Chapter 7
Federal Programs for Collecting and Managing Oceanographic Data

CONTENTS

Box

Figures

Table

Chapter 7

Federal Programs for Collecting and Managing Oceanographic Data

INTRODUCTION

Several Federal agencies have responsibility to survey and collect data on the ocean. They are:

- U.S. Geological Survey (USGS),[1]
- National Oceanic and Atmospheric Administration (NOAA),[2]
- U.S. Coast Guard (USCG),[3]
- U.S. Environmental Protection Agency (EPA),[4]
- U.S. Department of Energy (DOE),[5]
- Minerals Management Service (MMS),[6]
- the Bureau of Mines (BOM),[7] and
- the U.S. Navy. [8]

Some of the designated agencies do not maintain active research programs in the Exclusive Economic Zone (EEZ). Of those collecting data, some are involved in survey activities while others conduct more localized research. The agencies conducting ***broad-scale*** exploration of the EEZ are NOAA (the Department of Commerce) and USGS (the Department of the Interior). Several agencies and public and private laboratories collect EEZ information ranging from site-specific mineral analyses to assessments of biological resources and various physical and chemical parameters of the oceans; these data collectors include NOAA (four groups),[9] MMS, BOM, USGS, the National Aeronautics and Space Administration (NASA), the U.S. Navy, private industry, and academic and private laboratories (see box 7-A). All of their data must be archived and accessed.

Exploration and development of the U.S. Exclusive Economic Zone is not proceeding economically or efficiently under current programs. There is no systematic mechanism for data collection, with the exception of plans to ' 'map' the EEZ (by USGS using the GLORIA side-looking sonar system and NOAA using multi-beam systems). The NOAA and USGS efforts will provide the first survey of the vast territory contained in the EEZ; these projects, however, are plagued by budget problems, and completion is uncertain. The many other stages of research necessary before development of U.S. seabed resources can take place (e. g., comprehensive three-dimensional mineral assessment, development of rapid sampling technologies, etc.) are largely either unplanned or proceeding in a piecemeal fashion.

[1] *43* U.S. C, *31* (a) and (b), The Organic Act of 1879, as amended; 16 U.S. C. 1451-1456, Public Law 94-370, The Coastal Zone Management Act Amendments of 1976; 43 U. S.C. 1865, Public Law 95-372, The Outer Continental Shelf Lands Act Amendments of 1978; 30 LT. S.C.1419 et seq., Public Law 96-283, The Deep Seabed Hard Mineral Resources Act of 1980; 43 U.S.C. 1301, Public Law 92-532, The Marine Protection, Research, and Sanctuaries Act of 1972; and Proclamation #5030, 48 Fed. Reg. 10605, Mar. 10, 1983.

[2] 33 U. S.C. 883 et seq. , The Act of Aug. 6, 1947, as amended; 84 Stat 2090, Presidential Reorganization Plan No. 4 of 1970—Establishment of NOAA; 33 U. S.C. The National Ocean Pollution Planning Act of 1978; 16 U.S. C. 1451-1456, Public Law 94-370, The Coastal Zone Management Act Amendments of 1976; 43 U.S.C. 1847, Public Law 95-372, The Outer Continental Shelf Lands Act Amendments of 1978; 30 U. S.C. 1419, Public Law 96-283, The Deep Seabed Hard Mineral Resources Act of 1980; 16 U. SC. 1432, 33 U.S. C. 1441, Public Law 92-532, The Marine Protection, Research and Sanctuaries Act of 1972; 16 U .S .C. 1801 et seq., Fishery Conservation and Management Act of 1976, and Proclamation No. 5030, 48 Fed. Reg. 10605, Mar. 10, 1983.

[3] 43 U. S. C, 1865, Public Law 95-372, The Outer Continental Shelf Lands Act Amendments of 1978.

[4] 33 U .S. C. 1251 et seq. , Public Law 95-217, The Clean Water Act, as amended; 33 U. S.C. 1401, et seq., Public Law 92-532, The Marine Protection, Research, and Sanctuaries Act of 1972.

