* s.s. in all samples below 293cm. Admixed Miocene material is indicated by the presence of *Calocyclas virginis, Cannartus pettersoni, Cyrtocapsa pyrum, Ommatocampe hughesi, Panarium antepenultimum,* and *P. penultimum* s.s.

Remarks. Less than 60cm of Quaternary sediment (apparently compressed, because at least 150cm is present in the associated gravity core) overlies Pliocene radiolarian ooze that extends to the bottom of the core. The significance of the fourfold repetition of a definite lithological sequence below 574cm eludes us: it is not a result of multiple penetration of the bottom. This core was briefly discussed by Riedel *et al.* (1963) (see Discussion).

SAMPLE OF GEOLOGIST'S LOG OF CORE TAKEN FROM THE OCEAN BOTTO

Source: Quarterly Jnl. Geol. Soc. Lond., Vol. 120, 1964.

GEOLOGICAL CORES

FIGURE 30d

Ripple marks on the sea bottom at a depth of 1800 fathoms on the south side of the Java trench show a strong bottom current. (Official Photograph, U.S. Navy)

Source: "The Sea." Random House, Inc., 1966, p. 66.

SEA BOTTOM PHOTOGRAPH

FIGURE 30e

MARINE ZOOPLANKTON

Source: Fishery-Oceanography Center, La Jolla,
Bu. Commercial Fisheries Circ. 232, 1965.

BIOLOGICAL SPECIMENS

FIGURE 30f

e.g., physical specimens and cores. The ability to handle non-machinable specimens is one of the more formidable challenges imposed upon the National Marine Data Program.

2) Trends in Recording Needs. Although analog recording and transmission of major portions of marine data will continue to occur in large volumes, a greater emphasis is being accorded digital recording. The increasing use of instrument systems that obtain measurements of several parameters at the same point in time and space, such as the ASWEPS system, implies the increasing availability of continuous sensing of the oceanographic environment, with the consequent need for automation of the data recording and storage process. A major part of developing instrument systems, regardless of the nature of the recording platform, is the provision for a centralized output system. Digital computer processing of oceanographic data has already been successfully employed aboard ships by the Navy[1], Coast Guard[2], and various research institutions such as Scripps and Woods Hole[3]. Required peripheral equipment exists now for digitizing data for input into a computer and for data display.

Continuous automated measurement instruments which, with the available peripheral equipment, can provide computer/recorder input were reported for many types of measurement programs listed by the Operations Research Inc.[4] report with few exceptions.

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1. Tajima, G. K. 1965 - Shipboard and Buoy Data Collection and Handling. Proceedings of the ONR-NSIA Symposium on Automatic Collection, Processing, and Analysis of Oceanographic Data. Univ. of Calif., San Diego 11-12 Dec. 1964. Lockheed-Calif. Co. (DN 66)

2. O'Hagon, R. M., Lt. 1964. Data Processing at Sea. Geo. Marine Technology, Vol. 1, 2, pp. 18-21.

3. Bernstein, R., 1966. Data Processing at Sea. Geo. Marine Technology, Vol. 2, 5, pp. 11-15.

4. Operations Research Inc., 1966. Operations Research Reports for the National Ocean Survey Program. Prepared for Environmental Science Services Administration. (DN 107)

One broad exception is that continuous in situ sensors were not reported for chemical determinations, except for salinity. Further automation of bottom or sub-bottom samples, biological samples, and water samples is in its infancy and major sampling problems remain to be solved.

The trend in the automated instrument systems is to be able to establish a continuous flow of data from the sensor to the ultimate desired form suitable for use in computers or in data transmittal. The virtue of continuous sensing has its drawback, however. The provision of a continuous flow of information implies a flood of information that needs to be processed or at least scanned for its information content. Thus, there is the related problem of the development of automated data processing systems. Also, with the increased rate of data collection and data processing, it is more important than ever that there be an assurance of data quality. Here automation can assist by providing automatic checks on the data and, where feasible, automatic checkouts of the entire sensor-data-processing chain. Substantial effort during Phase II must also be devoted to defining the various criteria and related methods which will ensure that the proper peripheral information related to data quality is obtained. With the aid of instrument manufacturers and data collection organizations, information on instrument accuracy and reliability, specific marine environmental conditions, data formats and reduction, can accompany data earmarked for national usage. In this manner, the proper conversion programming for multi-source data aggregations, the required statistical safeguards, and other related tools for achieving data quality assurance can be achieved.

The trend towards digital recording of most physical and chemical data obtained from automated sensors has both positive and negative aspects. On the positive side, it will enable efficient programs for data processing, storage, and retrieval programs to be developed; however, on the negative side, the problem of standardization arises. Unless concentrated efforts are maintained by the oceanographic community to standardize and maintain rigid calibration of their instruments, the resulting data will be of doubtful value. Observations from similar instruments, but from different manufacturers, could prove to be incompatible for required data aggregation. The impacts of standardization will be discussed later in this section.

3) Recording Systems. The importance of sensor instrumentation to the development of a National Marine Data Program is often degraded on the grounds that data flow and user requirements are of primary importance. The fallacy of such reasoning is aptly discussed by one author.[1]

> "While there is no intention to argue that the switching, data processing, computing displ and other electronic subsystems are of lesser importance than the sensing component, the fact remains that any increment of increased effectiveness in the transducer will be directly reflected in like increases in other subsystems and in overall system effectiveness."

As in space technology, some tendency exists apparently to design elaborate data capture, transmission, and processing systems without adequately accounting for the quality of the sensing device. It is important in the development of the National Marine Data Program to view instrument development and data processing as a single integrated system.

The direction of the efforts to upgrade oceanographic instrumentation and platforms to meet the evolving data collection requirements can be fairly comprehensively documented:

- Development of low-cost expendable instruments and an expansion in the use of free-falling instruments with more flexible recall methods for recoverable instruments.
- Standardization of specifications for a small but steadily increasing number of primarily survey instruments.
- Introduction, on a wide scale, of solid-state and micro-electronic circuitry; also, much greater attention paid to mechanical design of instruments where moving parts are used.
- Design of all new sea-going oceanographic vessels to include highly integrated electronic instrumentation subsystems.

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1. McGrath, Thomas, Capt., USN (Ret.), "The Program Package: Some Cautions" Data, Vol. 11, No. 1, January 1966, p. 55.

- Heavy expansion in use of digital output sensors coupled with shipboard data processing systems and standard format data submission.

- Increased effort to improve telemetering systems and remote sensing devices.

- A rapid increase in plans for use of satellite-monitored ocean instruments, especially buoy and fixed platform systems.

- Attempts to achieve major improvements in deep ocean, air-sea interface, marine biology, and buoy-mounted instruments and instrument systems.

a) Instruments. The primary development of specific graphic instruments affecting the data collection process is the conversion of one-measurement, shipboard-analyzed instruments into continuous data collection, in situ devices with remote recording on the ship, buoy, aircraft, or satellite. Coupled with these developments are instruments of the free-fall, remote-reading, expendable and/or underway-operations variety that permit high speed data measurement and collection by air and/or sea platforms. The total impact on data accumulated from such instruments will continue to offer the greatest challenge to the national data management effort. As might be imagined, even the cost-conscious funds administrator will most likely encourage continued development of such instrumentation with the costs per bit of information collected being substantially lower than traditional methods, e.g., the expendable BT measurement, amounts to less than half the cost of the BT, considering extra handling, ship time, and fuel costs. (DN 382)

b) Instrument Systems. The rising costs of ship operation and the increasing demand for stepped-up oceanographic study of the oceans and their parameters will necessitate further compactness and mating of compatible instruments into instrument systems. Some of the primary objectives of instrument system development are:

- Removal of instrument handling limitations.

- Elimination of excessive manual processing of oceanographic data.

- Minimization of ship and crew time in measurement operations.
- Insurance of uniformity in measurements, calibration, and recording quality.
- Standardization of instrument parts.
- Reduction in manufacturing costs through standardization and the elimination of duplicative equipment.
- Simplification of data handling and transfer from the ship's collection system to data storage centers ashore.
- Development of fast response instrument systems to increase data collection potential and to reduce ship's <u>on station</u> or slow speed time losses.
- Design of instrument packages that are readily adaptable to harsh sea conditions, e.g., buoy system sensor packages.
- Packaging of a number of sensors while still maintaining the characteristics of portability.

The advent of instrumentation systems has already had a substantial impact on oceanic data flow. Electronically integrated packages of sensors are producing increased data collection efficiency. The development of instrument packages like the Shipboard Synoptic Survey System and the Salinity-Temperature-Depth (STD) measurement system contribute to the achievement of the ideal situation of maximizing the number and types of measurements on a research or survey platform. Also, by maintaining a degree of portability and changeability, new instrument systems are making Ships of Opportunity more feasible as ocean survey vessels.

It should be remembered that although the technology of instruments and instrument systems is improving substantially, the improvements are still sparse. Many of these improvements are still in the experimental stage or have not been perfected past laboratory conditions. The hardware technologies are years away from providing across-the-board continuous, synoptic measurement systems for all oceanographic needs. Some of the critical, unsolved instrumentation problems are:

- Corrosion and biological fouling as serious deterrents to long-term unattended sensor operation.
- Sea water leakage at high pressure which produces a high percentage of failures.
- Telemetry over several thousand miles of open ocean involving complex international agreements as well as technical problems.
- Data gathering at high ship speeds, especially when the data link involves hardware.
- Electrical power for unattended instruments placed in the ocean for long, unattended periods.
- Density, chemical, and biological measurements which still can't be made in situ.

The primary implications to be derived from these problems and constraints is that marine program planners must apply considerable effort to the effective time-phased planning of systems requirements so as to ensure continual harmony with concurrent technological developments.

c) Recording Platforms. The ensuing discussion touches on the current thinking regarding the developmental trends and requirements of oceanographic platforms in relation to anticipated data collection requirements. It is not the intention of this discussion to describe the detailed operation of the various platforms.

Basically, there are six (6) platform types that are of primary concern in long-range oceanographic planning: ships, buoys, stable platforms, satellites, aircraft and submersibles. Often combinations of these platforms such as buoy-ship, buoy-satellite, and ship-submersible will provide increased effectiveness in oceanographic data collection.

1) Ships. At the present time ships still represent the most feasible method of oceanic data collection. The U.S. oceanographic fleet currently consists of approximately 80 ships and of these, 49 are more than 20 years old (DN 124). These ships are actively employed in basic research,

military research and development, ocean surveys, and fisheries research under the auspices of various government and civilian agencies and institutions. The steady advancements in shipboard design are improving shipboard capacity to perform research work at reduced cost and time. Primary emphasis on future design is directed towards:

- Experimental vessels designed for optimum usefulness for specific kinds of research.
- General-purpose vessels designed for the greatest versatility possible.
- Improved sea keeping ability for research work under adverse conditions.
- Greater capability to handle a variety of heavy over-the-side equipment such as buoys, submersibles, and towed instruments.
- Increased automation of machinery and instrumentation to reduce the number of both operating and scientific personnel.

All of these improvements point towards increased productivity of ocean data collection both in terms of cost-savings and increased data collection volume. The trends towards the use of multiple sensor devices and shipboard data processing as mentioned previously, are providing the key to a prime oceanographic bottleneck--data reduction and analysis. As an example of the current planning towards large-scale automated data collection, processing and retrieval, the ten-year national program to survey 30 percent of the world's ocean serves as a useful basis to guage the magnitude of future survey data handling problems (DN 107, pp 53-55). In the planning of this program (SEAMAP), all shipboard data from automatic recording sensors and manually operated samplers, such as plankton nets, are converted to digital format and entered into the shipboard computer. The function of the computer is:

- To combine data necessary to compute the properties desired from the survey.

- To make corrections to measurements required by the sensing techniques and geometry.

- Combine the output data set into a single collection of measurements representing the cruise accomplishment.

Another use of ships in the overall oceanographic sampling program that is still in its infancy, but which could turn out to be a significant contributor of large amounts of various oceanographic data, is the "Ships of Opportunity" program. The concept of this program is to place portable self-contained sampling systems aboard the numerous ships carrying cargo and passengers over the sea to obtain oceanographic data. Although there are several technological problems associated with this sampling program concept, a start has already been made by several organizations. Among these are:

- A manned portable instrumentation laboratory aboard the S.S. Java Mail, through the joint efforts of the American Merchant Marine, ONR, Naval Missile Center, American Mail Line, and General Motors in 1964.

- A small "Ships of Opportunity" program sponsored over the years by BCF in cooperation with the Matson Navigation Lines and various commercial fishing fleets.

- Biweekly XBT drops by Matson Navigation Company vessels in cooperation with BCF and the Fleet Numerical Weather Facility, beginning in late 1965.

It is often implied that ships will become obsolete for time-dependent surveys once the proposed buoy and satellite observational programs are implemented. The greater likelihood is that the two platforms will perform in complimentary and joint operations. Moored buoys can be utilized to provide a continuous record at a fixed point in space and time (local rate of change). However, unless buoys are deployed in a relatively dense network, they cannot detect advection between areas which is partially responsible for changes observed. Therefore, it is often considered necessary to utilize ships to establish areal patterns of change after which buoys can be employed to monitor the defined ocean processes.

2) Buoys. Although surface ships are presently the basic platform for obtaining oceanographic data, they are costly to operate and must be kept underway in performance of a variety of oceanographic functions. As mentioned previously, time-series and synoptic oceanographic observations are important to the understanding of the physical processes in the ocean. The inability of ships historically to obtain measurements on the scale necessary to understand the dynamics of air-sea interaction, circulation, and water transports represents one of the main reasons for oceanography's lag behind meteorology in the development of scientific theory and environmental prediction.

This need for time-series and synoptic marine oceanographic meteorological data has provided the impetus for the recent acceleration in the development of buoy systems. The extensive buoy study by Travelers Research, Inc. (DN 83, Vol I-V), will undoubtedly have bearing on any future development of buoy systems. This study has documented the national requirements for marine meteorological and oceanographic data over the next fifteen years in terms of: data requirements, state-of-the-art of data collection buoys, feasibility of a National Data Buoy Systems, and cost-effectiveness of the buoy systems which are capable of meeting the national requirements.

A total of 54 buoy systems were investigated in accordance with proposed National Data Buoy Systems requirements. They were evaluated for a series of different scale buoy networks with various purposes and data requirements. A number of conclusions drawn from the report have special relevance to the identification of data requirements during Phase II. These are as follows:

- A centralized pool of buoy components could be made available on a short-term basis to pertinent organizations which are unable to acquire their own buoys given budgetary restrictions. A designated federal agency would be responsible for acquiring, maintaining, and allocating such equipment to those organizations and/or researchers requiring such platforms to enhance their capabilities and capacity in field observations. The centralized pool concept has obvious implications in terms of data flow and data requirements which must be evaluated during Phase II.

- A majority of potential users cited in the Buoy Report expressed the desire and/or needs for at least pseudo real-time data acquisition. This user need, coupled with the risks of buoy sinkage, specifies a corresponding need for some form of electrical transmission (e.g., HF telemetry or UHF satellite transmission).

- It becomes apparent that even with the rather extensive buoy networks envisaged in the Travelers Buoy Report the data management requirements would not be overwhelming. For example, from a network of 415 buoys, strategically located globally, within 500 mile horizontal spacing, having 18 sensors sampled on an hourly basis, 26×10^6 binary bits/day would be accumulated.[1] This represents less than one reel of magnetic tape.

- Besides the impact that large and continuous amounts of data will have on national data management requirements, important aspects of user requirements for buoy data must be given careful consideration. Care must be taken to plan the buoy data acquisition system around the highest priority needs of the various user organizations in pursuit of National Marine Science Program objectives.

- There is currently a divergence of opinion among oceanographers regarding the usefulness of large buoy networks (DN 79 Vol I, p 165). On the one hand, certain academic oceanographers believe that prior to monitoring a system, it

1. This is based on the figure of 2604 binary bits per complete transmission from a single buoy sampling twenty depth levels given in the Travelers Buoy Report (DN 83 Vol. I, Part 3, p 2-6).

is necessary to understand the total system before the monitored data can be properly interpreted. On the other hand, synoptic, military and fisheries oceanographers agree that although a basic understanding of the system is required, the existence of a large-scale buoy network would itself provide oceanographers with the opportunity to gather data to understand the system.

This divergence of opinion has important ramifications for the planning of a National Marine Data Program. The immediate needs of the "synoptic oceanographers" such as those involved in meteorology, the military, and fisheries research, are for the rapid processing and dissemination of the buoy data. This requirement will, no doubt, be met by those agencies now providing this service, such as the U.S. Weather Bureau (ESSA), Fleet Numerical Weather Facility, BCF, and ASWEPS. The problem arises when the synoptic use of the data has been fulfilled and both the raw data and processed products are considered. What are the user needs for historical data of this nature? Should only the raw input data be stored? How should the data base be structured for maximum future use? Who are the potential users of these data? What are their needs? Is it necessary to store the products of the synoptic data, such as the processed data used in the preparation of average monthly charts of various parame . Is this a responsibility of the produc agency, or of a data center? The answers to these questions must be pursued in Phase II.

3) Satellites. Basically, a dichotomy of satellite use in marine activities exists:

- Direct: sensor systems aboard the satellite make direct measurements of the ocean beneath its orbital track.

- Interrogative: the satellite serves as an element in a telecommunication monitoring system that interrogates, relays and possibly pre-processes oceanographic data from buoys, ships, and fixed platforms for immediate use at shore stations.

Although HF telemetering from buoy to ship or shore was recommended in the Buoy Report as a mode, realizable in the short run, for the transmission of oceanographic and meteorological buoy data, synchronous satellite relay communications has a high probability of implementation in the near future. The largest drawback to this type of system at the present time is cost. It has been shown, however, in the Buoy Report that a system of three earth satellites, separated by 120° at altitudes of 22,300 miles would be capable of communicating simultaneously with approximately 70 percent of the earth's surface.

The major drawback to the use of satellites as sensing platforms is that existing sensor technology, when applied to satellite platforms, is generally inadequate for the user needs. For example, the measurement of sea-surface temperature from satellites is hampered by the vapor content and often the opacity of the atmosphere itself.

Perhaps the greatest effect that spacecraft oceanography will have on the planning of a National Marine Data Program will be the generation of a wide diversity of data which include the following: (DN 430, p 6-66)

- Photographic images - black and white, color and infrared film.
- Audio and video signals on magnetic and thermoplastic tape.
- Analog and digital voltages converted and stored in logical memory devices.
- Radar, infrared, and microwave signals processed by cathode ray tubes for recording on photographic film.

These various forms of data presentation imply data collection rates that vary over several orders of magnitude. Estimates of data acquisition rates from satellite transmission which have important data management implications have been summarized in the Annual Report of NAVOCEANO's Spacecraft Oceanography Program (SPOC) (DN 430). It is significant from a data management planning viewpoint that the subjects of data processing, storage or retrieval received only scant mention in both "Oceanography from Space" (DN 68, p 224) and the annual report of SPOC. Given the potentially extensive data volumes that may be acquired through satellite-sensor and satellite-transmission systems, substantial emphasis must be placed on automatically handling the data flows in accordance with user requirements.

A significant task to be performed during Phase II will be to determine the user requirements for each type of satellite-sensor system that serves an important national data program function. The interdisciplinary applications of most proposed satellite sensors will also require that coordination between user organizations be specified in order to optimize data collection and dissemination through avoidance of duplication. Regarding the problem of the diversity of data output from the spacecraft, it is planned to seek assistance from NASA and ESSA's National Environmental Satellite Center regarding the experience that they had in handling similar data problems from satellite sensors. Also, the methods used for handling the data from the Tiros and Nimbus weather satellites will be examined in detail.

4) Aircraft. Given the increasing interest in ocean processes, and the military and civilian requirements to monitor such processes on a more or less synoptic basis, there has been a rising interest in the use of fixed-wing and rotary wing aircraft-borne sensor platforms. Among the most promising techniques is the use of the airborne radiation thermometer (ART) for sensing and recording ocean surface temperatures. Within the last four years, a number of agencies, including ESSA (Coast and Geodetic Survey, Weather Bureau), U. S. Bureau of Sport Fisheries and Wildlife, and the Coast Guard[1]

1. U. S. Bureau of Sport Fisheries and Wildlife 1964, Techniques for Infrared Survey of Sea Temperature. Bureau Circular No. 202, issued at the Sandy Hook Marine Laboratory.

have cooperated in undertaking monthly charting of the surface water temperature from aircraft, along much of the Atlantic, Gulf, and Pacific Coasts of the United States.

Civilian and military (ASWEPS) interests in ART sea-surface temperature mapping coincide in the area of large-scale aerial surveys. The use for this type of data combined with visual observations and infrared photos has widespread use in thermal prediction, fisheries exploration and weather forecasting.

At the present time, aircraft as vehicles for sensing the ocean environment face a similar problem to that of spacecraft, namely, the lack of accurate, reliable sensors. For example, sea surface temperatures can presently be obtained with an accuracy of $\pm 1.0^{\circ}$F. which for most research purposes is inadequate. Programs have been proposed (DN 79 Vol 1, pp 209-223) for widespread use of helicopters and "airplanes of opportunity" in extending the present coverage of sea-surface temperature observations now obtained by merchant vessels. The ideas are sound and only await the development of lightweight, rugged, and accurate automatic sensing units, to the degree that the basic physics of remote sensing permits.