[5] 4, Public Law 93-577, Federaf Non-Nuclear Energy Research and Development Act of 1974; 301, Public Law 95-91, Energy Organization Act

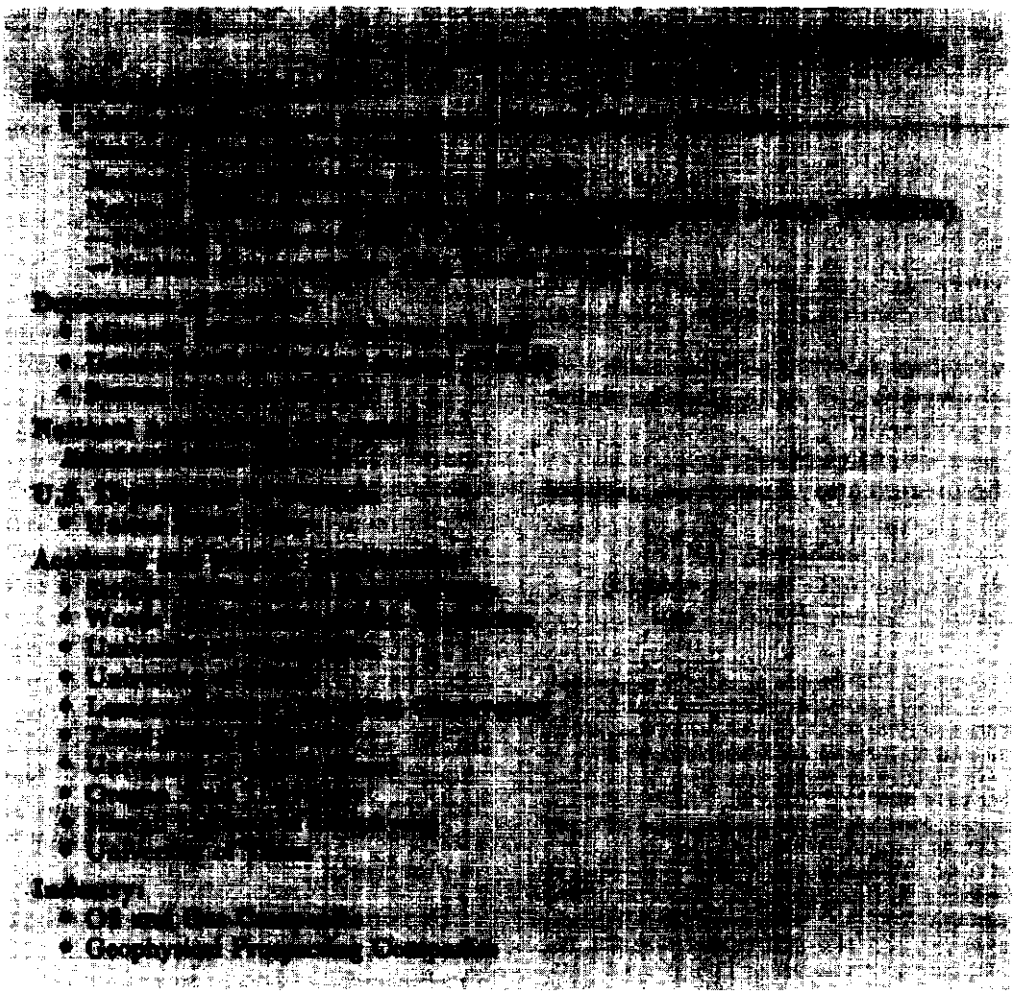
[6] 43 U.S. C. 1131-1356, Public Law 83-212, Public Law 93-627 and Public Law 95-372, The Outer Continental Shelf Lands Act of 1953 as amended; 43 U.S.C. 1301-1315, Public Law 83-31, The Submerged Lands Act; 33 U.S. C. 1101-1108, Public Law 89-454, The Coastal Zone Management Act of 1972; 43 U.S.C. 4321 ,4331-4335,4341-4347, Public Law 91-190, The National Environmental Policy Act of 1969; Proclamation No. 5030, 48 Fed. Reg. 10605, Mar. 10, 1983, Exclusive Economic Zone of the United States of America.

[7] 30 U.S. C. 21 (a), Public Law 91-631, The Mining and Minerals Policy Act of 1970; 30 U.S. C. 1602, 1603, Public Law 96-479, The National Materials, and Minerals Policy, Research, and Development Act of 1980.

[8] 10 U.S.C. 7203 and 10 U.S.C. 5 151.

[9] National Ocean Service, including the Strategic Assessment Branch and Charting and Geodetic Services; National Marine Fisheries Service; the National Environmental Satellite, Data, and Information Service, including the National Geophysical Data Center and the National Oceanographic Data Center; and the Office of Oceanic and Atmospheric Research.

72-672 0 - 87 -- 9



MANAGEMENT OF DATA RESOURCES

Effective data management is a critical part of any systematic survey or research effort,[10] but management of EEZ data has been elusive. There are several aspects to the problem. Many different groups (Federal laboratories and agencies, State geologists, academic research laboratories, and industry) collect, use, and/or archive many kinds of data from the EEZ. Data of many kinds and different quantities are collected. Consistent reporting formats are not necessarily used. These problems will worsen as sensors (e. g., satellites, multi-beam echosounders, and multi-channel seismic reflection recorders) produce data at faster rates. Realization of the scope of this data management problem is growing.[11,12,13]

[10] Data management is defined as the process of planning, collecting, processing, and analyzing for primary use (e. g., for research); and storing, archiving, and distributing the acquired data for secondary users.

[11] "There are problems with the way data are currently managed. The distribution, storage, and communication of data currently limit the efficient extraction of scientific results . . ." National Research Council, *Data Management and Computation, Volume 1: Issues and Recommendations* (Washington, DC: National Academy Press, 1982).

[12] "Given the lack of long-term interest in managing the national environmental data archive in academia and the private sector, the Federal government must be responsible for maintaining this national asset . . . " National Advisory Committee on Oceans and Atmosphere, *An Assessment of the Roles and Missions of the National Oceanic and Atmospheric Administration,* unpublished report, 1987, p. 71;

[13] . . . Current NOAA data management systems and policies need to be carefully reexamined. . . . If urgent steps are not taken, . . . the utility of the NESDIS data centers, a national asset, will continue to

There are several possible constraints to an effective EEZ data management program. They are:

- ***technology***— hardware/software,
- ***conceptual***—how should the data be managed,
- organization—capacity for collecting and archiving data, and
- economic—adequate funding.

Technology

Computer, software, and recording technologies have advanced dramatically during the past few years and are expected to continue to advance rapidly. Technologies for collecting, aggregating, transmitting, and accessing data are not limiting. None of the key data managers queried by OTA[14] thought the rate of EEZ data acquisition would exceed the capacity of, or tax, existing high-density magnetic tape storage. The promise of optical laser disks a few years hence could make digital data storage easily manageable. Storage of analog data, or actual physical and chemical samples (e. g., sediment cores), remains a substantial problem. However, these are physical space problems as opposed to data management problems per se. If all data could be converted to digital form, technology options for storage, maintenance, and dispersal are not limiting.

Conceptual

Data management has been the subject of many exhaustive studies. [15] While the volume of information collected from the EEZ does not nearly approach the volume of space data collected by satellites, many of the principles and recommendations for handling space data are applicable to the EEZ as well. These principles include:

- involvement of scientists in data collection programs from inception to completion,
- peer-review of data management activities by the user community,
- proper documentation of all data sets that have been validated, and
- adequate financial resources allocated early in each project for database management and computation activities. [16]

There are also important differences in data obtained in the EEZ and data taken from space. Unlike satellite information, much of the EEZ data has not been collected in digital form and cannot be easily archived or manipulated. EEZ data also vary in geographic scales and degree of detail (a 60-km-wide GLORIA swath v. a 200-m-wide SeaMARC CL swath) and may consist of different measures, e.g., water current measurements, sediment depth, and bedrock type. Researchers would like to be able

---

decline. " Ibid., p. 63; " . There are three principal requirements that are integral to this issue: (1) steadily upgraded computer systems are needed to manage the expanding rate of data acquisition; (2) complicated data management decisions must be made regarding (a) amount and type of data to archive and (b) optimal format for future use; and (3) a more responsive and efficient mechanism for the continued delivery of valuable and timely data products . . . must be found. Ibid.

[13] 'The quantity of geophysical data obtained with public funding has increased dramatically in the past few decades. These data are used not only by the scientific community, but are also important to the general public for use by engineers, lawyers, and insurance actuaries as examples. Collected often at enormous expense, they represent a national resource that must be managed carefully to ensure they are preserved and available when needed. Because of a substantial increase in the amount and complexity of geophysical data being collected and in the demands for them, the management policies and procedures that have been developed are no longer adequate. " National Research Council, *Policy Issues Concerning Geophysical Data,* A Draft Report prepared by the Geophysics Study Committee for the Geophysics Research Forum, February 1986.