At the present time, the ART data is recorded on analog strip charts from which values are manually read at predetermined intervals for averaging and plotting to develop horizontal sea-surface distribution charts. It is significant that little consequential discussion of the data processing, storage and retrieval problems associated with the current and proposed aircraft sampling programs is found in the literature. During Phase II, the use of aircraft for sensing ocean parameters must be carefully screened to determine the importance of this type of platform in the planning of the National Marine Data Program. The stepping-off point for this type of investigation should be the identification of user requirements and realistic collection capabilities, both in current and expected marine science programs.

5) Towers. The term tower, for purposes of this study refers to the type of structure fixed to the sea-bed by structural members, as exemplified by the U.S. Coast Guard's off-shore light and observation stations.

A principle advantage of oceanographic towers over ships and buoys anchored in a similar location is their stability. Additionally, many parameters can be sensed simultaneously by automatic sensor packages. Thus, over a period of time, continuous measurements can be obtained for only a fraction of the cost of a corresponding vessel operation. Another advantage is that buoys can be deployed around the tower and the data transmitted via hard wire to the tower for processing and storage, thus allowing the tower to also serve as a research facility.

The U.S. Coast Guard is experimenting currently with a Shallow Water Oceanographic Research Data System (SWORD). The present system provides for approximately 45 days of unattended sensing of current speed and direction, temperature, depth, salinity and pressure from offshore light stations. The data are stored in digital form on magnetic tape for later computer processing ashore. Future Coast Guard plans call for additional sensors and for an array of three buoys around each light station. Additionally, long-range planning calls for the establishment of lines of monitoring buoys extending from the Offshore Light Stations across the continental shelf. These buoys would telemeter their data to a communication center ashore or to a space satellite relay system, such as Nimbus. Computer analysis ashore will provide a time-series and synoptic record of what is occurring in coastal waters and eventually reach the point where it may provide environmental prediction services to users of the coastal waters.

Considering the ambitious plan of the U.S. Coast Guard for obtaining observations in shallow coastal waters, it is apparent that this aspect of the marine data collection system will require special attention during Phase II. The development of the SWORD system and other competing automated oceanographic sensing and storage systems must be evaluated closely in connection with the various requirements that agencies such as ESSA and BCF have for synoptic coastal oceanographic data.

6) Submersibles. The present advantages offered by submersibles are centered mainly around direct human observation and work beneath the earth's surface. The first modern Deep Research Vehicle (DR/V), Trieste, has been followed by the construction of a wide range and variety of both small and large research submarines ranging from the single passenger Perry Cubmarine to the forty passenger and nine crew capacity of the DR/V August Piccard.

In the past, little of the instrumentation used on DR/V's was originally designed for submersible operation. However, at the present time, an effort is being made to develop instrumentation especially for DR/V's, such as the miniaturized temperature/salinity/sound velocity/depth sensor for DR/V ALVIN that is being developed under the auspices of NAVOCEANO. These measurement types and those associated with bottom and subbottom materials (e.g., cores and bottom photographs) have some potential for becoming important considerations in defining national data system requirements.

At the present stage of DR/V data collecting capability and that projected for the near future, the DR/V will continue to function in a research capacity and, thus, the resulting data can be expected to be as varied as the spectrum of present and projected research projects.

During Phase II, the capabilities of the National DR/V Program, in terms of fulfilling user needs, must be investigated. The types and amounts of data generated by the DR/V's must be documented in relation to the past, present and future user needs in order to properly assess the importance of these data to the National Marine Data Program.

b. Data Transmission

With the advent of pseudo-real time, synoptic marine measurement requirements, considerable attention is being directed to problems of transmitting data from platforms to recovery facilities. Numerous approaches to radio communications of oceanographic data have been suggested over the years. Among the most notable approaches are:

- Short-burst telecommand signals from receiving stations to activate ocean platform transmission and to determine channel availability.

- Series of telecommand signals over a wide range of frequencies to locate an open channel for transmission.

- High altitude aircraft interrogation of oceanographic platforms and the on-board magnetic tape recording of the data.

These approaches have exhibited various technical and cost deficiencies which have diminished their attractiveness for extensive ocean systems communications. Some important developments and requirements that have particular relevance to the National Marine Data Program are discussed below:

- Surface Platform-to-Satellite-to-land receiving station systems have received the greatest notoriety in recent years as the solution to oceanic data communication problems. Advocates of this approach have argued that short line-of-sight satellite communications in the uncrowded UHF frequency band represents the most feasible approach, regardless of the substantial cost factor. However, there is some evidence that the overcrowded HF frequency band is simply inefficiently utilized by the maritime community; upgrading transmission equipment would relieve substantially these existing full capacity conditions. It should also be noted that accelerated requests for satellite communication time have produced overcrowded conditions in the UHF band. The implications of this situation are extremely important in the determination of National Marine Data Program requirements. The eventual methods of transmitting marine data to recovering stations are of particular relevance to data management system requirements. Evaluations of alternative modes of transmission during Phase II must be conducted to determine the most feasible and probable approaches.* Flexible long range National Marine Data Program plans must incorporate such information.

* An apparently tenable approach, utilizing the HF frequency band, has evolved from the National Academy of Sciences Committee on Radio Frequency requirements for Scientific Research. A programmed telecommand approach is proposed which would utilize single frequency bands to interrogate a wide array buoy system in accurately defined time blocks, as opposed to a random interrogation basis (TM 388, p 396).

- Effectively planned receiving-interrogation stations should also reap substantial benefits for the scientific community. In the future, it may be possible to establish an extensive network of remote terminals from oceanographic data collection centers to research institutions, thereby allowing the scientist quick access to raw or processed synoptic and time series oceanographic data. In addition, the advanced technology of the data centers may provide scientists who have launched their own research platforms with a convenient and efficient mechanism for retrieving and processing incoming data.

- The advanced concepts of the HF telemetering systems may also be applied effectively in solving the accumulative data backlogs that are arising in the use of Ships of Opportunity. The increasing requests for more types of measurements with greater frequency has made the 16 words per minute transmission capabilities of the Morse system completely inadequate. The frustrations arising from these data queings have almost caused a collapse in the Ships of Opportunity program. A small, economical telemetering package activated by shore command might help to alleviate the current difficulties.

- The limitations imposed by short duration transmitting and receiving periods often necessitate some form of data reduction at sea before telemetering to shore is commenced. For example, an initial effort in the ASWEPS program to transmit raw data to shore took so much transmission time that the data had to be reduced to essential data points before the system became operational. Under such circumstances the data management system must provide adequate facilities and procedures for handling preprocessed synoptic data as well as raw data.

c. Modes of Data Collection for Various Response-Time Requirements

The purpose of the following discussion is to summarize modes of data collection in terms of their response time.

1) Synoptic Real-Time. The primary criteria for conducting successful synoptic observations are:

- Substantial area coverage.
- Numerous observation points.
- Rapid data telemetry capability to a central receiving-processing facility.

The primary use of these data is for display of the current situation and for predicting short term future conditions. Prime users of synoptic oceanographic-meteorological data currently are the military (FNWF, ASWEPS, FWF) in support of their tactical missions; ESSA (Weather Bureau) in providing marine and terrestial weather information; and the Bureau of Commercial Fisheries (BCF, LaJolla) in providing the commercial fishing fleet with both fisheries information and supporting environmental data. In the future, as in the past, synoptic data will undoubtedly be collected, processed and disseminated by organizations such as ESSA (Weather Bureau) and the Fleet Numerical Weather Facility, Monterey, California, that have traditionally provided these services for other users.

Large-scale buoy networks are currently in the planning stage to increase both the coverage and quality of the data for large ocean areas. In terms of data management, such systems pose numerous problems which must be resolved. Phase II analyses must answer such questions as:

- What becomes of the raw data and the data processed for computer products preparation (e.g., forecast charts)?
- How much standardization of input-output formats is required and how much is feasible?
- What will be the user requirements for historical synoptic data which, in effect, becomes historical time-series data?
- In what form should such data be stored for maximum use?
- How should the data base be structured in terms of content, space, time, etc.?
- Should the raw data and/or the processed data remain at the forecasting facility or be deposited at some central facility?
- How much data purging will be required to maintain reasonably manageable data bases?

2) Short-Time Response. Synoptic data, once the synoptic need has been satisfied, come under the short-time response category as well as oceanographic-meteorological data from various research projects. Ships, buoys, aircraft, submersibles and towers will all be utilized to collect research data, the nature of which is not critical in terms of rapid transmission or processing. Rather, the compilation and analysis of these data are the critical factors. A data management system must concentrate on the user need for reducing a voluminous amount of data to the volume and format amenable to interpretation and analysis. For example, a station recording current velocity and direction every 30 seconds for a period of six months would produce a record that in itself would be incomprehensible; however, through processing techniques, these data can be reduced to filter out unwanted content.

   An example of short-term response requirements is an international situation where military planners might require a complete historical picture of the marine environment within a limited area. This type of situation poses the problem of what to keep and how long a storage period is necessary before the data becomes obsolete.

   Short-time response requirements will be evaluated in detail during Phase II.

3) Long-Term Response. Long-term response data needs arise in research in which the completion of the project is not constrained by response time. For example, the preparation of atlases showing the distribution of various oceanographic and meteorological parameters would fall under this category. In this case the researcher is interested, often to the exclusion of time requirements, in including all of the available data that meets his specific needs and is most concerned with the statistical manipulation of these data to obtain a meaningful distribution. The problem in meeting this need is the structuring of the data base for selective retrieval, rather than providing the entire data base. Phase II studies must include an identification of the most important of these needs for consideration in the design of the National Merine Data Program.

d. Data Standards

The nature of the data standards covering the collection, storage, processing, and dissemination of marine data represents possibly the most important consideration in designing the National Marine Data Program. No data management system, national or otherwise, can operate effectively without well-defined and documented standards, covering all facets of the data flow process from input to output. It is only necessary to view the data management problem faced by NODC to recognize the complexities and deficiencies that are introduced by non-standardization.

The past record on the development of data standards is not good. Except for isolated and specialized standards that have arisen from identical hardware, such as the Nansen bottle and deep-sea reversing thermometers, there has been relatively little accomplished in the systematic development of working standards. The primary cause of this non-standardization has been the philosophy that individual researchers' needs are first to be satisfied and other users' needs are granted a very insignificant second priority.

A byproduct of this lack of standardization has been inefficient communication processes between various elements of the marine community. Without standards, it has been impossible for researchers and operational personnel from diverse, but complementary, disciplines to communicate effectively. It has also been impossible for the marine community to avoid duplication of data collection efforts because of the lack of benchmarks for determining the characteristics of seemingly similar data and the operational circumstances under which such data were collected. Furthermore, the lack of adequate standards has degraded any attempt to aggregate and reduce similar data that has been collected by different organizations, using different instruments and collection methods, and operating under different environmental circumstances.

Standards are needed not only for instrument characteristics but also for the conditions under which such data are obtained, the format with which they are collected and reduced, and the nature and response characteristics of storage, retrieval, and dissemination. In general, standards must be established which will assure the smooth flow of data between sources and users with diverse operations but common needs.

The current situation is rapidly changing, and physical, chemical, biological, geological, and meteorological phenomena are being investigated on increasingly larger scales, both in time and space and with considerable interrelationships and overlap. With this trend comes the need for greater aggregations of higher quality data than that required previously. Owing to the high cost of obtaining marine data the individual researcher is often unable to obtain large quantities of specialized data for his individual purposes but must usually rely on a cooperative data collection effort involving many individual projects and organizations. An example of this is the proposed National Buoy Program (DN 83, Vol. I-III) designed to meet the national needs for synoptic and time series oceanographic-meteorological data. Clearly the task of standardizing the collection, processing and dissemination of data from this program is a key to its success.

For existing data bases presently held by various organizations, including NODC, attempts at standardization based on user needs must be continued. The Phase II identification of methods for achieving standardization must account for these relationships between important historical data bases and those related data bases which will be implemented in the future.

The development of marine data system standardization will require close cooperation between National Marine Data Program planners, hardware manufacturers, data centers and data users and producers. Identification of the required standards will be followed by the determination of incentives through which the various sets of standards can be successfully implemented within the marine community. The evaluation of standards requirements and required incentives will be a high priority Phase II task.

IV. CONSTRAINTS

A. INTRODUCTION

Constraints will have an impact on the implementation and future rate of growth of a National Marine Data Program.

The identification of constraints and their impacts on system effectiveness is an extremely important, yet often overlooked, facet of problem analysis. By acting as a filter through which idealistic systems needs are passed, constraints analysis provides a realistic perspective of what can be practically achieved.

Constraints analysis is not a static concept; it must be applied continuously throughout the design and implementation stages of the National Marine Data Program. During Phase I the following was accomplished:

1. The preliminary identification of major constraint areas.
2. The design of an approach for detailed constraints analysis during Phase II.

A discussion of (1) and (2) follows.

B. CONSTRAINTS IDENTIFICATION AND ANALYSIS

Constraints analysis does not end with the identification of constraints; the relationships between constraints and their importance to the successful development of the proposed system require attention. Figure 31 presents an analytical framework for conducting a constraint analysis during Phase II. The matrix format serves as an aid to visualizing the complex interrelationships of the constraints and their effects on system development. The basic components of the matrix are as follows:

1. Constraints

   Listing of constraints, divided into their spheres of influence--political, legal, economic, technological, physical and environmental, organizational, attitudinal and social.

2. Constraints Evaluators

   Evaluation of the significance of constraints to the development of a National Marine Data Program. Evaluation factors include:

	CONSTRAINTS	CONSTRAINTS EVALUATORS: IMPORTANCE TO MARINE PROGRAM OBJECTIVES	CURRENT EFFECT OF CONSTRAINTS ON NATIONAL PROGRAMS	IMPACT OF CONSTRAINT VARIATIONS ON DATA PROGRAM DESIGN	PROPENSITY FOR REDUCTION OR ELIMINATION	"COST" OF REDUCTION OR ELIMINATION	INTERFERENCE CREATED BY SPECIAL INTEREST SUPPORT	INADEQUATE INFORMATION FOR REVIEW OF NATIONAL PROGRAM LEGAL AND FUNDING REQUIREMENTS	DISRUPTIONS IN COOPERATION CAUSED BY INTERNATIONAL POLITICAL TURMOIL	POLITICAL AND NATIONAL OPINION CONSTRAINTS TO THE APPROVAL OF NECESSARY OCEANIC PRO[GRAMS]	EFFECTS OF POLITICAL ACTIONS EX[OGENOUS TO] MARINE ENVIRONMENT	RESEARCH AND TECHNOLOGY [VOIDS FROM] MISDIRECTED EFFORT [AND FUNDING]	DATA GAPS [FROM "VOLUNTARY" ASSOCIATION WITH] NATIONAL [DATA PROGRAMS]	
POLITICAL	INTERFERENCE CREATED BY SPECIAL INTEREST SUPPORT	H	M	H	M	L	—	M	S	S	M	S	W	W
POLITICAL	INADEQUATE INFORMATION FOR REVIEW OF NATIONAL PROGRAM LEGAL AND FUNDING REQUIREMENTS	H	H	M	H	M		—	M	S	S	S	W	M
POLITICAL	DISRUPTIONS IN COOPERATION CAUSED BY INTERNATIONAL POLITICAL TURMOIL	M	M	L	M	H			—	M	S	M	S	M
POLITICAL	POLITICAL AND NATIONAL OPINION CONSTRAINTS TO THE APPROVAL OF NECESSARY OCEANIC PROGRAMS	H	L	M	H	M				—	S	S	M	M
POLITICAL	EFFECTS OF POLITICAL ACTIONS EXOGENOUS TO MARINE ENVIRONMENT	H	M	L	L	H					—	S	M	W
POLITICAL	RESEARCH AND TECHNOLOGY VOIDS FROM MISDIRECTED EFFORT AND FUNDING	M	M	M	M	M						—	S	M
LEGAL	DATA GAPS FROM "VOLUNTARY" ASSOCIATION WITH NATIONAL DATA PROGRAMS	M	H	H	L	H							—	M
LEGAL	DATA COLLECTION AND HANDLING INEFFICIENCIES FROM LEGALIZED OVERLAPPING MISSIONS	M	H	M	M	H								—
LEGAL	DATA GAPS ARISING FROM DATA PRIVACY REQUIREMENTS	M	H	M	L	M								
LEGAL	INTERNATIONAL, FEDERAL, STATE JURISDICTIONAL BARRIERS TO EFFECTIVE MARINE ACTIVITIES	M	M	L	L	H								
LEGAL	EFFECTS OF LEGAL ACTIONS EXOGENOUS TO MARINE ENVIRONMENT	M	L	L	L	H								
ECONOMIC	INADEQUATE KNOWLEDGE FOR ADEQUATE COST BENEFIT ANALYSES OF ALTERNATE PROGRAMS	M	M	M	M	M								
ECONOMIC	INEFFECTIVE RESOURCE ALLOCATION FROM AMBIGUITY OF NATIONAL PROGRAM PRIORITIES	H	L	M	H	L								
ECONOMIC	ECONOMIC IMPACTS OF OTHER HIGH PRIORITY NATIONAL PROGRAMS	H	L	M	M	M								
ECONOMIC	INADEQUATE FUNDING TO SATISFY OCEAN SURVEY REQUIREMENTS FOR IMPROVED TECHNOLOGY	M	H	H	M	M								
ECONOMIC	INADEQUATE INCENTIVES FOR PRIVATE INDUSTRY TECHNOLOGICAL DEVELOPMENT	M	H	M	H	M								
ECONOMIC	INEQUITABLE FUNDING OF ORGANIZATIONS IN RELATION TO IMPORTANCE TO NATIONAL PROGRAMS	M	L	M	H	L								
ECONOMIC	SHORTAGES OF MARINE ENVIRONMENT MANPOWER RESOURCES	M	L	M	M	M								
ECONOMIC	ECONOMIC CONSIDERATIONS IN DEVELOPING INTERNATIONAL OCEANIC COOPERATION	M	L	L	M	H								
ECONOMIC	EFFECTS OF ECONOMIC ACTIONS EXOGENOUS TO MARINE ENVIRONMENT	M	L	M	M	H								
TECHNOLOGICAL	INADEQUATE NATIONAL PROGRAM COORDINATION FROM CUSTOMIZATION, RATHER THAN STANDARDIZATION	H	H	H	M	M								
TECHNOLOGICAL	LIMITED SUCCESS IN PRODUCING RUGGED, RELIABLE INSTRUMENTATION AND EQUIPMENT	M	H	M	M	M								
TECHNOLOGICAL	INEFFICIENCIES FROM DISCREPANCIES BETWEEN DATA COLLECTION & PROCESSING TECHNOLOGICAL ADVANCEMENT	M	L	H	M	M								
TECHNOLOGICAL	LIMITATIONS OF UNDERDEVELOPED FOREIGN OCEANIC TECHNOLOGIES IN INTERNATIONAL PROGRAMS	L	L	L	M	M								
TECHNOLOGICAL	INEFFICIENCIES CAUSED BY JUDGEMENTAL DATA SUPPLEMENTING INSTRUMENTATION LIMITATIONS	M	M	M	L	H								
TECHNOLOGICAL	LACK OF UNIFORM CAPABILITIES OF ORGANIZATIONS IN MARINE ACTIVITIES	M	M	M	H	M								
TECHNOLOGICAL	DIFFICULTIES OF HANDLING INCREASED MASSES OF UNSTRUCTURED DATA	L	H	M	H	M								
PHYSICAL AND ENVIRONMENTAL	SAMPLING LIMITATIONS CREATED BY OCEAN EXPANSE AND DEPTH	M	H	L	L	H								
PHYSICAL AND ENVIRONMENTAL	LOW DATA AND RESEARCH QUALITY PRODUCED FROM INEFFECTIVE EXPERIMENTAL CONTROL	M	M	M	L	H								
PHYSICAL AND ENVIRONMENTAL	UNDESIRABLE IMPACTS OF VIOLENT OCEANIC AND AIR-SEA DISTURBANCES ON MARINE RESEARCH	L	M	L	L	H								
PHYSICAL AND ENVIRONMENTAL	UNDESIRABLE IMPACTS ON DATA COLLECTION PROGRAMS FROM CORROSION, FOULING, SEA STATE, ETC	L	M	L	M	M								
PHYSICAL AND ENVIRONMENTAL	LOSSES OF VALUABLE RESOURCES CAUSED BY MARINE CONDITIONS AND [illegible]	L	L	L	M	H								
PHYSICAL AND ENVIRONMENTAL	EFFECTS OF PHYSICAL AND ENVIRONMENTAL ACTIONS EXOGENOUS TO MARINE ENVIRONMENT	M	M	L	L	H								
[illegible]	INEFFECTIVE COORDINATION OF ALL AGENCIES AND INSTITUTIONS	H	H	H	M	M								
[illegible]	INEFFECTIVE PLANNING OF NATIONAL PROGRAM GOALS AND PRIORITIES	M	M	M	H	L								
[illegible]	DIFFICULTIES IN SATISFYING DIVERSITY OF NEEDS THROUGH NATIONAL DATA PROGRAM	M	[illegible]	L	M	H								
[illegible]	[illegible]	H	[illegible]	H	M	M								
[illegible]	[illegible]	M	[illegible]	[illegible]	M	H								
[illegible]	[illegible]	[illegible]	M	H	M	M								
[illegible]	[illegible]	M	M	L	M	M								
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	H								
[illegible]	[illegible]	M	[illegible]	M	M	M								
[illegible]	[illegible]	M	[illegible]	[illegible]	M	M								
[illegible]	[illegible]	M	[illegible]	M	M	M								
[illegible]	[illegible]	M	H	M	M	H								
[illegible]	[illegible]	M	M	[illegible]	[illegible]	[illegible]								

[illegible]

3/00

INTERRELATIONSHIPS AMONG CONSTRAINTS

POLITICAL					LEGAL					ECONOMIC									TECHNOLOGICAL							PHYSICAL							
...EXPERIENCE CREATED BY SPECIAL INTEREST ...PPORT	INADEQUATE INFORMATION FOR REVIEW OF NATIONAL PROGRAM LEGAL AND FUNDING REQUIREMENTS	DISRUPTIONS IN COOPERATION CAUSED BY INTERNATIONAL POLITICAL TURMOIL	POLITICAL AND NATIONAL OPINION CONSTRAINTS TO THE APPROVAL OF NECESSARY OCEANIC PROGRAMS	EFFECTS OF POLITICAL ACTIONS EXOGENOUS TO MARINE ENVIRONMENT	RESEARCH AND TECHNOLOGY VOIDS FROM MISDIRECTED EFFORT AND FUNDING	DATA GAPS FROM "VOLUNTARY" ASSOCIATION WITH NATIONAL DATA PROGRAMS	DATA COLLECTION AND HANDLING INEFFICIENCIES FROM LEGALIZED OVERLAPPING MISSIONS	DATA GAPS ARISING FROM DATA PRIVACY REQUIREMENTS	INTERNATIONAL, FEDERAL, STATE JURISDICTIONAL BARRIERS TO EFFECTIVE MARINE ACTIVITIES	EFFECTS OF LEGAL ACTIONS EXOGENOUS TO MARINE ENVIRONMENT	INADEQUATE KNOWLEDGE FOR ADEQUATE COST/BENEFIT ANALYSES OF ALTERNATE PROGRAMS	INEFFECTIVE RESOURCE ALLOCATION FROM AMBIGUITY OF NATIONAL PROGRAM PRIORITIES	ECONOMIC IMPACTS OF OTHER HIGH PRIORITY NATIONAL PROGRAMS	INADEQUATE FUNDING TO SATISFY OCEAN SURVEY REQUIREMENTS FOR IMPROVED TECHNOLOGY	INADEQUATE INCENTIVES FOR PRIVATE INDUSTRY TECHNOLOGICAL DEVELOPMENT	INEQUITABLE FUNDING OF ORGANIZATIONS IN RELATION TO IMPORTANCE TO NATIONAL PROGRAMS	SHORTAGES OF MARINE ENVIRONMENT MANPOWER RESOURCES	ECONOMIC CONSIDERATIONS IN DEVELOPING INTERNATIONAL OCEANIC COOPERATION	EFFECTS OF ECONOMIC ACTIONS EXOGENOUS TO MARINE ENVIRONMENT	INADEQUATE NATIONAL PROGRAM COORDINATION FROM CUSTOMIZATION, RATHER THAN STANDARDIZATION	LIMITED SUCCESS IN PRODUCING RUGGED, RELIABLE INSTRUMENTATION AND EQUIPMENT	INEFFICIENCIES FROM DISCREPANCIES BETWEEN DATA COLLECTION & PROCESSING TECHNOLOGICAL ADVANCEMENT	LIMITATIONS OF UNDERDEVELOPED FOREIGN OCEANIC TECHNOLOGIES IN INTERNATIONAL PROGRAMS	INEFFICIENCIES CAUSED BY JUDGMENTAL DATA SUPPLEMENTING INSTRUMENTATION LIMITATIONS	LACK OF UNIFORM CAPABILITIES OF ORGANIZATIONS IN MARINE ACTIVITIES	DIFFICULTIES OF HANDLING INCREASED MASSES OF UNSTRUCTURED DATA	SAMPLING LIMITATIONS CREATED BY OCEAN EXPANSE AND DEPTH	LOW DATA AND RESEARCH QUALITY PRODUCED FROM INEFFECTIVE EXPERIMENTAL CONTROL	UNDESIRABLE IMPACTS OF VIOLENT OCEANIC AND AIR-SEA DISTURBANCES ON MARINE RESEARCH	UNDESIRABLE IMPACTS ON DATA COLLECTION FROM CORROSION, FOULING, SEA STATE, ...	LOSSES OF VALUABLE ... CONDITIONS AND TELEMETRY	EFFECTS OF P... EXOGENOUS TO ...	INEF... INF...
M	S	S	M	S	W	W	W	M	S	M	M	S	M	M	M	W	M	M	W	W	W	W	W	W	W	W	W	W	W	W	W	S	M
—	M	S	S	S	W	M	W	M	M	S	S	M	S	S	M	M	M	M	M	W	M	M	W	M	M	W	W	W	W	W	W	M	M
	—	M	S	M	S	M	S	S	S	W	M	S	S	M	M	M	S	S	M	W	W	M	W	M	W	S	W	W	W	S	M	M	M
		—	S	S	M	M	M	S	M	M	S	S	S	S	S	M	M	S	S	W	M	M	M	M	M	M	W	W	W	W	W	S	M
			—	S	M	W	M	S	S	M	M	S	S	M	S	M	M	S	W	W	W	M	W	M	M	W	W	W	W	W	M	M	M
				—	S	M	W	M	M	S	S	S	S	S	S	S	M	S	M	S	S	S	S	M	S	S	M	M	M	M	W	S	M
					—	M	S	S	M	M	M	M	M	M	M	M	M	M	M	W	W	M	W	S	M	M	W	W	W	W	W	S	M
						—	S	S	S	S	S	M	M	M	M	M	W	S	S	W	M	W	M	S	S	M	W	W	W	W	W	S	S
							—	S	S	W	W	W	W	M	M	M	W	W	W	W	M	M	S	S	S	W	W	W	W	W	W	S	M
								—	S	M	M	S	S	M	M	M	S	S	S	W	M	M	W	S	M	S	W	W	W	W	M	S	M
									—	M	M	S	M	M	M	M	S	M	M	M	M	S	W	M	M	W	W	W	W	W	W	M	M
										—	S	S	S	S	S	S	M	S	M	M	M	M	W	S	S	W	M	W	W	W	W	S	S
											—	S	S	M	S	M	M	S	S	S	S	M	W	S	M	W	W	W	W	W	W	S	S
												—	S	S	M	M	M	S	M	M	M	M	M	M	M	S	M	M	M	M	S	M	S
													—	S	S	S	S	S	S	S	S	S	S	S	S	S	M	M	M	M	M	S	S
														—	S	S	M	S	S	S	S	S	S	S	S	M	M	M	M	M	M	S	S
															—	S	M	M	M	S	M	M	M	S	M	M	M	M	W	W	M	S	S
																—	M	S	M	M	M	W	M	S	S	W	M	W	W	W	W	S	S
																	—	S	S	S	S	S	M	M	M	S	W	W	W	W	M	S	M
																		—	W	M	S	M	W	S	M	M	M	W	W	W	W	M	S
																			—	S	S	S	S	S	S	W	S	M	S	M	S	S	S
																				—	W	W	M	M	W	W	M	S	S	S	S	M	M
																					—	W	M	M	W	W	M	S	S	S	S	M	[illegible]
																						—	S	S	M	W	W	W	W	W	W	S	S
																							—	M	W	W	M	S	S	S	S	M	M
																								—	M	M	W	W	W	W	W	S	S
																									—	W	W	W	W	W	W	S	M
																										—	M	M	M	M	M	M	[illegible]
																											—	S	S	S	S	M	M
																												—	S	S	S	M	[illegible]
																													—	S	S	M	[illegible]
																														—	S	M	[illegible]
																															—	M	[illegible]
																																—	

CONSTRAINTS RELATIONSHIPS

FIGURE 31

b

INTERRELATIONSHIPS AMONG CONSTRAINTS

ECONOMIC: ...IONS IN ...NAL PROGRAMS; ...IRONMENT MANPOWER; ...SIDERATIONS IN DEVELOPING ...AL OCEANIC COOPERATION; EFFECTS OF ECONOMIC ACTIONS EXOGENOUS TO MARINE ENVIRONMENT

TECHNOLOGICAL							PHYSICAL AND ENVIRONMENTAL						ORGANIZATIONAL								ATTITUDINAL AND SOCIAL					
INADEQUATE NATIONAL PROGRAM COORDINATION FROM CUSTOMIZATION, RATHER THAN STANDARDIZATION OF	LIMITED SUCCESS IN PRODUCING RUGGED, RELIABLE INSTRUMENTATION AND EQUIPMENT	INEFFICIENCIES FROM DISCREPANCIES BETWEEN DATA COLLECTION & PROCESSING TECHNOLOGICAL ADVANCEMENT	LIMITATIONS OF UNDERDEVELOPED FOREIGN OCEANIC TECHNOLOGIES IN INTERNATIONAL PROGRAMS	INEFFICIENCIES ADDED BY JUDGMENTAL DATA SUPPLEMENTING INSTRUMENTATION LIMITATIONS	LACK OF UNIFORM CAPABILITIES OF ORGANIZATIONS IN MARINE ACTIVITIES	DIFFICULTIES OF SAMPLING INCREASED NUMBERS OF UNSTRUCTURED DATA	SAMPLING LIMITATIONS CREATED BY OCEAN EXPANSE AND DEPTH	LOW DATA AND RESEARCH QUALITY PRODUCED FROM INEFFECTIVE EXPERIMENTAL CONTROL	UNDESIRABLE IMPACTS OF VIOLENT OCEANIC AND AIR-SEA DISTURBANCES ON MARINE RESEARCH	UNDESIRABLE IMPACTS ON DATA COLLECTION PROGRAMS FROM CORROSION, FOULING, SEA STATE, ETC.	LOSSES OF VALUABLE RESOURCES CAUSED BY MARINE CONDITION(S) AND THIEVERY	EFFECTS OF PHYSICAL AND ENVIRONMENTAL ACTIONS EXOGENOUS TO MARINE ENVIRONMENT	INEFFECTIVE COORDINATION OF ALL AGENCIES AND INSTITUTIONS	INEFFECTIVE PLANNING OF NATIONAL PROGRAMS, GOALS, AND PRIORITIES	DIFFICULTIES IN SATISFYING DIVERSITY OF NEEDS THROUGH NATIONAL DATA PROGRAM	INSUFFICIENT SUPPORT OF NATIONAL PROGRAM FROM USER AND SUPPLIER ORGANIZATIONS	IMPACTS OF LIMITED INTERNATIONAL COOPERATION	EFFECTS OF TRADITIONAL VIEW OF DATA CENTERS AS LIMITED SERVICE FACILITIES	INABILITY TO COORDINATE WITH COMPLEMENTARY SCIENCES (E.G., METEOROLOGY)	IMPRACTICAL TIME REQUIREMENT FOR NATIONAL DATA PROGRAM TO PROVIDE USEFUL RESULTS	DETRIMENT CAUSED BY SKEPTICISM TOWARDS NATIONAL DATA PROGRAM AS USEFUL SERVICE	LACK OF NATIONAL PROGRAM SUPPORT THROUGH PUBLIC APATHY	UNDESIRABLE PUBLIC REACTIONS TO EXTENSIVE NATIONAL PROGRAM COSTS	DETRIMENT TO COORDINATED NATIONAL DATA PROGRAM FROM RESEARCHER'S FEAR OF DATA PRIVACY LOSS	DETRIMENT OF UNDESIRABLE INTERNATIONAL ATTITUDES TOWARDS COOPERATIVE OCEANIC EXPLORATION	NET TOTAL IMPACT
W	W	W	W	W	W	W	W	W	W	W	W	W	S	M	M	M	M	M	S	W	M	M	W	M	M	W
M	W	M	M	W	M	M	W	W	W	W	W	W	M	M	W	M	W	W	W	M	M	M	M	M	W	M
M	W	W	M	W	M	W	S	W	W	W	S	M	M	M	M	M	S	W	M	M	W	M	M	W	S	M
S	W	M	M	M	M	M	M	W	W	W	W	W	S	M	M	M	M	M	M	S	S	S	S	S	M	M
W	W	W	M	W	M	M	W	W	W	W	W	M	M	M	W	M	S	W	W	W	M	M	M	M	S	M
M	S	S	S	S	M	S	S	M	M	M	M	W	S	M	M	S	S	M	M	M	M	S	S	M	W	S
M	W	W	M	W	S	M	M	W	W	W	W	W	S	M	M	S	S	S	S	M	S	M	S	S	S	M
S	W	M	W	M	S	S	M	W	W	W	W	W	S	S	M	M	M	W	M	S	W	W	W	W	W	M
W	W	M	M	S	S	S	W	W	W	W	W	W	S	M	S	S	S	M	M	S	S	M	M	S	S	M
S	W	M	M	W	S	M	S	W	W	W	W	M	S	M	M	S	S	M	M	S	M	M	M	S	S	M
M	M	M	S	W	M	M	W	W	W	W	W	W	M	M	M	M	S	W	M	W	M	M	M	W	S	M
M	M	M	M	W	S	S	W	M	W	W	W	W	S	S	M	M	W	M	W	W	M	M	M	W	W	M
S	S	S	M	W	S	M	W	W	W	W	W	W	S	S	S	M	M	M	M	M	M	M	S	W	W	W
M	M	M	M	M	M	M	S	M	M	M	M	S	M	S	M	M	M	M	S	S	S	S	S	W	W	S
S	S	S	S	S	S	S	S	M	M	M	M	M	S	S	S	S	S	W	S	W	S	S	S	M	M	S
S	S	S	S	S	S	S	M	M	M	M	M	M	S	S	S	S	M	W	M	W	W	S	S	S	M	S
M	S	M	M	M	S	M	M	M	M	W	W	M	S	S	M	M	M	M	M	M	M	M	M	W	M	M
M	M	M	W	M	S	S	W	M	W	W	W	W	S	S	S	S	W	W	M	S	W	S	M	W	W	M
S	S	S	S	M	M	M	S	W	W	W	W	M	S	M	M	M	S	W	M	M	W	[illegible]	S	W	M	M
W	M	S	M	W	S	M	M	M	W	W	W	W	M	S	M	M	M	M	M	M	S	S	S	W	M	M
—	S	S	S	S	S	S	W	S	M	S	M	S	S	S	S	S	M	M	M	M	M	M	M	S	M	S
	—	W	W	M	M	W	W	M	S	S	S	S	M	M	S	S	W	W	M	M	M	S	S	M	W	M
		—	W	M	M	W	W	M	S	S	S	S	M	M	M	S	W	W	M	M	M	S	S	M	W	M
			—	S	S	M	W	W	W	W	W	W	S	S	W	S	S	M	M	M	M	W	W	W	S	M
				—	M	W	W	M	S	S	S	S	M	M	M	S	W	W	M	M	M	S	S	M	W	M
					—	M	W	W	W	W	W	W	S	S	S	S	M	M	S	M	M	S	S	S	M	M
						—	W	W	W	W	W	W	S	M	S	S	W	M	M	S	S	S	S	M	W	M
							—	M	M	M	M	M	M	M	M	M	S	W	M	S	M	M	M	M	S	M
								—	S	S	S	S	M	M	M	S	M	W	M	M	W	S	M	W	W	M
									—	S	S	S	M	M	M	M	M	W	M	M	W	M	M	W	W	M
										—	S	S	M	M	W	M	M	W	W	M	W	W	M	W	W	W
											—	S	M	M	W	M	S	W	W	M	W	W	M	W	W	W
												—	M	M	W	M	W	M	M	M	M	M	M	W	W	W
													—	S	M	S	M	W	S	M	S	S	W	S	S	S
														—	M	S	M	W	M	M	S	S	S	W	W	M
															—	S	M	M	M	S	S	M	M	S	M	S
																—	M	M	M	M	S	M	S	S	M	S
																	—	M	M	M	M	M	W	W	S	M
																		—	M	W	S	M	M	S	W	M
																			—	M	S	M	W	W	W	M
																				—	S	M	M	W	W	W
																					—	[illegible]	S	S	W	M
																						—	M	M	W	W
																							—	W	W	M
																								—	W	M
																									—	

...TIONSHIPS

C

a. Constraint's impact on the achievement of national marine program objectives.

b. Constraint's current effect on the operations of the national marine program.

c. Constraint's effect on national data program design through reduction or elimination of the constraint.

d. Constraint's propensity for reduction or elimination and the "cost" to do so.

3. <u>Interrelationships Among Constraints</u>

This comprehensive constraints analysis can be used to identify constraints with the strongest interrelationships and the greatest importance to the National Marine Data Program. Emphasis will be placed on determining the effects of these constraint conditions on the cost and effectiveness of developing components of the National Data Program. Decisions on which constraint conditions are acceptable and which ones must be eliminated or modified can then be established.

C. SAMPLE CONSTRAINTS

The following lists a sample of the constraints that will be subjected to the above analysis during Phase II:

- Lack of singularity and popular sense of high nationalistic thrust in marine program goals.
- Vested interests in marine resources by industry and the states.
- Extensive international turmoil with its effect on international cooperation.
- Economic impacts created by other priority national programs.
- Problems concerning the ownership of marine data.
- Lack of central coordination authority on the one hand, and distrust on the part of the marine community of such central authority, on the other.
- Divided loyalties of federal agencies responsible for contributions to more than one national program.

- Lack of sufficient industrial incentives to justify extensive capital investment in customized equipment and technology development to serve a limited market.

- Data privacy requirements of proprietary and classified data, e.g., the problem of declassification of national security-oriented data for other oceanographic research and technology needs.

- Inertia of the traditional view of some data centers as limited service facilities rather than integral support elements of the national program.

- Reluctance of investigators to release data until after publication of results.

- Fear of standardization and loss of control over the quality of data collection and research results.

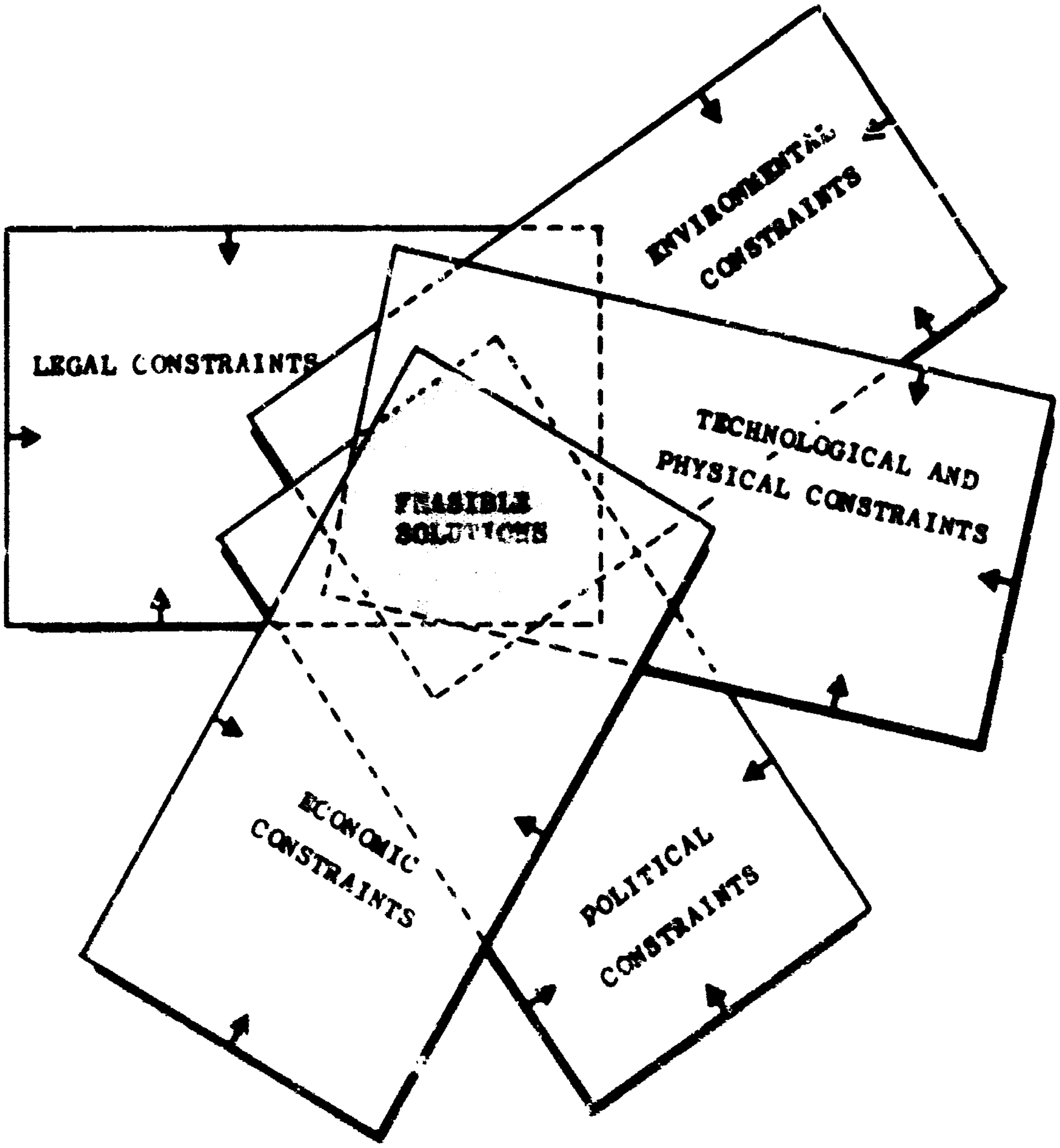
This fragmentary abstract of a truly impressive spectrum of constraints illustrates the forces tending to impede the development of this program. But perhaps more than any other aspect, incentives and benefits are the basic tools which must be used in breaking down these essentially non-technical barriers. A discussion of these tools and suggested ways in which they might be utilized is included in the Summary.

D. PHASE II APPROACH TO CONSTRAINTS ANALYSIS

The primary purpose of the Phase I effort has been to identify the major constraints within which the National Marine Data Program must operate. Some preliminary analyses of the interactions between the various major constraints have been conducted. A description of the Phase II approach follows.

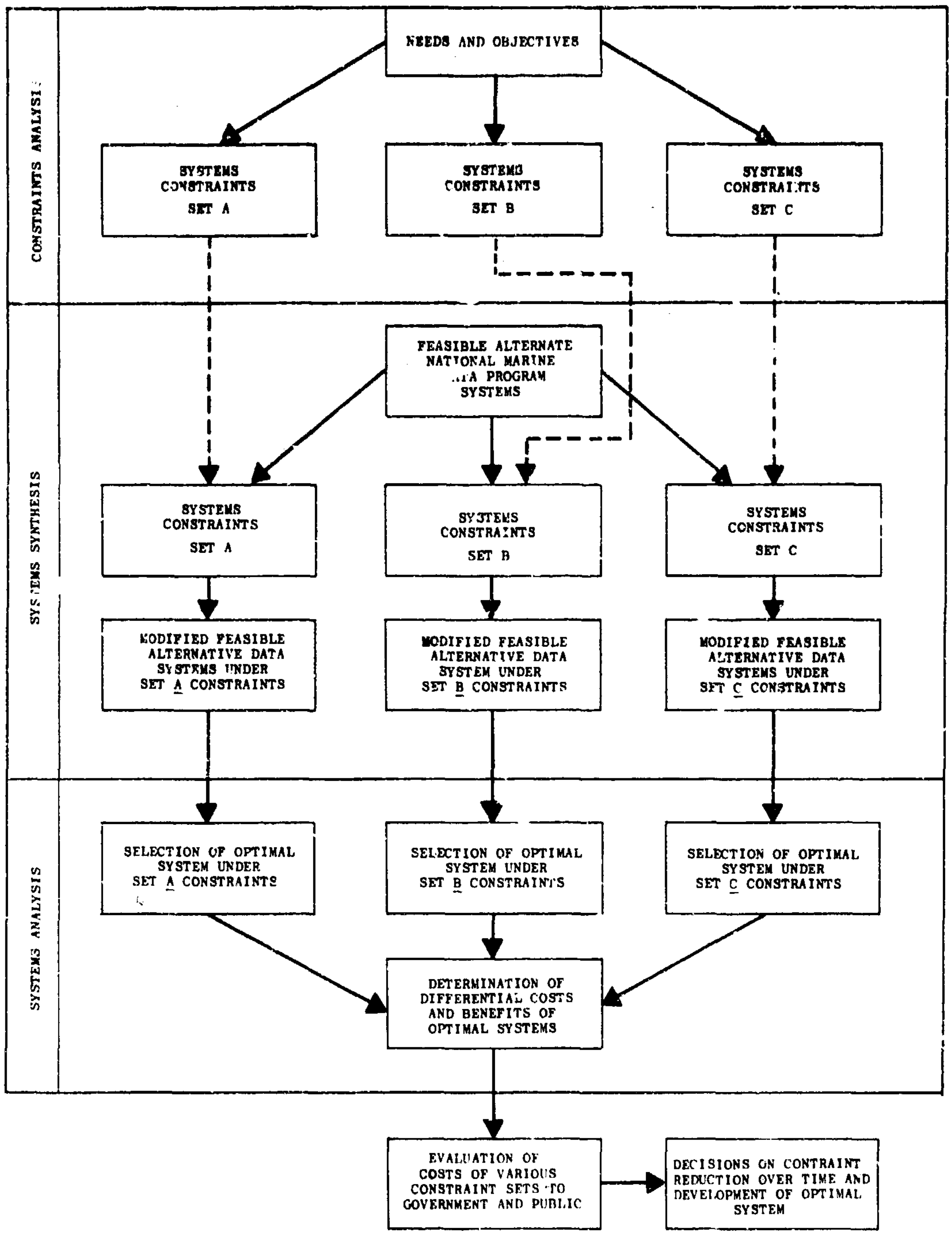
As was indicated in previous paragraphs, interactions between various important systems constraints represent an important part of constraints analysis. Figure 32 is an attempt to depict the interaction of constraints. Many constraints operate concurrently on the development of a National Marine Data Program. Schematically, only in the central hatched area, Feasible Solutions, is there an area within which feasible alternate National Marine Data Programs can be developed.

The Phase II approach to constraints analysis is schematically represented in Figure 33 . The process will first involve analyses of needs and objectives in relation to constraints. An analysis of the importance and interrelationships of the various constraints,



EFFECT OF CONSTRAINTS

FIGURE 32



CONSTRAINTS ANALYSIS
FIGURE 33

organized into the format of Figure 31 , will help define the important sets of constraints. Estimations of the "cost" differentials between these sets of constraints, which are the costs to the federal government and the public of varying (reducing or eliminating) the various constraints, will be made.

As depicted in Figure 33, feasible alternative systems will be determined. These alternative systems will then be modified to best harmonize with each set of constraints under evaluation. Systems are then selected which are expected to perform most effectively under each particular set of constraints. Cost and effectiveness in relation to national program objectives will then be determined.

The above-described process sounds complex and highly proceduralized, and obviously cannot be applied rigorously in all cases. In practice, however, its processes form a clear framework of steps which are applied to the extent practically possible. In this way, systematic treatment of constraints is achieved in the most effective manner.

To aid the reader in understanding the complexity and importance of the concept of constraints analysis with respect to the overall planning of a National Marine Data Program, the remainder of this section is devoted to a discussion of some non-technical constraints concerned with legal matters, military classification, and ownership of marine data.

E. LEGAL CONSTRAINTS

The legal aspects of constraints analysis cut across all other constraint categories. The following selected examples of legal issues illustrate the need for a systematic and on-going attack on that constraint area.

Starting inshore and moving to sea:

1. The existing legal research tools may appear to suffice with respect to inland waters, that is, problems arising under federal and state statutes with respect to territorial waters within the three-mile limit or other limit conceded to the states by the Federal Submerged Lands Act; but they do not. For example, what is the base line from which this distance is measured? In the second United States vs. California case, the court applied the criteria of the 1958 Convention on the Territorial Sea and the Contiguous Zone, which, among other things, authorizes the drawing of a base line across the mouths of "historic" bays which would not qualify as "bays" by the

stated mathematical ratio of width to indented distance or area. The state's briefs contain quotations from historical material on scores of "historic bays" all over the world, apparently not collected in any other place; and, of course, the federal-state jurisdictional problem is not unique to the United States. Germany, Australia, and Malaysia, among others, divide jurisdiction over submarine resources between central and state or local governments. Where shall an American (or other foreign) lawyer look to discover what law, what administrative system governs? Is the internal allocation of jurisdiction in such a country the same with respect to fisheries, control of navigation, criminal jurisdiction, etc., as with respect to subsurface minerals?

2. What countries of the world adhere to the three-mile zone as the outer limit of their territorial waters? Six miles? Twelve miles? Greater distances? Are these asserted for all purposes, or only some? What straits or other openings are affected by the differing contentions?

3. What is the right of "innocent passage" through territorial waters, as recognized by international law and protected by the Geneva Conventions? Is it suspended by an undeclared war, e.g., Haiphong Harbor or the Strait of Tiran? Can it be exercised by an exploratory or commercial submarine without surfacing and showing its flag, as military submarines must do under the conventions?

4. What nations have ratified each of the 1958 Geneva Conventions: the Convention on the Territorial Sea and the Contiguous Zone, the Convention on the High Seas, the Convention on Fishing and Conservation of Living Resources of the High Seas, the Convention on the Continental Shelf; and with what reservations? While this information can be kept up to date without much difficulty, it happens that several important oil-producing countries (including most of the Arab nations) have not ratified the Convention on the Continental Shelf, but have nevertheless followed its principles in bipartite agreements. These facts are not readily available. Moreover, there are offshore boundary disputes (many of them generated by the presence of islands) in various areas of the world, some arising under this convention, others between non-ratifying countries. Their status, from time to time, is not readily available.

5. With respect to the Continental Shelf: the general scheme of the Convention is that the coastal nation has exclusive jurisdiction of the resources of the seabed (so that if it does not exploit them, no other nation can), but that the overlying waters retain their status as high seas. The

Continental Shelf is defined, in substance, as the seabed of submarine seas adjacent to the coast but outside the territorial sea, "to a depth of 200 metres or, beyond that limit, to where the depth of the superjacent waters admits of the exploitation of the said areas." All kinds of questions remain to be resolved, and data for their resolution are hard to obtain; so are the decisions, over the world, which attempt local solutions. Among the prosaic ones are the collection of data on exploitation laws and concession agreements issued by the more than 100 nations which front on the sea. Keeping up with them is a large task. This is an important subject. About a sixth of the world's petroleum now comes from offshore wells, and the proportion is likely to grow. Much of the world's tin and most of its magnesium and diamonds now come from the sea. The existing world-wide scheme of concessions and leases, and their future pattern, are of obvious importance. Their terms are often available only through friendly professional connections.

As to the legal questions, just for samples: Can the United States validly lease submerged lands on a bank separated from the coast by a submarine trench exceeding 200 metres in depth? (It has purported to do so.) How far toward Hawaii, for example, or offshore from New England can it do so? Can the United States validly issue mineral leases at a depth of, say, 600 metres? (It has purported to do so.) If oil is successfully developed at such a depth, does this automatically extend all coastal nations' jurisdiction to a like depth all over the world? (A Japanese writer says so.) Among more esoteric questions: Can a distant nation explore our continental shelf (or vice versa) with submarines? What if they extrude wheels, and explore the sea bottom? (This has been done.) What recourse do we have if, say, Cuba leases submerged lands on its continental shelf to Russia for oil development, but the drilling platforms house military equipment of various kinds? A computer cannot answer these questions, but it can store and retrieve the data as to precedents, similarities, current developments, etc. A great deal of useful information is contained in papers and speeches which do not deal by title with marine resources, e.g., the recent paper of AEC Chairman Seaborg on "Proliferation of the Peaceful Atom," which contains information not collected elsewhere on minerals recoverable from the sea, and the energy which could be produced from fusion of heavy hydrogen atoms contained in sea water. So also with a recent Scientific American article on influence of salt availability (from evaporation of sea water) on trade routes, hence on historical advancement of various cultures.

6. Beyond the continental shelf, howsoever defined: What regime shall govern acquisition of rights in the seabed? The law of the flag of the discoverer? The United Nations? How shall the non-exclusive multiple uses of the high seas overlying this operation be accommodated to the exclusive possession of the seabed, a possession of the seabed, a possession that can only be maintained by some degree of access from the surface, through buoys, cables, pipelines, mother ships, etc.?

Many of these problems are in their infancy, and the lawyers will be groping for solutions as they did a hundred years ago in the evolution of the law of waters, and a little later in the evolution of the law of oil and gas. Some of the analogies developed then by well-meaning lawyers ignorant of physical laws still haunt us, e.g., the analogy of oil and gas underground to wild beasts, "ferae naturae," title thereto to be acquired by capture. So also with the abysmal ignorance of the behaviour of groundwater, and its relation to surface flows, with which our law of waters is plagued to this day.

Perhaps early establishment of an interdisciplinary data retrieval system applicable to marine resources, giving rapid access to information not known or even suspected of existence by the inquirer, may help to avoid mistakes like those of the courts and legislatures with respect to other resources.

F. CLASSIFIED DATA CONSTRAINTS

The problem surrounding the classification of national security-oriented marine data is of real concern and acts as a constraint on the overall planning of the National Marine Data Program. Appendix E identifies some of the types and estimated volumes of classified NAVOCEANO-collected data which could perhaps provide benefits to other marine organizations if declassified. At the present time the extent of the benefits that could be derived from declassification are unknown and await a detailed study of the problem in Phase II. For example, would there be a reduction of survey ship-operating costs of the U.S. Coast and Geodetic Survey if classified bathymetric data were released for specific areas? Or, if data on bottom samples were declassified for the Continental Shelf, would the resulting data reduce the planned bottom sampling costs of the national resources programs of the U.S. Department of Interior?

Aside from the problem of declassification itself, the planning for the National Marine Data Program must also consider the high cost of declassification, which in itself poses a serious constraint acting against declassification of military-oriented marine data. It may well turn out that in order to derive additional benefits from currently classified marine data, user-organizations will be required to bear a portion of the cost of declassification on a share-the-cost funding arrangement.

As a first step, the real demand for classified data must be determined. The best index of demand is perhaps the sum of money organizations are willing to pay for the cost of declassifying data. Concurrently, the cost of declassification must be determined for various types of data. In this analysis, a distinction must be made between secret and confidential data. This categorization is important because of differences in amounts of data, demands for data, and costs of declassification for the two groups.

During Phase II, the following must be accomplished:

- Determine the nature of classified data in terms of type, volume, age, quality, location, extent of mechanization and other characteristics.

- Determine procedures and costs for declassifying data of various types.

- Determine the sums of money which users are willing to pay for declassifying data of various types.

- From the above analyses recommend a policy for the declassification of data.

G. OWNERSHIP OF DATA CONSTRAINTS

Essentially all marine data collected can be grouped into two categories of ownership; public and private. While the desire for confidentiality of private data is generally obvious, as in the case of competitive oil industry data, publically owned data, perhaps surprisingly, is also often restricted from dissemination. The routine charting and public dissemination programs do not of course fall into this class. But there are many other examples in which data are gathered for a more specialized purpose and are prevented from flowing to others until publication of original results. By the same token, private industry would often release data if it could be assured of protection against infringement in the field of investigation for which the data were gathered.

The key to deriving multiple-use benefits from data originally collected for less-broad purposes, therefore, lies in the protection of the original owners rights. Thus, agreements between collectors and suppliers which provide for all uses except for those dear to the collector will become a valuable asset in the marine community. Examples of such cooperation were found between the Standard Oil Company of California and the Navy. The entire concept can doubtless be expanded to the benefit of the National Marine Data Program.

Additional and perhaps less-clear aspects of the data ownership problem include:

- If raw data is merged with other data and summarized, does the original data lose its identify and consequently does the collector lose his ownership rights to the data?

- If an organization collects data which is considered classified by the Federal Government, can it be legally classified? Will the collector lose his ownership rights if the data is classified?

The whole question of the ownership and use of the near-shore environment by the federal, and state governments and by private industry creates problems about the ownership of data collected in these disputed areas. Do ownership rights of the physical property apply to the data collected thereon? Or, is there a different set of criteria which apply to the collection and use of data?

Obviously, questions of this legal complexity cannot be resolved during Phase II. However, some tools, as mentioned previously for national marine planners and lawyers could be devised. For example, an aid to resolving questions of this type might be a computer-based system of statutes, traditional practices, international treaties and conventions, ruling of international bodies, concession, and lease and settlement practices. During Phase II, an assessment of the utility and cost of such a system will be made, and if its cost-effectiveness is proven, will be incorporated in the development of the National Marine Data Planning System.

V. EFFECTIVENESS OF DATA PROGRAMS

A. PURPOSE

The purpose of this section is to describe the approach which will be employed during Phase II to evaluate the effectiveness of data programs after these programs have been subjected to the constraints analysis described in Section IV. A data program is the specification of the requirements for collection, storage, processing, and dissemination arising from a functional activity of an organization in response to the requirements of national programs. For example, the ocean surveys undertaken by BCF in response to new federal initiatives in the Food from the Sea Program will generate requirements for physical, chemical and biological data. Given the constraints which would affect the collection, storage, processing and dissemination of data, how effective will the data program be? Future funding levels to support ocean surveys for the Food from the Sea Program could have great impact on the duration of surveys, the amount of data collected, types of data collected, data quality, and subsequent storage, processing and dissemination activities. International agreements affecting the geographic areas of data collection could also have an impact. The extent of international political turmoil will affect the effectiveness of data programs. For example, certain parts of the oceans may be inaccessible for data collection purposes due to military action. The lack of standardization in biological data collection is an example of a technical constraint which bears on the effectiveness of Food from the Sea data programs.

The evaluation of data program effectiveness does not mean that evaluations will be made of the efficiency of organization data collection programs. The questions of what data to collect, where to collect it, and how to collect it are matters to be left to the individual organizations; they are in the best position to assess their data needs. However, an evaluation should be made in Phase II of the effectiveness of these programs to the nation and the marine science community as a whole, for the purpose of identifying programs with large potential national benefits. This evaluation is one of the elements used in the determination of the relative importance and priority of data programs in the design plan for Phase II. It is also used as one of the inputs for determining the resources to allocate for enhancing the effectiveness of data programs. It is important as a tool for determining the schedule for the employment of resources. This part of the systems engineering process is indicated as step 8 of the study methodology, Figure 2 of Section I.

It is not sufficient to limit the evaluation of effectiveness to technical factors. Technical considerations become submerged in the much larger problems of inter-agency cooperation, availability of funds and legal constraints which affect the ability to implement data programs as originally conceived.

It is especially important to assess the potential effectiveness of data programs as determined by changing conditions in technical, economic, political and legal constraints. For example, what effect will the law of the seas have on the placement of buoys? This problem was described in the article "The Law and Data Buoys."[1] A national buoy program may result in protests being brought against the federal government by private fishing fleets or foreign nations if buoys were to be placed in established sea lanes. This is just one example of the factors which must be taken into consideration when assessing the potential effectiveness of data programs.

B. EFFECTIVENESS CRITERIA

The first step in the process of evaluating the effectiveness of data programs conducted by the various organizations is to establish a set of criteria. The criteria are tentatively classified by data collection and data center activities. These criteria provide the set of performance measures used to evaluate the effectiveness of the various organization data programs. A partial list of preliminary criteria for measuring the effectiveness of data programs follows:

1. Data Collection Activity

- Usefulness of data to purpose of collection.
- Usefulness of data to Marine Science community as a whole.
- Volume of data collected per unit of time.
- Quality of data collected (accuracy, range, precision).
- Rate of data obsolescence.
- Time between data collection and availability of data to marine science community.
- The portion of data collected which can be placed at the disposal of the interested segments of the marine science community.
- The efficiency with which data can be routed from collection to data center and from data center to users.
- The need for security classification or data privacy.
- The extent of data compatibility among producer, processor and user organizations.
- The degree to which the data program can respond to changes in technology -- e.g., satellite data collection and changes in data requirements -- e.g., synoptic data reporting.

1. Clergan, Thos. A., Jr., Stand, David P., "The Law and Data Buoys." UnderSea Technology, September 1967, pp. 11-40

2. __Data Center Activity__

- Extent of duplication with other data centers of data bases and services provided.
- Size of collections in data center.
- Quality of data center collections.
- Nature of requests and the percentage of requests which can be answered to the satisfaction of the requestor.
- Response time for answering requests.
- Capability for absorbing increases in data collection volume and data analysis requirements due to synoptic, buoy, satellite and aircraft collection programs.
- Capability for adequately servicing an increasing number of requests.
- Capability for rapidly disseminating data to the user.
- Capability for making data readily accessible to the user community.
- Capability for providing research analysis on the data.
- Capability for reducing existing backlogs.
- Capability for providing space-time correlation of data.
- The extent of data purging required because of excessive data volumes.
- Capability for data purging and providing various levels of storage and response times compatible with user needs.

The criteria listed above are primarily determinants of physical effectiveness. The benefits to be derived from the data programs, e.g., the need to reduce water pollution for health and recreation reasons are described in qualitative terms. Benefits analysis will be discussed as part of the cost/benefits/effectiveness analysis in Section VI. The purpose of evaluating data programs against such sets of performance criteria is to establish the relative importance of the various data programs.

C. POTENTIAL EFFECTIVENESS VS. CURRENT EFFECTIVENESS

Data programs are not static: they evolve over time with development in platforms, instrumentation, communications and data processing. Data programs are also subject to changes in emphasis on collection requirements as evidenced by increasing demand for synoptic reporting systems. Therefore, an important element in effectiveness analysis is the determination of the impact on data programs of developments in technology and collection requirements. Data program effectiveness should be evaluated for at least five years in the future in order to properly gear improvements in data management to both near term and long range data program requirements. Future data management systems must have the capability of responding to potentially large increases in data traffic responding to potentially large increases in data traffic and the need for real-time reporting of ocean state and weather conditions. The history of developments in data collection and data processing suggests that improvements in technology never lead to a decrease in the volume of data collected and processed. Rather, there is an increase in data collection due to expansion of research activities made possible by new techniques of data gathering.

By way of illustrating the potential impact of evolving technology, the Travelers' Buoy Study[1] states that the measurement of 40 parameters is feasible by buoys within the next five years. The study also indicated that the data collection requirements of 40 organizations could be completely satisfied and 38 could be partially satisfied by buoys within the next five years.

Buoy technology appears to be developing at a rate commensurate with the expectations of the Buoy Study. For example, The National Environmental Satellite Center of ESSA has a buoy program under development for the collection and transmission to ground stations via satellite link of wind speed, wind direction, compass reference, air temperature, sea surface temperature, pressure, sea state, anchor line tension and battery voltage. The Navy Acre buoy program for the ASWEPS project is designed to test the feasibility of buoy collection and HF transmission to shore of the vertical distribution of temperature, salinity and current speed and direction.[2]

If a national buoy program along the lines indicated in the Buoy Study were implemented or if prototype developments such as that of ESSA and the ASWEPS program reach full scale implementation, a flood of new data would be imposed on data centers which already have large backlogs. Additionally, if large-scale buoy programs are implemented there will not necessarily be a corresponding decrease in the use of ships in the near term. Several years will elapse, while buoy systems are proven, before there would be a discernible decrease in the use of ships.

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1. National Requirements for Marine Meteorological and Oceanographic Data, TRC Report 7485-253, April 1967. (DN 83)

2. Booda, Larry L. "Major Buoy Programs." UnderSea Technology, September 1967, p 24.

These developments highlight the need for a National Marine Data Planning System to be specified during Phase II for the purpose of anticipating significant changes in data requirements and to alert the marine science community to these changes. Such a system will allow the individual organizations to be highly responsive to changes in collection, storage, processing and dissemination requirements. Details of the proposed system are described in Section VI. Data program effectiveness should be evaluated on an incremental basis. In order to provide for orderly growth of data management systems, it is necessary to evaluate each increment of additional capability on the basis of its effectiveness and cost relative to competing data program requirements. It is important to determine what additional capability is needed in order to provide a data program with the capability required to respond adequately to the demands of national programs.

Levels of increased effectiveness are related to points in time when implementation of the series of data management system modules will occur. A set of building blocks of increases in capability will be delineated for implementation on a schedule which is in accordance with the priority of need for meeting national program objectives and the time required for implementation.

An example of the evaluation of incremental effectiveness is the determination of the increments in systems, personnel, hardware and software capabilities which would be required in order to accommodate the influx of data at data centers from programs involving buoy data collection. In this case a determination would be made of the requirements for personnel, systems design, programming, and computer hardware and software which would be required to augment data center data base development and increased processing activity.

The extent of additional capability required in each data program will be determined by comparing present data program effectiveness with the desired level of effectiveness. The desired level of effectiveness is determined by the needs for data independent of what data bases are in existence. That is, one must not fall into the trap of evaluating the need for data based on requests for data in existing collections.

The demand for data cannot be entirely measured by the frequency of requests for data in existing collections, since users who are acquainted with data center collections will not request non-existent data, or existing data of indadequate quality. It is necessary to assess the need for data in terms of data desired rather than data availabilities. The best method for making this assessment is by interviewing important data users with large operations and/or substantial marine community influence. Also, the data management plans of such organizations will provide considerable useful information. This process was started during Phase I and will be continued on an expanded scale during Phase II.

Another illustration of the necessity of evaluating potential effectiveness is the question of the benefits to be derived from the declassification of certain data collected by the Navy.

Appendix E identifies types of Navy-collected classified data which could provide benefits to other organizations if it were declassified. What increase in effectiveness would result in the Coast and Geodetic Survey mapping and charting program if classified bathymetric data collected by the Navy were declassified? Or, if bottom samples were declassified, what impact would there be on the natural resource programs of the Department of Interior? Also, the cost of declassifying data must be considered in relation to its potential usefulness to the marine community.

D. RELEVANCE TO PHASE II

1. Phase II Study Approach

Although the delineation of data flows, data volumes, data processing, etc., are facets of data requirements analysis described in Section III, the determination of how well these requirements are satisfied is the province of data program effectiveness, e.g., volumes of data collected per unit of time of a specified quality.

The Phase II activities required for evaluating data program effectiveness are described in this section. They are followed by a description of the analytical approach to be used in Phase II for making the evaluations.

Several marine data programs which bear on the effectiveness analysis are listed below:

- Buoy programs. (Travelers' Study, ESSA World Weather Watch Buoy Program, Monster Buoy Program)
- Satellite data collection (Joint NAVOCEANO-NASA Activities)
- Aircraft data collection (NASA Studies)
- Shipboard use of digital computers (Oceanographic Data Center Developments)
- Aperture card recording of BT data (Canadian Oceanographic Data Center Developments)
- Effect on data programs if declassification of certain data occurs (Navy-collected BT's and Bottom Samples)

- Effect on data programs of improving existing collections (biological collection at NODC) and providing currently non-existent data collections (ocean engineering data)
- Effect on data requirements of current and future ocean survey programs (SEAMAP, EASTROPAC)
- Synoptic data collection (real-time weather prediction, Fleet Numerical Weather Facility)
- Space-time correlations (World Weather Watch)
- Present day operations of existing data centers
- Future plans of existing data centers

The analysis of intra- and inter-organizational data flow is an important facet of data program effectiveness evaluation. The analysis of data flow which is described below will be performed during Phase II for the specific short-term purpose of identifying in quantitative terms the impact of the important developments summarized above. In particular, the effectiveness analysis will focus on the capability of the marine science community to absorb not only the significant increases in data volume to be generated by the above programs but also the capability to respond adequately to other emerging data programs which differ significantly from past requirements. The data program needs which are evolving will require the data facilities to provide space-time correlation of vast quantities of oceanographic and meteorological data. Some of this data will be required on a real-time basis. This development imposes requirements on data center capabilities much more severe than the static retrieval of historical data.

It is necessary to identify the type, volume, time schedule and frequency of data generation of major collection activities and the requirements for storage, processing and dissemination. A <u>forecasting capability</u> will be one of the modules of the National Marine Data Planning System.

In order to produce tangible results for the agencies in Phase II, an analysis will be made of the data management resources of several key agencies. However, analysis will also be performed of the needs and capabilities of organizations with data management requirements at the federal, state, institutional and industrial levels.

The activities of developing forecasts with a National Marine Data Planning System and evaluating the needs and resources of data management in the pertinent organizations will result in a delineation of the personnel, hardware (computer and instrumentation), software, and communications requirements which will be necessary to adequately respond to data program requirements.

Data program effectiveness analysis will result in the following outputs:

a. Effectiveness evaluation of data programs resulting from a comparison of data requirements with performance criteria.

b. Funding, manpower, hardware, software and communication requirements to implement data management improvements.

c. Schedule for implementing data management improvements in the organizations involved.

Once the various data management improvements have been defined, the final part of the analysis prior to making a decision about implementation will be to perform a cost/benefit/effectiveness analysis of the various data management alternatives (Section VI).

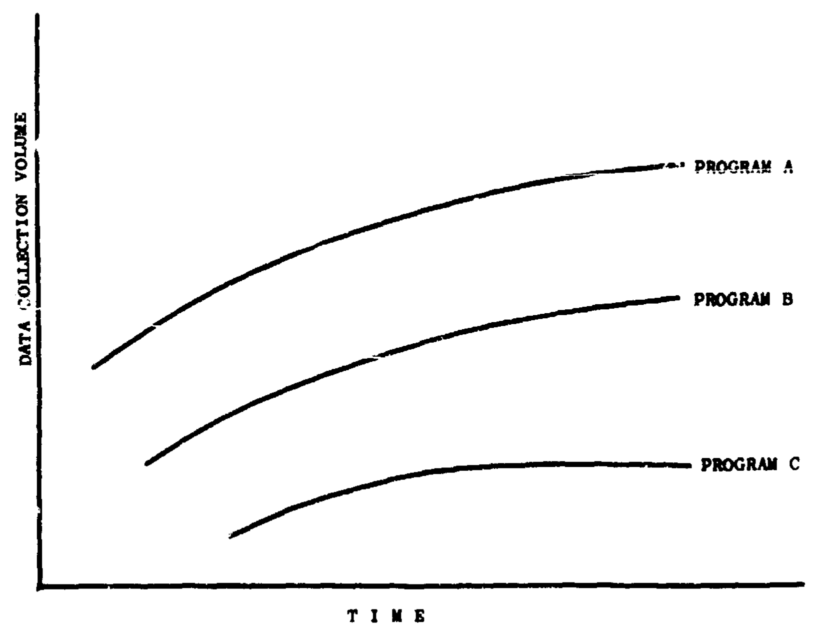
The cost/benefit/effectiveness analysis is performed in order to evaluate the utility of the various data management programs relative to one another and to select a set of improvements within the relevant organizations which provide the greatest benefit to the nation, given the total funds and time available for marine science data programs. The cost/benefit/effectivenss evaluation is discussed briefly in Section VI.

2. Analytical Approach

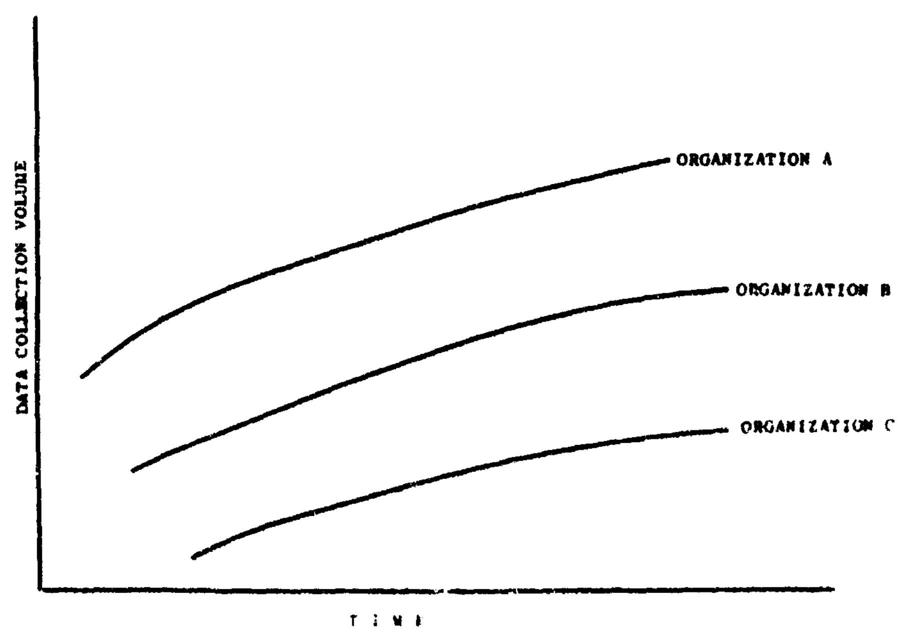
Several analytical tools for data program effectiveness analysis will be utilized during Phase II. One of these tools is shown in Figures 23 and 24, Section III-C.3. These plots illustrate one aid in Phase II for analyzing data requirements. Data collection volumes as a function of time are plotted for NAVOCEANO.

a. Data Collection Effectiveness Analysis: Figure 23 shows in situ measurements for the Navy from 1949 to 1974. Figure 24 covers the same period for Navy underway measurements. Figure 34 is an example of a format to be used in Phase II for plotting forecasts of the volume of data to be collected by national programs (defense, fisheries, etc.), organization (NAVOCEANO, BCF, etc.), function (surveys, research, etc.),

PROGRAMS (DEFENSE, FISHERIES)

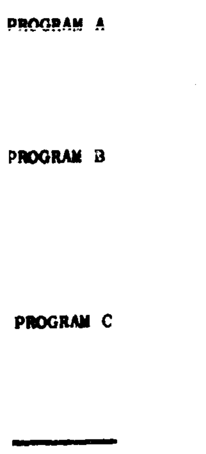


ORGANIZATIONS (NAVOCEANO, BUREAU OF COMMERCIAL FISHERIES)

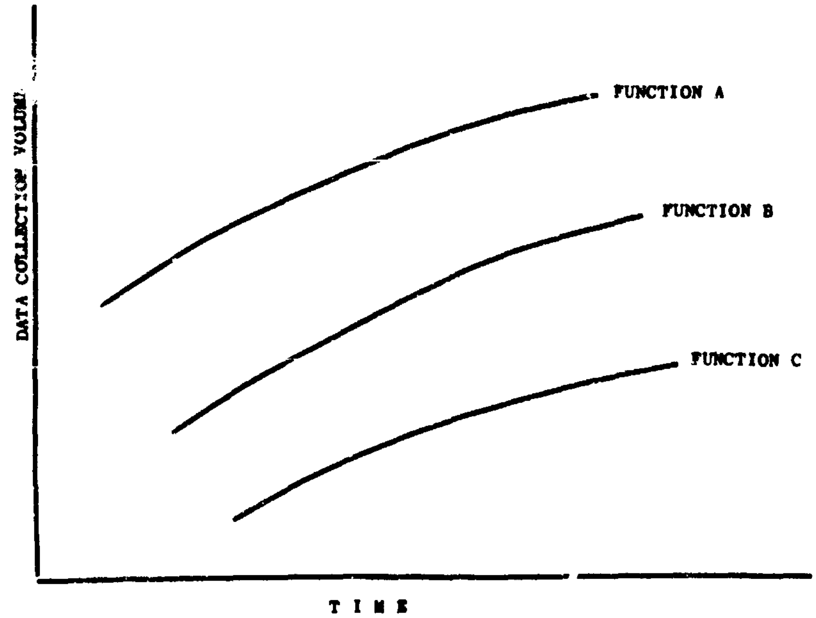


SCHEMATIC REPRESENTATIONS OF DATA VOLUME GRO
BY PROGRAMS, FUNCTIONS, ORGANIZATIONS A

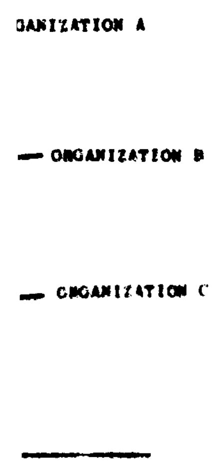
FIGURE 34



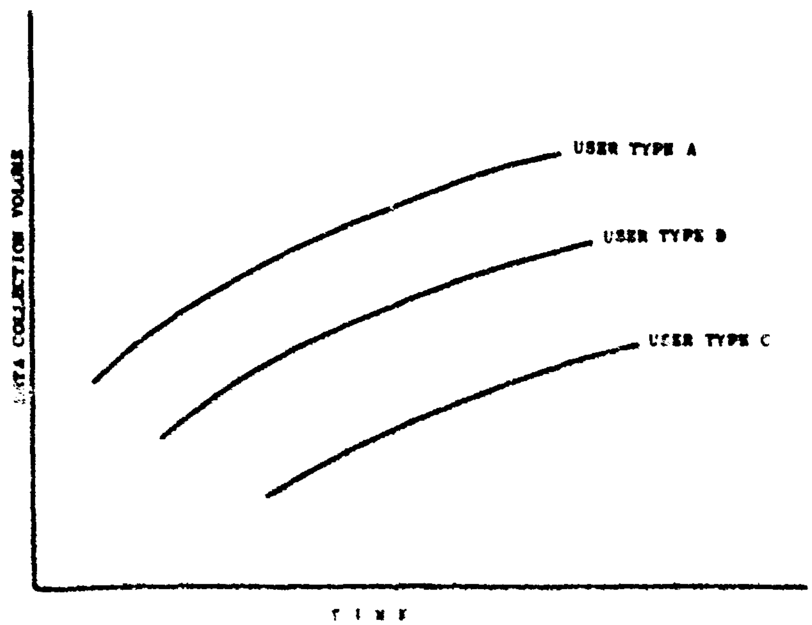
FUNCTION (SURVEYS, RESEARCH)



HERIES)



TYPE OF USER (OPERATOR, MANAGER)



ESENTATIONS OF DATA VOLUME GROWTH PATTERNS
MS, FUNCTIONS, ORGANIZATIONS AND USERS

FIGURE 34

B

and type of user (operator, manager, etc.).[1] The purpose of the forecast is to anticipate future data requirements, in terms of type and volume of data, by program, organization and function. These forecasts will permit the agencies to plan appropriate responses to data collection programs. For example, it will be necessary to forecast the impact of the ONR/Convair Monster Buoy Program on data collection, storage processing and dissemination requirements in the Marine community. The purpose of the Monster Buoy Program is the collection of synoptic data over broad geographic areas for long periods of time.[2] The emphasis in the program is on the development of buoy technology rather than on the use of buoy-collected data for research purposes. The system is being developed so that any number of buoys or command stations eventually can operate simultaneously anywhere in the world, even on identical radio frequencies -- with a central data acquisition facility controlling an entire ocean or hemisphere. If this program achieves its objectives, there could be a dramatic impact on the use of buoys by other agencies.

b. Data Center Effectiveness Analysis: How well will data centers, for example, be able to respond to the influx of data generated by buoys, if the feasibility of buoy-to-shore communication and buoy survivability is demonstrated and results in other agencies employing buoys on a large scale? The evidence suggests that they will not be able to respond well in view of existing backlogs, limited funds and the need to increase the effectiveness of existing data collections, let alone be prepared to respond to additional floods of data resulting from other technological developments.

Using NODC as an example, an examination of Figure 21 reveals that there are several existing data collections which require increased emphasis on processing activity in order to be in balance with national program requirements as measured by data collection activity. The need at NODC to augment its biological data base activity to serve the needs of national

1. Figures 23 and 24 are only illustrative of one format for information during Phase II. Obviously, the volatile nature of the marine sciences requires a more thorough coverage and continued updating of predictions of future data characteristics and volumes. Other methods are discussed periodically in this report.

2. Geo Marine Technology, Vol. 2, Number 4, April 1966, p. 11.

security, oceanographic research, fisheries development, transportation, pollution, deep ocean technology, health and estuary studies is an example of the need for increased activity on existing collection.

More important, however, is the need to develop collections which are required for national programs but are not now available in the data centers. Examples of virtually non-existent data collections are:

1) Subsurface currents
2) Time series data
   - Shore stations
   - Weatherships
   - Offshore light stations
   - Towers and offshore platforms
3) Buoy Data
4) Ocean Engineering Data
   - Offshore

     Engineering properties of sea floor (sediment strength, bottom type, etc.)

     Corrosion, open ocean fouling rates

     Engineering data on buoys
   - Nearshore and Coastal Engineering Data Base

     Geological - Beach types, erosion, beach profiles

     Biological fouling

     Chemical
5) Fisheries Data Base
   - Sightings (fish and bird flocks)

     For example: ASWEPS has need for a fish school and mammal sightings data base in order to infer in any region that some of the "false sonar targets" might be biological. For example: in an area through which whales migrate during various seasons of the year.
   - Catch/effort - various fisheries
   - Distribution of fish, eggs and larvae
   - Catch data - various fisheries

c. <u>Data Collection Volumes Effectiveness Analysis</u>: It is also necessary to forecast the effect on data program effectiveness of data collection volumes which will be generated by ship cruises. Examples of data volume plots as a function of time for past cruises are shown in Figures 25 and 26 of Section III-C3. One of the ways in which ship data collection requirements can be estimated is from scheduled cruise information and estimates of data collection rates calculated from previous cruises. Figure 20 of Section III-C2 shows sample calculations of the average rate of data collection for specified parameters for cruises of NAVOCEANO, SCRIPPS, BCF, the University of Washington, and CCOFI. The purpose of this exhibit is to indicate a possible method for estimating the amount of data to be collected for specified organizations and parameters. The average daily collection rates multiplied by the number of scheduled cruise days would provide a gross estimate of the amount of data which will actually be collected on new cruises. The average collection rates shown in Figure 20 have been calculated from the following sample sizes:

Organization	Years of Data
BCF (Hawaii)	9
Scripps	16
University of Washington	8
NAVOCEANO	18
CCOFI	17
Coast Guard	1

Sample sizes will be expanded during Phase II. Confidence limits will also be computed for mean collection rates in order to place upper and lower bounds on the estimates of data collection.

Because of differences in the collection characteristics of organizations and types of survey (research as compared to the Navy, for example), the average collection rates for parameters must be separately computed for each organization. Scheduled cruise characteristics should correspond to the characteristics of the cruises used to calculate average collection rates in order to obtain accurate estimates of future data collection volume.

d. <u>Data Flow Effectiveness Analysis</u>: Once data collection activities have been defined and forecasted in terms of the total collection requirements as a function of time, it is necessary to develop flow charts for evaluating the effectiveness of data flow. These charts show specific functions and organizations involved in collection, storage, processing and dissemination which would result, for example, from ocean surveys mounted in response to national program requirements. An example of this type of flow chart is illustrated in Figure 18 of Section III-C1. This figure shows the flow of data and interactions among Scripps, CCOFI, BCF (Hawaii) and the University of Washington in the collection and processing of data for these programs. The figure also indicates flow of collected data to NODC. This exhibit serves to illustrate the long time delays between data collection and the receipt of data at national centers. The use of this type of chart in Phase II would serve not only as an effectiveness evaluating aid but also focus attention on the need to make collected data available at national centers earlier in the data program than has been possible in the past. An important measure of effectiveness is the efficiency of data flow within organizations and between organizations. There are two major aspects of this analysis: one is concerned with inter-organization data traffic, and the other is concerned with intra-organization data traffic.

1) <u>Inter-Organization Flow Analysis</u>. In inter-organization flow analysis, it is necessary to identify the type, volume, frequency and criticalness of data flowing between organizations. An aid in accomplishing this function was illustrated in Figure 15, Section III-C.1 which shows the preliminary results of the Phase I effort to identify types of data flowing between major marine science organizations in the United States. A summary column at the right of the chart indicates the major outputs of each organization and the row at the bottom broadly summarizes the major inputs to each organization. Detailed versions of input-output charts of this type help to:

- Identify the importance of a given organization as a data provider to other organizations.
- Identify the importance of an organization as a receiver of data from other organizations.
- Identify the amount of overlap which exists in the providing of data.
- Identify likely interagency flows of data as new collection, processing and dissemination requirements evolve.

- Identify the diversity of data requirements.
- Identify data of critical importance.
- Identify areas where data deficiencies exist.

During Phase II this chart will be augmented to include information on data volumes.

2) Intra-Organization Flow Analysis: Intra-organization data analysis is concerned with describing and identifying the internal data requirements of organizations. However, it also describes requirements at the input-output interface. Tools for performing this analysis are shown in Figure 28 for ESSA and in Figure 29 for NODC, Section III-C.3. These exhibits show inputs for an organization: data stored and processed and data outputs. Information display tools of this type help to describe:

- The variety and magnitude of data inflows.
- The variety and magnitude of data outflows.
- The variety and magnitude of data stored and processed.
- The current data handling capability based on variety and magnitude of inflows/outflows, storage and processing.
- The potential data handling capability based on rate of data inflows and outflows in relation to existing data backlogs.

In Phase II, similar charts will be constructed for other organizations and will be used as one means of identifying additional data management capabilities which may be required by individual organizations in order to provide an adequate response to existing and evolving data program requirements. If these charts were constructed for many organizations they would provide an indication of an organization's capability to absorb and process data generated by a national buoy program and still maintain an on-going activity of data processing for data collected by ship.

VI. COST/BENEFIT/EFFECTIVENESS ANALYSIS OF DATA PROGRAMS

A. APPROACH

The purpose of this section is to discuss briefly an approach for the cost/benefit/effectiveness analysis of data programs. Cost/benefit/effectiveness analysis (C/B/E) of data programs is not concerned with evaluating the need for data programs. The determination of need is derived from the functions (ocean surveys) which organizations (BCF) perform in response to National Marine Science Programs (Food from the Sea). The need for data and the sums expended on data collection and processing are governed by the requirements of national programs and associated agency functions.

In carrying out national program objectives, organizations employ data management systems with varying levels of capability and states of mechanization. In order to respond adequately to national goals, additional increments of data management capability are needed as data requirements increase with expansion in marine science activities. Whereas, a data program is the specification of data requirements, a data management system is the mechanism for satisfying data requirements. It consists of personnel, procedures, hardware and software sub-systems necessary to collect, store, process and disseminate data.

The C/B/E analysis described in this section will be employed during Phase II to determine which set of data management improvements should be made in consideration of the following factors.

1. The benefits to be derived from a national marine science program which the data management system supports. Measures of benefits are more qualitative than quantitative, e.g., reduce water pollution for health and recreation purposes.

2. The increase in effectiveness of the data management system, e.g., the reduction in response time for meeting user requests for data. Measures of effectiveness can usually be quantified.

3. The increase in cost resulting from an increase in data management effectiveness, e.g., increased personnel, systems development and hardware costs.

4. Availability of resources for data management improvements.

5. Implementation schedule requirements.

During Phase II an analysis will be made of the existing data management capabilities of pertinent organizations. This analysis will include a determination of the personnel, data systems, hardware and software resources currently employed in marine science data management functions. These data management capabilities will be related to data program requirements. Data program requirements will be forecasted for several areas which exert a major impact on data collection and processing volumes.

An example of this approach is the identification of the need for coastal and engineering data. Unsatisfied demand for data can be identified by employing matrices of the type shown in Figure 21, Section III, C. 2. This exhibit indicates some data demands which are currently satisfied by collections in NODC and some demands which are unsatisfied due to the lack or insufficient development of the collection. In Phase II, data demands in terms of parameter type, volumes, quality and time when data required, will be identified for the potential data users: Navy, ESSA, Coast Guard, Federal Water Pollution Control Administration, Corps of Engineers and USGS. The total data demand would be forecasted for several years in advance. Once this forecast is available, an evaluation will be made of the capabilities of data centers to provide this data. Using NODC as an example, an analysis would be made of resources required to implement and operate a coastal and estuarine data base. Required increments in personnel and hardware will be identified. Effectiveness will be measured using the set of criteria for data center activities described in Section V. Some of these are: data completeness, selectivity of retrieval, user response time and data quality. Examples of benefits are the data made available to the Federal Water Pollution Control Administration, AEC and the Corps of Engineers (Great Lakes) for water pollution abatement. The availability of these data would also benefit the Engineers in shore stabilization projects. Concurrent with this assessment, other data demands and additional capabilities for servicing the demands will be identified. For example, the demand for Navy collected environmental prediction data, as identified by Figure 22, Section III, C. 2, will be forecasted. Some beneficiaries of this data would be BCF (fish migration studies), Coast Guard (weather reports), and the Federal Water Pollution Control Administration (water pollution).

The two examples presented above are representative of two major sets of activities which will occur in Phase II. One set is called the National Marine Data Planning System and is described at the end of this section. This is the set of activities concerned with identifying and forecasting the data needs for national programs which will require the application of significant amounts of resources in the agencies.

Another major set of activities is the concurrent determination within the affected agencies of the additional resources required in order to satisfy the data requirements of national programs. There will be constant interaction between the two efforts. As data program requirements are identified in the National Marine Data Planning System they will be made available to the groups working at the agency level. This information will be used by the agency groups for matching data demands with capabilities for satisfying these demands. Increments of data management resources and costs will be identified for satisfying data demands. There would also be communication in the other direction in the form of updated data management plans and the status of resources in the agencies for responding to national program requirements.

This dual procedure will be accomplished for each of the major data programs--examples are indicated on the Work Plan--and for each of the agencies indicated on the Work Plan. At the conclusion of this process, there will be a specification of the resource requirements, for each of the relevant organizations, necessary to support national program data needs. These specifications will include the following requirements for each organization:

- Personnel
- System design
- Hardware (instrumentation, computers, communications equipment)
- Software
- Costs
- Implementation schedule

Finally, the above specifications of requirements for each organization need to be evaluated relative to one another and in relation to available funds for data management improvement. Cost/benefit/effectiveness analysis will be used to provide a priority ordering of the various data management improvements. The data management improvements and their recommended priorities will be submitted as recommendations to the Federal Government for implementation. Once approval is obtained for a specific set of data management improvements, the requirements for implementing these improvements will be documented as one of the end-products of Phase II.

B. MARINE DATA PLANNING SYSTEM

In order to provide an aid for the planning and monitoring of national marine data programs, the development of a National Marine Data Planning System (NMDPS) is proposed for Phase II. The purpose of this system is to assist in providing:

- Better allocation of national resources to data handling problems.
- Capabilities for evaluating the effectiveness of data programs in relation to their costs.
- Capabilities for fiscal planning of national marine programs.
- Early identification of data requirements on a national basis and the highlighting of potential bottlenecks in data flow.
- Early identification of technological developments in sensors, platforms, communications and information processing.
- Legal data retrieval capability which will provide assistance in resolving legal constraints.
- Early identification of significant changes in data types, volumes and flow paths resulting from expanded or contracted national marine program efforts.
- Identification of data collection storage and processing overlaps.
- Better distribution of processing and dissemination workloads among data centers.
- More efficient routing of data from collection points of data centers and from data centers to users.
- A reduction in the delay between data collection and data availability to the marine community.
- Identification of emerging data collection programs for interested data users.
- Education and public information programs about the marine sciences.
- Monitoring of implemented data programs for comparing results with objectives.

This system will consist of the following subsystems:

Subsystem	Function
• Policy	National planning and allocation of resources.
• Program	Data requirements and cost/benefits/effectiveness analysis and data program monitoring.
• Fiscal	Budget planning and financial analysis.
• Technical Information	Technological and scientific information.
• Education and Public Relations	Distribution of information about marine science programs to the marine community and general public.
• Legal	Retrieval and analysis of legal information which has an effect on national marine policy and the implementation of data programs.

In addition, several modules which provide data requirements input to the above subystems are necessary. These are:

Module	Function
• Data Collection	Identification and forecasting of data collection requirements.
• Data Storage and Processing	Identification and forecasting of data storage and processing requirements.
• Data Dissemination	Identification and forecasting of data dissemination requirements.

The development of the NMDPS system would be in consonance with the need to plan and evaluate data requirements on a <u>program</u> basis. This need is important due to the large number of joint agency data collection efforts and the new emphasis in the Federal Government for budgeting on a program basis. This trend is exemplified by the current use of the Program Planning and Budgeting System. There is a need at the national level to make available to the pertinent organizations information which will assist them in planning and implementing data programs. Situations which will severely stress existing data management capabilities require early identification in order that affected organizations may plan appropriate responses to changing conditions. An example of this need is the potential requirement for data centers to process large volumes of satellite collected data. Existing and potential duplicative data collection and processing efforts need also to be identified with a view to possible reduction of these overlaps. An example is the common requirement for fish-catch information by BCF and California Fish and Game. The Fleet Numerical Weather Facility and ASWEPS also have common environmental prediction data requirements.

A major element of the National Marine Data Planning System is the forecasting of data collection, storage, processing and dissemination requirements in the marine sciences. It is necessary to forecast data program requirements over a 5-10 ye . period, where a data program is defined to be the total requirements for data collection, storage, processing and dissemination for national marine science programs. The following are some of the data requirements which will result from the implementation of the NMDPS:

- Data types to be collected.
- Organizations involved in collection, processing and use.
- Geographic location of data collection, storage, processing and use.
- The need for platforms: ship, buoy, satellite, aircraft, etc.
- The effect of evolving instrumentation systems on collection, storage, processing and dissemination.
- Requirements for various data forms: analog, digital, specimens, photo, etc.
- Requirements for security classification.
- Requirements for data privacy.
- Data flow paths from collection points to data centers and from data centers to users.
- The need for synoptic and time series data.

VII. DATA SYSTEM REQUIREMENTS

Data system requirements are the personnel, sensors, data transmission equipment, computer hardware and software subsystems which are required to implement data program requirements. One of the end-products of Phase II is the definition of the requirements for the above subsystems for each of the organizations to be analyzed.

In addition, a schedule will be developed for implementing data system improvements.

A. DATA TRAFFIC MANAGEMENT

The fundamental data system requirement is to provide better management of data traffic within the marine community. Data traffic management is concerned with the following factors:

1. <u>Data Collection</u>

   - Data type, media, format, and volumes at collection points.
   - Frequency of data collection.
   - Frequency of data transmission to processing points.
   - Routing of data from collection points to processing points.
   - Mode of data transmission to processing point.
   - Size of data batches transmitted to processing points.

2. <u>Data Storage and Processing</u>

   - Size, format, media, and levels of storage at processing points.
   - Processing point workload.
   - Volume of data input.
   - Frequency of data input batches.
   - Size of data input batches.
   - Routing of data between processing points.

3. Data Dissemination

- Data type, media format and volumes distributed from processing points.

- Frequency of data transmission.

- Size of data batches transmitted.

- Routing of data from processing points to users.

B. DATA NETWORK

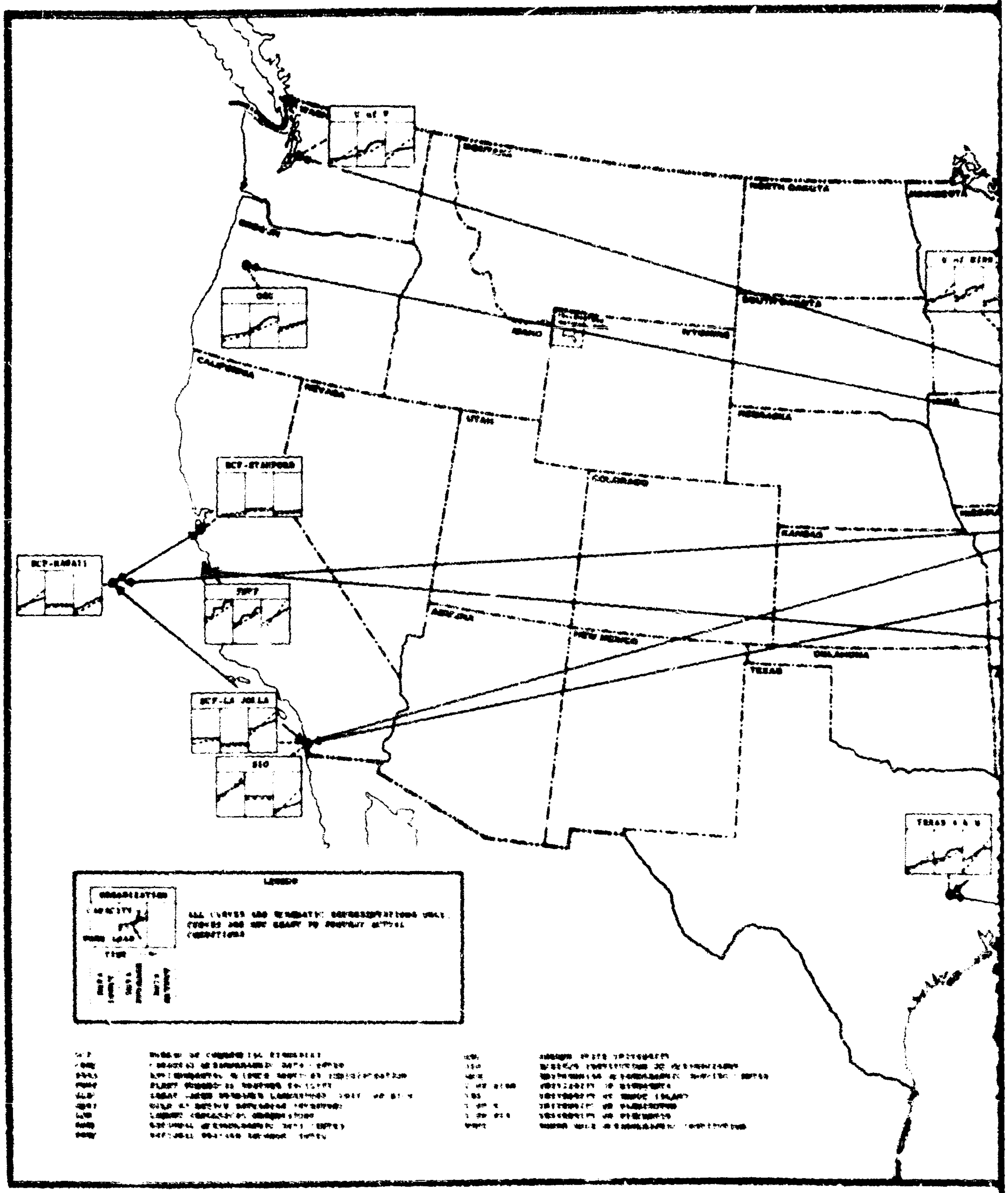
A conceptual aid to analyzing data traffic is to view the national marine data system as a network. The network consists of collection points, processing points, using points and the data transmission paths which connect these points.

The forcing function of this network is data collection. Rates of data flow in the network are governed by data collection rates and impedances to data flow which exist.

One of the largest impedances is the retention by collectors of data for long periods of time before submission to data centers. In addition to large impedances, there are extreme impedance mismatches. An example is the low resistance path of data flow at points of data collection, where continuous recording devices are employed, and the high resistance which exists where there is inadequate data processing facilities to rapidly and efficiently store, process and disseminate data to the user.

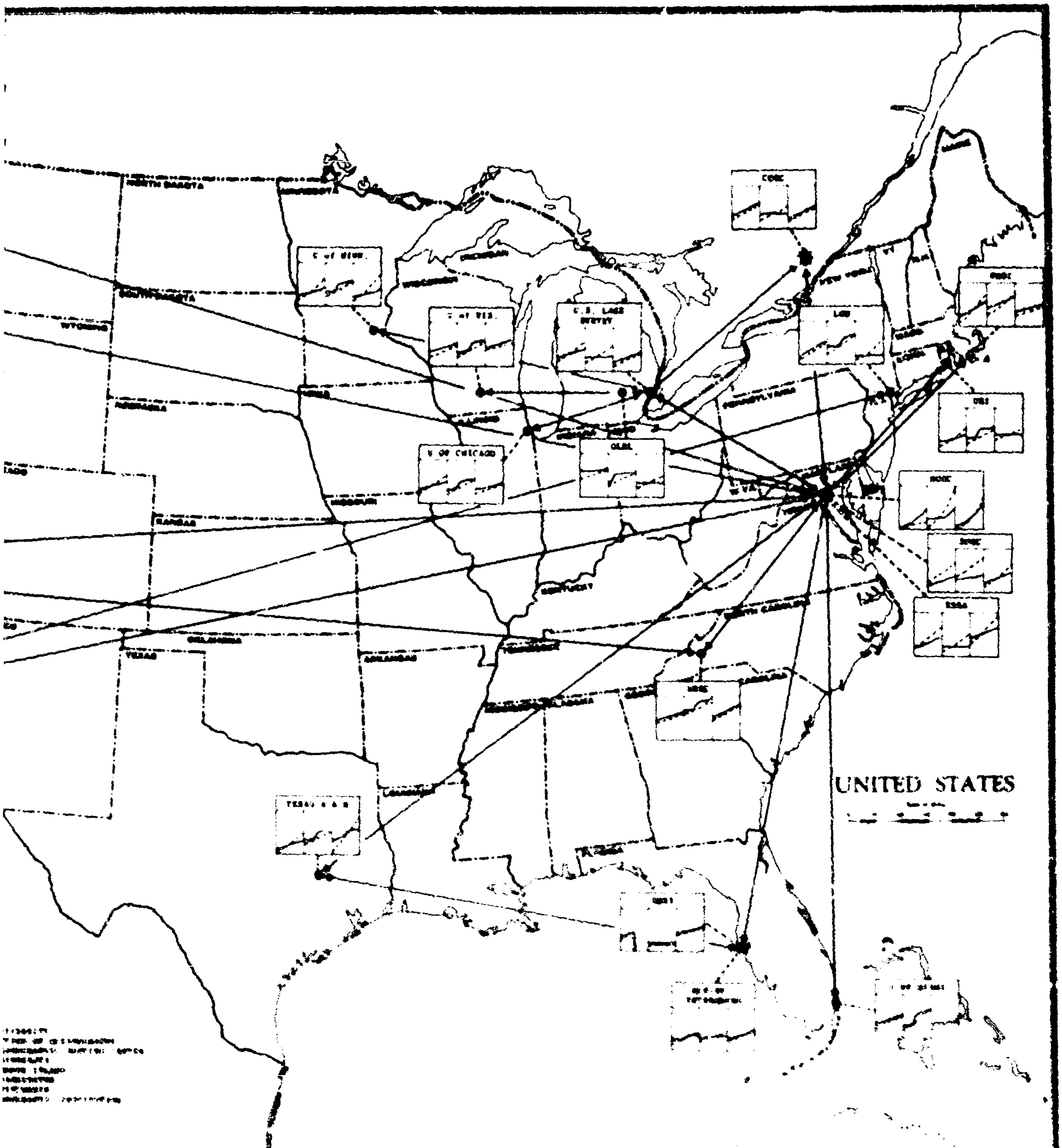
In order to reduce information transfer losses in the data network, it is important to match impedances as closely as possible. Impedance mismatches will be identified in the data network during Phase II.

When the workload of a data facility, such as a data center, exceeds facility capacity, the impedance to data flow in excess of capacity becomes infinite. In this situation, other means must be found to process the excess data, such as manual processing, or additional capacity must be acquired. An objective of Phase II is to provide early identification of these potentially critical points in the data network. One means of accomplishing this end is to analyze the time-varying workload requirements of data facilities and determine resource requirements as a function of time needed in order to prevent system overloads and to prevent underutilization of data facilities. Figure 35 is a schematic of a marine data network. This exhibit schematically portrays data transmission paths which exist among



SCHEMATIC REPRESENTATION OF MA

FIGURE 35



PRESENTATION OF MARINE DATA NETWORK

FIGURE 35

B

data facilities. The exhibit also provides a schematic representation of actual workload versus facility capacity. The figure does not contain actual data. Rather, the exhibit is presented to indicate a Phase II approach for identifying and analyzing workload imbalances. By providing an "early warning system" of impending system overloads, the required resources can be programmed in advance to provide additional capacity when needed. The capability for alerting the marine community to the need for additional resources and the redistribution of resources will be one of the major benefits of the National Marine Data Planning System.

VIII. PLANS, PRIOR STUDIES AND LITERATURE

Much of the information drawn from plans, prior studies and literature, has been discussed in previous sections of this report. This section serves to draw together and categorize the principle conclusions and recommendations of these documents.

A. APPROACH

During Phase I, plans were obtained from 39 federal organizations either documented or by interviews with various members of the marine science community, see Table A-1, Appendix A. A composite of 17 of the more complete plans was analyzed in order to derive conclusions relevant to Phase II. Accordingly, some of the conclusions drawn may be somewhat more general than individual plans support.

The procedure employed in reviewing the plans was as follows: Major topics thought integral to the implementation of each plan were extracted, cast into major subject groups and collated on forms as illustrated in Table 9. The major subject groups derived from plans and literature are listed below:

A. PHYSICAL OCEANOGRAPHY
B. BIOLOGICAL OCEANOGRAPHY
C. CHEMICAL OCEANOGRAPHY
D. METEOROLOGY
E. GEOLOGY
F. GEOPHYSICS
G. SURVEYS
H. FOOD AND FISHERIES
I. MINERALS AND DRUGS
J. WATER RESOURCES
K. RECREATION
L. POLLUTION
M. RADIOACTIVITY
N. ENGINEERING
O. DATA MANAGEMENT
P. PLATFORMS
Q. SENSORS, INSTRUMENT SYSTEMS
R. FACILITIES
S. LEGAL, MANAGEMENT
T. ORGANIZATION
U. EDUCATION, TRAINING
V. INTERNATIONAL
W. MISCELLANEOUS

A similar processing was applied to 27 of the more significant prior studies and relevant literature. Many more relevant documents were studied during Phase I, but time did not permit the summation of their contents into tabular form. Complete sets of the review collation forms covering plans, prior studies and the literature are contained in Appendices A and B. Sample literature and plan review forms and procedures are included in Appendix C.

The individual topics listed under the major subject groups were then evaluated as to their effect on data collection activities, processing functions and data use. Both their effect on present procedures and on the systems of the future were considered. Following this evaluation process, which generated the relative

TABLE 9

COLLATION OF PLANS FOR THE
NATIONAL MARINE DATA PROGRAM

A. PHYSICAL OCEANOGRAPHY

DOCUMENT TITLE

RECOMMENDATION OR CONCLUSION / Accession* No.	Draft of a General Scientific Framework for World Ocean Study	Plan for a National Marine Weather Service	National Oceanographic Program Fiscal Year 1967	Utilization of Industry's Capabil... for an Integrated Data Manage...	A Plan for the Accelerat... of Marine Natural Res...	Proposed U.S. Co... Plan for 1966	Briefing... Coast...	
	56	374	90	310	344	27	226	22
1. Survey current delineation						2		
2. Study subsurface currents								
3. Survey water mass flow							X	
4. Prediction of temperature in the ocean								
5. Study heat flow at air-sea interface	32							
6. Identify thermal fronts								
7. Study internal waves	33					35		
8. Study deep ocean surface waves	12,26							
9. Develop surface wave prediction capability		67						
10. Study waves, near shore	28,58 59							
11. Study wind-driven wave generation	12	67						
12. Study tides	34							
13. Improve tide prediction capability	27							
14. Improve tidal current prediction	27							
15. Obtain experimental verification of theoretical ocean circulation								
16. Obtain more Arctic bathymetry								
17. Obtain more Arctic ice information						21		
18. Study diffusion processes near deep bottom								
19. Study diffusion processes in bays, near coasts	58							
20. Survey interchange of water between North Atlantic and adjacent areas								
21. Develop ice prediction capability		68						

Numbers in matrix are document page numbers where recommendation or conclusion is discussed
* Accession Number - See Bibliography

** ∅ Little or No Impact
1 Minor Impact
2 Major Impact

...tific Framework
...l Marine
...ce
...l Oceanographic Program
...l Year 1967
Utilization of Industry's Capability
for an Integrated Data Management System
A Plan for the Accelerated Development
of Marine Natural Resources-Interior Dept.
Proposed U.S. Coast Guard Oceanographic
Plan for 1966 Thru 1976
Briefing Data for NASCO Review Panel -
Coast Guard Oceanography
--Plan for -- Automatic Computer for
use at CGOU
The Ocean Science Program of
the U.S. Navy
Seismology Project for the
Continental Shelf Program - ESSA
Federal Plan for Meteorological Services
and Supporting Research, FY 1968
Information Storage & Retrieval System ---
Smithsonian Institution
Briefing Statement for
FY 1969 Budget - NODC
J. E. King, Div. of Bio Sciences, Bureau
of Commercial Fisheries
T. A. Wastler, Federal Water Pollution
Control Administration
A. C. Rayner, Coastal Engineering Research
Center, U.S. Corps of Engineers
T. A. George, Earth Resources Division
National Aeronautics Space Administration
T. Austin, National Oceanographic
Data Center
D. Tidrick, Developmental Surveys Div.
Naval Oceanographic Office
L. Bolen, Acoustic Vibration Laboratory
NAVSHIPS, Research & Development Center

																			Impact on Data **		
0	344	27	226	228	403	404	123	437	436	Inter-view	Inter-view	Inter-view	Inter-view	Inter-view	Inter-view	Inter-view			Col-lec-tion	Pro-ces-sing	Use
		4			19	13,35 76													2	1	1
									9										2	2	1
			X		19				2										2	2	1
					21														2	2	1
					21,49 91														2	2	2
					21														2	2	1
		15			21,90														2	2	1
					26														2	2	1
					26,49 70														2	2	1
																			2	2	2
					35														2	2	2
					26														1	1	1
					26														1	1	1
																			1	1	1
					69,90														2	2	1
					77														1	1	1
		21			77														2	1	1
					92														1	1	1
																			1	1	1
					9,15 19,20														2	1	1
																			2	2	1

B

scoring value given in the right margin of the listings, Table 9, a subset list was derived comprising the topics that were rated in at least two out of the three columns with a value of 2 (see legend). Related topics were subsequently grouped. Reevaluation of the topics in terms of their relative importance further reduced the list to a manageable number of entries that could be grouped into areas of major concern appropriate for study and evaluation. These areas are briefly described here. Also provided is a recommended preliminary approach for gathering requisite information relative to each major area and an indication of how the derived information is to be used during Phase II. Some of the Phase II Study Approach (Section IX) activities reflect the plans and literature findings of Phase I.

B. FINDINGS AND RELEVANCE FOR PHASE II

It was found that most of the topics of major interest could be grouped under the headings of new sensors, new platforms, new surveys, new resources and new programs. Two additional topics of major interest but not included in these groupings are data service center operations and water pollution, which are treated separately.

1. New Sensors

a. Mention was made many times in the available plans of intentions for acquiring an extensive range of new devices such as: 1) sonar, side scanning and narrow focus; 2) ultra sensitive magnetometers and gravimeters; 3) remote sensing systems; 4) data acquisition packages for buoys; 5) long range detection and communication acoustic systems; 6) instruments for Ships of Opportunity (new packages); 7) STD's; 8) XBT's; 9) auto-chemical analyzers; and 10) shipboard wave sensors.

The application of these devices will increase tremendously the volumes of data collected and will also tend to increase the accuracy of the data, in part through reduction of human error. Many of these devices are multi-channel and collect information on more than one variable. Their application implies a wide diversity of user needs and is indicative of the burgeoning new interest in collection of physical, chemical, and biological oceanographic data.

b. During Phase II, the investigation of effects of new instrumentation will begin, where applicable, with acquisition of the manufacturer's manuals for the instruments of concern and the manufacturer's list of users. Expert opinions will be obtained from the U. S. Naval Oceanographic Instrumentation Center, Washington, D.C., and the Bureau of Commercial Fisheries' Oceanographic Instrumentation Program, among others. In addition, instrument users will be contacted in person and by questionnaire and information obtained on use, calibration, reliability, modifications that they have made, and their criticisms and comments. During Phase II, opportunities for standardizing data and instruments will be explored. Problems of coordination of instrumentation and data processing will be identified. Particular attention will be given to instruments of large current or potential usage, such as XBT, STD, and continuous recording systems having both single and multiple sensor capabilities.

During Phase I this approach was used successfully for obtaining information on the S-T-D, manufactured by the Bissett-Berman Corporation. One hundred and four (104) S-T-D sales were listed up to September of this year, and from this list preliminary questionnaires were mailed to six S-T-D users. At the time of this writing, three replies were received. Significant for data management is the fact that all three users reported <u>different procedures</u> for calibration, over-the-side lowering and data processing.

2. <u>New Platforms</u>

a. New platforms were frequently cited in the plans and literature. Of particular concern were 1) Buoy systems, 2) Towers, manned and unmanned systems, 3) Unmanned meteorological observation platforms, 4) Fully automated computer command vessels, 5) Aircraft, 6) Satellites (Apollo Application B), 7) Towed submersibles, and 8) Deep diving vessels.

The anticipated implementation of large numbers of new platforms (buoys in particular) will result in step-function increases in gathered data volumes and substantial increases in the types and forms of data as well. Aside from the increased data volumes the use of these data will undoubtedly be subjected to increasingly sophisticated methods of analysis.

b. The investigation of effects of new platforms will entail literature search, interviews with manufacturers and with agency personnel responsible for system acquisition. Particular attention during this analysis will be given to user requirements for data obtained from buoy systems, aircraft, and satellites.

c. The knowledge acquired during the study of platform data acquisition effects will support the assessments of current and future data volumes to be handled by data centers. The extent of shipboard computer pre-processing and the methods of data transmission will also be explored.

3. Resource Development

a. Marine resource development is heavily documented in much of the literature concerning the ocean environment. Fish and petroleum are two major resources now being exploited. Many others such as minerals, drugs, fresh water and chemicals are considered areas of high potential for development.

b. It will be necessary in Phase II to determine through questionnaire, interviews and literature search how much and what kind of data are required by industry in order to successfully proceed with their plans for future development of natural resources. Some of the basic assessments of user data requirements have already been made by the U. S. Coast & Geodetic Survey (DN-1). The Phase II investigation will use this document as a starting point.

c. Because the U. S. fishing industry is continuing to lose ground to foreign competition it becomes increasingly important to explore the possible assistance that can be provided by improved data management. Phase II study effort will be directed to this area.

d. Because of both the Federal government's critical role and the vested interests that most coastal states have in encouraging development of natural resources, it will be necessary to contact Federal, state, and local government natural resource agencies during Phase II to obtain detailed information on their data requirements in all areas of resource development. As information on user data requirements is obtained, it will be incorporated into the synthesis of user data requirements.

4. New Surveys

a. New surveys of various types were frequently mentioned in the plans and literature. Most new surveys were of a time series or synoptic nature including investigations of the Gulf Stream, North Pacific Ocean circulation (Porpoise Proposal), air/sea interaction, sea surface temperature anomalies (Issac's Buoy Program), as well as time-independent surveys to investigate the geological and biological nature of the Continental Shelf. Cooperative effort between agencies, research institutions and individual scientists was involved in almost all new surveys cited.

b. The anticipated implementation of most of these surveys poses both the problem of an increase in volume and types of data as well as the satisfaction of a large and varied group of users needs.

c. During Phase II, a study of the effects of new surveys involving local, national, and international organizations will be conducted through additional literature search, interviews, and questionnaires. Particular attention during this investigation will be paid to the use of new automatic sampling equipment and platforms, and the attendant data management problems caused by the execution of the new survey programs.

d. The techniques and procedures to support the survey study will be documented and used as an input in the development of the data collection forecasting segment of the Marine Data Planning System.

5. New Programs

a. Several new programs of varying degrees of significance were encountered during the course of the review of prior plans, studies, and literature. Among these were:

- Buoy data collection.
- Satellite data collection.
- Aircraft data collection.
- Shipboard use of digital computers.
- Improvements in existing data bases.
- Development of new data bases.
- Ocean surveys.
- Synoptic data collection.
- Time-series data collection.
- World Weather Watch.

The World Weather Watch plans are not included in those reviewed although its broad goals and functions are known and have been discussed in other parts of the report. In Phase II, it will be important to determine all of the functions of the World Weather Watch which relate to marine data requirements. Since ESSA is deeply involved with the World Weather Watch and oceanography, many of the meterological-marine data interface problems will fortunately occur within one organization.

6. Data Service Center Operations

a. It is significant that in the plans for new data collection there was considerable attention paid to the benefits of acquiring and using various types of data. Much less attention was given to the determination of the data processing capabilities that would best accommodate the types, forms and volumes of input data and best serve the users. To an extent this is understandable. Platforms, such as survey vessels, are visible indicators of capability. Collection programs tend to be discussed in terms of platforms and sensors. Not so visible but equally vital to the effective employment of such data capture instrumentalities is a well-planned data management system which provides appropriate accommodation of the data at a rate commensurate with data generation and makes available to the data user, at an appropriate response rate, well-selected information in the form and volumes needed. The requirements for such systems should be considered at the time of data program inception. If problems of data storage, processing and dissemination are not considered when data collection programs are developed, the overall data management system will produce minimal service. Large backlogs and slow response time will result and costs will be higher than in a properly planned system. This problem is evident in the literature of oceanography and was visible at some of the installations visited during Phase I. At these centers the data processing operation was hampered by the inertial forces of substantial volumes of data accommodated by classification systems, storage media and formats chosen for simplest, cheapest input. The data was stored as received. The retrieval problem was passed to the user who had to access essentially unprocessed data. The evidence, both in the literature and from observation and interview, leads to the conclusion that the problems in Marine data management are not due exclusively to lack of funds. Except in isolated cases, there are also problems of inadequate system design and insufficient use of available data management tools. Review of plans and literature has indicated that, in general, the marine science community has not been a sophisticated user of available data management resources.

A major task of Phase II is to assess the requirements for storage, processing and dissemination of new programs and provide for the integration of these requirements with data collection activities.

7. Water Pollution

a. The 1965 amendments to the Federal Water Pollution Control Act designated water quality control standards as a method for dealing with the increasing menace of water pollution. The individual states had until June 30, 1967 to prescribe acceptable standards for interstate water and if they failed to comply the Secretary of Interior had authorization to then set the standards. Federal, state and local government involvement in water pollution is growing rapidly in all aspects, including research, regulatory and legislature, and expenditures. Industrial concerns are also taking a harder look at the situation and are investing greater sums of money for research on pollution control.

b. As data on water pollution becomes more widely needed due to the enforcement of water quality standards, greater importance will be placed on uniformity of sampling and analytical procedures and the processing, storage and retrieval of data. The Federal Water Pollution Control Administration has recognized these needs and is currently in the process of developing a data management system for water quality control data called STORET.[1] In addition to this Federal program, several states are developing water quality control data systems along these similar lines.

c. During Phase II it will be necessary to investigate the state-of-the-art of water quality control data management systems in use or planned for the future. The most logical starting point for this investigation will be the Federal Water Pollution Control Administration and the Geological Survey of the Department of the Interior. Efforts will be made to describe the overall data manage-

[1] Dubois, Donald P. "STORET II, Storage and Retrieval of Data for Open Water and Land Areas," FWPCA, 1966.

ment problem in order to prevent duplication of effort in water quality control data collection, processing, and retrieval by the federal, state and local agencies.

d. In addition, an investigation will be made to determine to what extent the water pollution control data requirements can be satisfied from existing data collection programs within the federal, state, and local agencies. A logical starting point for this operation will be the Geological Survey, Office of Water Data Coordination.

IX. PHASE II STUDY APPROACH

A. INTRODUCTION

Advances in marine science and technology depend critically upon the effective flow of information from data producers to data users. Previously, oceanographic data were collected primarily by the same scientists and engineers who used the data. Now, with intensified and diversified interest in marine data and with data acquisition far more voluminous, complex, and costly, the data commodity and related products and services must be shared more widely. If we are to achieve practical objectives in the sea, marine data must both be generated and made available to meet a wide variety of user needs.

B. STATEMENT OF THE PROBLEM

A major problem today is that data are not moving expeditiously through channels from acquisition to end product. The increases in data traffic and the changes in the character of data resulting from new technology both impose new problems in data management. A comprehensive marine science data management study by System Development Corporation -- a fourteen-month study, following project definition during Phase I -- will consider the following parts:

Part I: Analysis of the Needs of Data Service Customers (Months 1-4)

Part II: Delineation of Marine Data and the Means for Handling Them (Months 5-7)

Part III: Evaluation of Data Functions (Months 8-10)

Part IV: Design of Data Program Implementation Plans (Months 10-14)

Part V: Design of a National Marine Data Planning System (Months 8-14)

Part VI: Data Program Synthesis (Months 8-14)

C. PART I - ANALYSIS OF THE NEEDS OF DATA SERVICE CUSTOMERS (MONTHS 1-4)

The problem to be considered is the need for improved understanding of the framework for data traffic from producers to users, with special emphasis on the needs of data service customers. Whether as producers and users, or as users alone, customers have current data needs and practices whose nature and frequency must be ascertained.

The Part I study will thus focus on the needs of Federal, State, academic, industrial, and private users of marine data and data products and services. We must estimate the magnitude, frequency, characteristics, and criticality of these needs and how they are likely to develop and change in the future. Further, we must understand more clearly at this point how diverse data move and through which channels they move from producers to users; how long this movement takes; and the role of responsible agencies in this process.

1. Objectives

The specific objectives of Part I are to:

- Identify data producers and user communities and estimate the size of each.
- Classify the user community in terms of data needs and use. Some of the determinants of classes of data use are the following: purpose of data use; data type; frequency; volume, format, geography, quality, sample size, etc.; time requirements for data acquisition, transmission, and retrieval.
- Determine common and unique data needs within the marine science community.
- Evaluate the validity of stated needs.
- Determine the adequacy of existing data products and services to meet user needs.
- Establish the need for new or improved data products or services in advancing toward marine science goals.
- Estimate data acquisition and data service costs and describe benefits derived.
- Identify priorities among stated needs.
- Identify and illustrate the nature of data flow from diverse producers to a variety of data users.

2. Approach

As an approach to the Part I study, subject to change as additional information is acquired, we will consider specific identifiable user categories and representative data applications for each:

Category	Representative Applications
1. Scientist	Research in: • physical oceanography • biological oceanography • chemical oceanography • marine geology and geophysics • air-sea interaction
2. Naval Planner and Operator	• safe navigation in coastal waters • avoidance of storms and other hazards to safety at sea • enhance performance of anti-submarine, undersea, and mine warfare systems • optimize deployment of naval forces
3. Environmental Forecaster	Preparation of: • marine weather and storm warnings • wave and sea ice predictions • tide and tidal-current forecasts • coastal surf and current predictions • tsunami and storm surge warnings • estuarine flushing predictions

Category	Representative Applications
4. Ocean Engineer	Design and development of:
	• coastal facilities, including harbors, sea walls, and breakwaters
	• offshore towers and oil drilling platforms
	• ships and submersibles
	• improved fishing gear, including aquaculture technology
	• ocean systems and equipment
	• coastal desalinization and power plants
	• waste facilities
	• operation of submersibles
	• installation of undersea pipelines and cables
	• salvage operations
	• offshore oil and mineral production
5. Industrial Manager	• industrial and operating decisions for offshore mineral and energy resources development, coastal development, etc.
6. Fishermen	• safe navigation in coastal waters
	• avoidance of storms and other hazards at sea
	• optimize fishing location to increase yield per unit effort

Category	Representative Applications
7. Merchant Mariner	• safe navigation in coastal waters • avoidance of storms and other hazards at sea • optimize track selection to reduce cargo damage and economize on operational costs • deployment of fishing fleets • transportation planning
8. Federal, State, and Municipal Planners	• enhancing water quality in the coastal zone and Great Lakes • aid in establishing Federal/State conservation and regulatory policies • facilitate planning for rational coastal zone use
9. Citizen Concerned with Recreational Use of the Coastal Zone	• safe navigation of pleasure craft in coastal waters • timely warning of storms and high waves • swimming conditions along coastal beaches

3. Research Methodology

The research in Part I will be conducted in the form of a survey of known producers and users of marine data. Owing to the extent and detail of marine data activities, this survey will be conducted by personal interviews with individuals in the categories identified above. The questionnaire that will be used in the interviews is shown in Appendix G of Volume Two of this report. The questionnaires will be transmitted personally -- not mailed -- although in some cases it may be left with an individual for completion of some section(s) that require(s) collection of additional information from within his organization.

It is important that the persons interviewed not simply be spokesmen for their organizations, but that they also be personally involved in the acquisition, processing, or use of marine data. Thus, while the respondents will be identified by virtue of their organizational involvement in marine data affairs, interviewees should also represent the expert opinion of knowledgeable men.

A number of interviews can be completed with the resources available during Part I. Interview data will be aggregated, analyzed, and interpreted to determine present and probable future characteristics of the marine data user population. Adequacies and deficiencies in current data services and the extent of user satisfaction with these services will be identified. Institutional and international exchange relationships will be examined. These analyses follow from the statement of objectives given above.

In addition to data derived by means of the questionnaire, respondents will be asked to illuminate the operation of the present marine data network with a case study or "life history" of a specific marine data activity in which they have been or are personally involved. The intent of these histories is to identify the nature of marine data flow from original acquisition through various processing channels to end use. It is to be emphasized that these data-flow histories represent the perspective of the respondent, and that no judgment of completeness or validity in all areas will be implied.

The histories will attempt to include such information as: description of data; original and proximate source of data to the respondent; processing performed prior to its availability to the respondent (where, by whom, for how long, etc.); ease and regularity of access; adequacy, relevance, and value to the respondent; quality; timeliness; cost of acquisition; processing by the respondent and his end use or output from the data; and respondent's projected future needs and recommendations for improved data services. While the selection of the subject matter of the data flow history will, to a large extent, depend on the respondent, attention will be given to the areas of activity listed below.

1) Ocean observation and prediction activities, especially as these bear on more accurate and longer-range marine and continental weather predictions.

2) Map and chart production services performed by the U.S. Navy, the U.S. Coast and Geodetic Survey, and the U.S. Geological Survey.

3) Academic research activities of marine scientists in the effort to gain new knowledge and understanding about the oceans and their processes, especially as these are influenced by new technology, discipline, and research goals.

4) The use of foreign data by U.S. marine scientists. What is the role of World Data Center A? Consider data exchange for the International Decade of Ocean Exploration.

5) Small craft charts prepared by the Coast and Geodetic Survey for recreational sailors and sports fishermen. Include respondents both from the Coast and Geodetic Survey and from the users themselves.

6) Environmental services forecasts prepared by the Bureau of Commercial Fisheries for west coast fisheries. Include respondents both from the Bureau of Commercial Fisheries and from the users. Are similar services needed for other fisheries in other areas?

7) Marine engineering data used for the design, testing, and operation of both military and non-military submersibles. Include respondents both from engineering designers and from operators.

8) Marine engineering data used in offshore platform construction, e.g., for oil drilling. Why have some of these towers collapsed (Texas Tower #4)?

9) Coastal warning services, especially of devastating storms, tsunamis, and storm surges.

10) Marine weather, storm, and wave forecasts, including forecasts for the Great Lakes, especially as used for recreational sailing, sport fishing, commercial fishing, and offshore tower and drilling operations.

11) U.S. Merchant Marine services and products provided by the U.S. Navy, including nautical charts, sailing directions, pilot charts, etc.

12) Ship track routing services used by both merchant and U.S. Navy ships to avoid storms and reduce transit time.

13) Research and publications of marine scientists. What becomes of data collected by scientists for their own use; how do others in the professional community learn of it?

14) Regulatory and conservation programs related to water quality and marine resources, as practiced by Federal, State, and municipal planners. Inquire about the value of estuarine flushing and non-tidal current prediction service.

15) Marine environment resource development activities of oil and mineral industries, especially in regard to data product services provided by the Federal Government. Include respondents from both the Federal Government and industry.

16) Sea-ice forecasting services supporting ice area operations of U.S. shipping, Coast Guard, and Navy. Include respondents from both forecasting services and the user/operations.

17) Beach and surf forecasts provided by ESSA in the Los Angeles area. Include respondents from both ESSA and the public.

18) Publications by BCF of the "faunal atlas" series summarizing knowledge in marine biological exploration and research. Include respondents both from BCF and the user community.

19) Marine data activities in the U.S. Navy supporting the design, development, test, evaluation, and operation of military systems and the deployment of naval forces. What happens to data collected by Navy laboratories and in the ASWEPS and marine geophysical survey programs, for example?

20) Operations and functions of marine and marine-related data centers: National Oceanographic Data Center; Great Lakes Data Center; National Weather Records Center; Smithsonian Oceanographic Sorting Center; gravity, magnetic, and seismology data centers. Include respondents both from the centers and from the user communities.

21) Sea search and rescue services provided by the Coast Guard.

22) Marine taxonomy, especially the collection and processing of specimens.

23) ESSA's SEAMAP program activities.

4. Products

The results of Part I will be presented in a formal report accompanied by briefings. The report will consist of a brief summary of major findings, together with a more detailed narrative report describing and analyzing the composition and characteristics of the marine data user community according to the statement of objectives given previously and the contract statement of work governing performance of the contract. Statistical data will be limited to tables and graphs except where communication and understanding dictate more complex schematic representation -- e.g., flow charts.

To assure satisfaction of the contract statement of work, data books will be developed for recording and classifying information collected from the interview schedules. Information will be organized by data use, program, organization, and data type. These data books will not be published for formal distribution but will be developed for use in remaining parts of the study.

D. PART II - DELINEATION OF MARINE DATA AND THE MEANS FOR HANDLING THEM (MONTHS 5-7)

1. Objectives

Based on the survey and analysis of the needs of marine data users performed in Part I, the objective of this part of the study is to identify and describe the marine data that should be subject to coherent management at the national level and to inventory and analyze the processing functions that various organizations currently perform on these data.

a. Data

Description of the data that should be subject to management and coordination in a national marine data program will include:

- Designation of the kinds and forms of data relating to pertinent phenomena (physical, biological, and socioeconomic) of the world oceans, coastal waters, estuaries, and the Great Lakes.

- The nature of data currently available in various categories designated above with respect to their source, quality, and usefulness in satisfying national needs.

- Specific description of the compatibility among current data storage media such as documents, maps, graphic or electronic analog records, graphic or electronic digital records, specimens, etc.

- Assessment of the national impact of data (to be) made available by new sensors, new recording technology, new designs of research, and the introduction of new collection platforms such as unmanned stations, aircraft, deep submergence research vehicles, and spacecraft.

- Estimates of the current and projected amount of data of various kinds and from various sources, rates of accumulation, and rates of possible obsolescence.

Based on the description of data requirements, apparent unfulfilled national-level data needs will be identified and explained. Unfulfilled data needs may prove to be the result of any one or several of the following: data are not being collected; data are collected but are not available to all who require them; data usage may be restricted by security classification controls; data usage may be restricted by industrial proprietary controls; data move too slowly through the marine data network; and data are incompatible in time, space, quality, or storage media.

A description and rationale will be given for excluding any categories of data that are not regarded as appropriate or required for incorporation in a coherent national marine data management program.

b. Services

An inventory of organizations that currently perform service functions on marine data is to be made and their processing activities described. These service agencies will not be limited to marine data centers but will include all Federal and government supported organizations that perform acknowledged and routine marine data services, in order to examine the degree to which these services lend themselves to coordination within a national marine data management program. The following aspects of these services will be emphasized:

- Affiliations, sponsors, suppliers, and customers (users).

- Nature and size of data collections, services offered, assessment of coverage, and areas of overlap.

- Degree and kinds of existing arrangements for coordination and data exchange.

- Feasibility or extent of international cooperation.

- Extent and practicality of expanded cooperative arrangements with domestic sources and users of marine data, such as State and local governments and private organizations.

- Adequacy of services and potential for growth, assessment of facilities, manpower, and personnel training programs.

2. Approach

In order to achieve the objectives stated, a threshold level of performance/cost relationship will be established to serve as a criterion for recommending inclusion of marine data categories within the scope of a national marine data program. In accomplishing the performance/cost analysis, several future funding levels for marine data management operations will be hypothesized in order to provide planning options. Similarly, performance/cost analysis will be performed on marine information service operations in order to assess the relative importance of existing service agencies in a national data management program; to identify service agencies that require upgrading in order to function properly as a component in a national program; and to indicate changes that will create a more effective operational facility.

3. Products

The results of Part II will be presented in a formal report accompanied by briefings. The report will consist of a brief summary of major findings, together with a more detailed report describing and analyzing marine data and data services that are recommended for a national marine data management program.

E. PART III - EVALUATION OF DATA FUNCTIONS (MONTHS 8-10)

1. Objectives

Part I of the study will have produced a report of the expressed needs of users of marine data and data products. Part II will have produced a delineation of the categories of marine data appropriate for national-level management, and of the marine information services in current operation that lend themselves to national-level coordination. Part III of the study will evaluate these data and information services in order to identify characteristics which marine data and data services should possess in the national-level program. From this will be derived a statement of functional requirements for the national program that will represent goals considered achievable within the next decade. Specific functional characteristics are enumerated and illustrated below; the study will investigate their scope of application, sources of current inadequacies, appropriate criteria, and expected standards of performance, as well as the opportunities for significant improvements.

a. Data Processing

With respect to the technology of data handling, the study will cover historic, contemporary, and future collections and will consider three primary processing activities: ship-board processing, land-based processing before data are deposited with a service agency, and processing performed at service agencies within the national marine data management program. The principal technological developments in terms of which the handling of marine data is being performed are to be identified, and the opportunities for their improvement are to be appraised.

The study will focus on the following:

1) Automated Equipment Utilization. Some facets of marine data handling appear archaic in the light of recent developments in automated electronic and mechanical devices and computer technology for collection, identification, storage, retrieval and publication. Therefore, automated equipment utilization

will be considered both integrally with collection of primary data and their processing, as well as in subsequent phases of processing. Of particular interest will be the employment of better and more economical services, either by means of parallel systems or through central systems operated on a time-shared basis; data processing by on-board computers; the use of analog-to-digital convertors; random-access, mass storage; graphic displays; and automated abort.

2) Communications Systems. Data communication systems and techniques that provide for the transmission of data from collection points to processing and storage facilities will be investigated. Communications systems that transmit data between data service agencies will also be studied.

3) Media and Data Codes. The multiplicity of codes, formats, and media for recording data is a significant deterrent to expeditious data flow and data exchange in the marine community, including international data exchange. The study will analyze the alternative media and codes that are employed to record oceanographic data and the issues of compatibility that must be resolved in order to permit unobstructed circulation of this information.

4) Storage and Retrieval. The matter of abstracting, indexing, and archiving will be addressed, with special reference to the timeliness and adequacy of coverage, indexing vocabulary, compatibility among related disciplines and subject matter, and integrity of long-term storage. Consideration will be given to the related requirements for storage and retrieval of environmental data, citations to environmental data in published reports and documents, and surrogates of published reports and documents in the form of abstracts, extracts, or bibliographic indexes.

b. Accountability

There does not now exist a comprehensive national marine data inventory. Provisions for creating and maintaining an account of the accumulating marine data will be recommended, including, but not limited to, the identification of:

- Conditions under which data were collected and transmitted.

- Data that are related in space and time.

- Data samples that are related in a common and uniform manner.
- Other data collected simultaneously.
- Retrieval programs that ascertain the density of "neighboring" data.
- Measures of expected obsolescense.
- Error statistics or confidence limits.

These and/or related criteria for maintaining accountability of marine data holdings will be developed, and appropriate methods for their application will be recommended.

c. Accessibility

Functional requirements for access to marine data holdings within the scope of a national marine data program will be identified. The study will include consideration of:

- Required response time distributions and how these compare with actual response time distributions today.
- Requirements for redundancy, to compensate for insufficiencies in data retrieval.
- Requirements for retrieval of related data by means of search, inference by prediction from models, or statistical correlation.
- Volume and significance of data of restricted access due to proprietary or security controls.

d. Quality Control

Requirements for quality control of marine data will include consideration of instrumentation, sampling design, and control of post-observation manipulation. Specific attention will be given to:

- Sources of current quality degradation, such as instrument inadequacy, sampling errors, and errors resulting from interpolation to standard conditions.

- Quality assurance techniques employed currently; inter-sample correlation techniques with observations of differing quality; indicators of quality that associate certain data as appropriate for use in connection with particular purposes.

- Established quality standards.

- Validity tests and organizational procedures to identify and correct data deficiencies.

e. Dissemination

Dissemination of marine data and data products will be investigated to determine the adequacy of existing dissemination methods in comparison with alternative or additional techniques. Consideration will be given to:

- Timeliness of transmission.

- Method of data transmission.

- Volume and frequency of data transmission.

- Forms of presentation, especially standard publications, and the needs for and arrangements of displays.

- Availability of inventory information and surrogates (abstracts, extracts, and bibliographic citations) describing data holdings.

- Adequacy of current methods for data exchange: compatibility for mutual use of data; economics of exchange arrangements; domestic and international data exchange.

- Rapidity of publication.

f. Input Structure

Consideration will be given to the requirement for establishing standards controlling the input structure and eligibility of marine data for the national program. Specific attention will be addressed to:

- Standardization of precision indicators, definition of concepts and units of measurement, formats of recording.

- Standards of sampling design, especially to conform to established doctrine of quantitative information theory.

- Standards for the selective acceptance of marine data into data collections with national service missions.

g. Archival Storage

Functional requirements for archival storage of marine data and data products will be based on assessments of the adequacy of current storage methods and retrieval services. The following factors will be considered:

- Identification of existing facilities and techniques.

- Compatibility between storage and retrieval methods.

- Retrieval times and costs, compared with times and costs achievable within the state-of-the-art.

- Size, duration, and reasons for backlogs; measures employed for data conversion.

- Formats, media, and processes used for storage.

- Coordination between storage repositories in marine sciences and in related fields.

- Available coverage by government, as well as by private organizations.

h. Data Analysis

Requirements pertaining to data analysis refer to the methods employed for analyzing, reducing, and packaging marine data to make them more generally useful. Consideration will be given to:

- Techniques of statistical analysis applicable to data aggregation and disaggregation.

- Detection and prediction of anomalies.

- Error detection and analysis.

i. Development

Firm recommendations for functional requirements to be established within the national marine data program should recognize not only the status of current operations, but also the technological feasibility of achieving significant improvements. A review of research and development will be conducted, concentrating on the following major problems of collecting, processing, recovering, publishing, and displaying marine data:

- Detection and correction of errors, both human and instrumental, in data acquisition. An analysis will be made of the feasibility of improved systems employing automatic techniques.

- Adequacy of sampling structures. An analysis will be made of modern methodology and equipment, such as continuous recording instruments, sensor arrays, and shipboard data loggers, to assess potential improvement in data sampling designs.

- Retrieval, publication, and display of data. An analysis will be made of contemporary computer-based mass storage and retrieval technology, coupled with advanced display methods, such as computer graphics and automated publication developments.

- Effects of new technology on the organization and structure of the national marine data program in terms of collection programs, communication systems, and marine information service operations in support of a national mission.

2. Approach

Part III will consist primarily of an analytic effort supported by highly selective interviews with appropriate experts in such technical fields as sensors, platforms, communications, library services, information processing, and displays. The emphasis will be on identifying functional requirements and establishing the technical feasibility of means for satisfying these requirements.

3. Product

The results of Part III will be presented in a written report accompanied by a briefing. The report will describe the functional requirements and the technical feasibility of implementing improvements for the nine topic areas enumerated under Part E.1, Objectives, above.

F. PART IV - DESIGN OF DATA PROGRAM IMPLEMENTATION PLANS (MONTHS 10-14)

1. Objectives

The technical analyses conducted during the Phase II study will result in the publication of a ten-year Technical Development Plan for the national marine data management program. On the basis of the information developed in preceding parts of the study, alternatives for improvements will be analyzed, and recommended data management initiatives will be presented with a view to their adoption by the various agencies. These improvements may fall into any of the following broad categories:

a. Introduction of available techniques and technology in order to update current operations, in both products and services, in the measurement and sampling of the marine environment, in the analysis, reduction and storage of data, and in retrieving and disseminating information to the user community.

b. Identification of promising opportunities for improvements in data functions that show prospects of yielding to techniques and technology under development within the next 10 years.

c. Improvements in the marine data acquisition process -- e.g., simultaneous collection of different kinds of data for which a need exists, to permit more thorough and efficient subsequent exploitation.

d. Conduct of applied research in order to increase the understanding of the entire process of measuring phenomena in the marine environment, reducing data, and utilizing the resulting information.

e. Modification or expansion of existing data handling activities and information service agencies in order to make their service more responsive, of higher quality, and more timely.

f. Increasing the compatibility of marine data and data products at all levels, from data definitions (e.g., units of measurement) to inter-system formats, media, and display.

g. Development of new information service systems, if needed.

The Technical Development Plan will recommend priorities and schedules for implementation, and will specify the resources -- personnel, equipment, facilities, and money -- considered necessary to implement the plan. Several options of the plan will be developed based on alternative levels of assumed Federal funding.

2. Approach

A performance/cost analysis will be made for each option of the Technical Development Plan. Factors to be considered in the performance/cost analysis are:

a. Potential benefits in relation to development and implementation costs.

b. Scope and intensity of validated needs for data and data services.

c. Trade-offs -- for example, between the establishment of standards for accountability and compatibility, on the one hand, and capital investment in new instrumentation and facilities, on the other.

d. Probable technological developments within the next ten years that will significantly influence either the availability or the application of marine data.

3. Product

The results of Part IV will be presented in the written report, Technical Development Plan, accompanied by briefings.

G. PART V - DESIGN OF A NATIONAL MARINE DATA PLANNING SYSTEM - NMDPS (MONTHS 8-14)

1. Objectives

Experience has shown that among the factors involved in implementing improvements to an information processing network as complex as the national marine data management program, effective coordination of the many activities is critical. The coordination, in this context, is the technical management and design and control that ensure that implementation schedules are appropriately phased and that resultant operations do indeed fulfill the objectives for which they were intended. The Phase II study will analyze requirements for a National Marine Data Planning System (NMDPS) to perform the planning and management functions for the national marine data management program. Consideration will be given, but not limited, to the following activities of the NMDPS:

a. Monitoring implementation of marine data program improvements to compare results with objectives.

b. Expediting availability of relevent data program information to the affected marine community.

c. Forecasting data program requirements.

d. Assessing the routing of data among marine data acquisition, processing and dissemination agencies and the distribution of workloads among the various marine data facilities.

e. Updating the Technical Development Plan for the national marine data management program to ensure its currency with events.

2. Approach

A concept of operations and a recommended organization of the NMDPS will be specified, based on discussions with personnel of the Marine Sciences Council and with personnel experienced in the design and control of analogous developmental programs in the military and civilian environment.

3. Product

The results of Part V will be presented in a written report, accompanied by briefings, setting forth the responsibilities, organization, and operational concept of the proposed NMDPS.

H. PART VI - DATA PROGRAMS SYNTHESIS (MONTHS 8-14)

1. Objectives

This part of the study is to be conducted concurrently with Part IV, Design of Data Program Implementation Plans. The purpose is to appraise the requirements and configuration of the total national marine data management program that has been recommended in preceding parts of the study and to ensure the consistency of each part with the whole: users' needs, scope of the data and service agencies supporting the national interest, functional requirements for improved data management, the Technical Development Plan, and the National Marine Data Planning System.

2. Approach

The approach will be that of reviewing for consistency each of the reports delivered in preceding parts of the study, with particular attention to the technical configuration for a national marine data management program contained in the Technical Development Plan.

3. Product

No independent product will result from this part of the study. If the synthesis indicates the need, revisions or addenda to preceding reports may be issued. The Technical Development Plan will reflect the findings of the synthesis in its recommendations.

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UNCLASSIFIED
Security Classification

DOCUMENT CONTROL DATA - R & D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author) National Council on Marine Resources & Engineering Development Executive Office of the President, Wash., D. C. 20500	2a. REPORT SECURITY CLASSIFICATION UNCLASSIFIED 2b. GROUP

3. REPORT TITLE

NATIONAL DATA PROGRAM FOR THE MARINE ENVIRONMENT: Phase I, Final Report Volumes 1 and 2

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Phase I, Final Report 1 December 1967 (Revised)

5. AUTHOR(S) (First name, middle initial, last name)

System Development Corporation
Santa Monica, California 90406

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
August 27, 1968	Vol. 1-361, V. 2-178	None

8a. CONTRACT OR GRANT NO. ONR N00014-67-C-0559 b. PROJECT NO. ONR:620:FDB c. d.	9a. ORIGINATOR'S REPORT NUMBER(S) 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)

10. DISTRIBUTION STATEMENT

Distribution of this document is unlimited.

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	Office of Naval Research

13. ABSTRACT

This report documents the Phase I Study of the National Data Program for the Marine Environment. This study was sponsored by the National Council on Marine Resources and Engineering Development. The end product of Phase I is a Study Approach for Phase II. In support of this approach, findings were derived from:

1. A review and analysis of the findings and recommendations of pertinent prior studies. Twenty-seven documents were reviewed.

2. A survey of the relevant literature on the informational structure, storage and retrieval, and reduction to sueful forms of marine information. Four hundred and thirty-nine documents were surveyed.

3. A collation of the plans of selected agencies for the development of improved marine data handling capability. Seventeen plans were reviewed.

Additional Phase I activities were as follows:

1. A questionnaire was developed to assess the size and characteristics of the marine data problem. (see continuation sheet)

DD FORM 1473

UNCLASSIFIED
Security Classification

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2. Interviews were conducted with:

   75 persons in 28 Federal Agencies.

   20 persons in six Scientific Institutions.

   10 persons in seven Regional Authorities and in Industry.

   These interviews included organizations whose activities spanned the entire spectrum of marine data functions; collection, processing, storage and retrieval, dissemination and use.

3. A detailed methodology was developed for structuring the Phase II design efforts. This methodology was applied during Phase I for the preliminary analysis of:

   - National Marine Science Program Objectives
   - Functional Requirements
   - Data Program Requirements
   - Constraints
   - Effectiveness Analysis of Data Programs
   - Cost/Benefit/Effectiveness Analysis of Data Programs
   - Data System Requirements

14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Data						
Marine sciences						
Marine science affairs						
Marine environment						
Marine resources						
Marine data						
Date management--Data management program						
Data programs						
Data requirements						
Data system						
Ocean exploration						
World Weather Watch						
National marine science programs						
National marine data program						
Functional data requirements						