[14] Roy L. Jenne, Head Data Support Section, National Center for Atmospheric Research; Michael Chinnery, Director, National Geophysical Data Center (NGDC); Michael Loughridge, Chief, NGDC Marine Geology and Geophysics Division; Gregory Withee, Director, National Oceanographic Data Center (NODC); Robert Locherman, Information Services Division, NODC; Edward Escowitz, Office of Marine Geology, USGS; D. James Baker, Director of JOI, Inc.; Ross Heath, Oregon State University.

[15] Four studies pertaining to data management have been produced by the National Research Council of the National Academy of Sciences alone (Washington, DC: National Academy Press): ' 'Geophysical Data Interchange Assessment, 1978; "Solar-Terrestrial Data Access, Distribution, and Archiving, 1984; ' 'Geophysical Data Centers: Impact of Data-Intensive Programs, " 1976; and "Policy Issues Concerning Geophysical Data, (in review). From other groups: "Research Data Management in the Ecological Sciences, *Proceedings of the 1983 Integrated Data Users Workshop, Nov.* 1-2, *1983,* USGS, Reston, VA (Oak Ridge National Laboratory, TN); "Frontiers in Data Storage, Retrieval and Display, " *Proceedings of a Marine Geology and Geophysics Data Workshop, Nov. 5-7, 1980* (Boulder, CO: National Geophysical and Solar-Terrestrial Data Center, 1980); and *Proceedings of Marine Geological Data Management Workshop,* May 22-24, 1978 (Boulder, CO: NOAA, 1978). Several papers by Roy L. Jenne, Head, Data Support Section, National Center for Atmospheric Research, include: "Strategies to Develop and Access Large Sets of Scientific Data, " 1980 and "Data Archiving and Management, 1986.

[16] National Research Council, Space Sciences Board, Data *Management and Computation, Volume 1: Issues and Recommendations* (Washington, DC: National Academy Press, 1982).

Photo credit: Ted Spiegel

Banks of disk-drive units retrieve and store information at USGS headquarters in Reston, Virginia.

to superimpose many kinds of features, e.g., site-specific mineral samples on bathymetric maps that include information about the physical and chemical properties of an area. Aggregation of such disparate data sets makes EEZ data management particularly difficult.

Missing components in the current EEZ data programs are interagency/intergovernmental approaches, regional databases/datacenters, and private-public cooperatives. Activities that require attention include acquisition of wider ranges of data sets, preparation of comprehensive inventories of public domain data sets, quality control of existing data sets, and reformatting data sets so that they can be integrated for interdisciplinary research. An ***inventor-y*** of available data is needed along with an assessment of its adequacy.

Organization

The nucleus for a comprehensive data management system exists. A joint USGS/NOAA Office for Research and Mapping in the Exclusive Economic Zone[17] is being created to coordinate the plans and activities of these two major government agencies concerned with the EEZ and to provide a focus for activities of other government agencies and private academic and industrial institutions. 18 Many interagency agreements exist that provide for and/or encourage the transfer of geophysical and

[17]Charter to be released in 1987.

[18]One of the functions of this office will be to "develop a 10-year National EEZ plan to include goals, priorities, resources, and short/long term strategies. An annual report will be made to Congress outlining yearly activities, significant results, and recommendations.

oceanographic data from the collecting agencies such as USGS, MMS, and the Department of Defense (DoD) to the two major NOAA national data centers—the National Oceanographic Data Center (NODC) in Washington, D. C., [19] and the National Geophysical Data Center (NGDC) in Boulder, Colorado .[20]

Data collected by the academic community under the auspices of the National Science Foundation (NSF), Division of Ocean Sciences, should be ultimately submitted to the national centers. The Division's Ocean Data policy specifies that lists of all data collected under its sponsorship (primarily marine geology and geophysics data) ' 'be submitted to the appropriate NOAA/NESDIS [National Environmental Satellite, Data, and Information Service] national data center within 30 days of the completion of each cruise, that surface and mixed-layer temperature and salinity data "be submitted in real time" (i.e., within 48 hours of the observation), and that longer term data be submitted within 2 years. This policy seeks to ensure an appropriate balance between the needs of NSF researchers and secondary users. Producers, managers, and secondary users of oceanographic data have responded well to this policy; unfortunately, there is no mechanism for *mandating* transfer of the actual data at the completion of a grant period. Incentives to suppliers, such as reimbursement for the cost of copying data, formatting it in a standard way, and other hardware/software expenses would greatly facilitate archiving of data. The details of the NSF requirements are now under review, and a revised data policy is expected in early 1988. At the request of U.S. academic research scientists,[21] NSF agreed to explore with other Federal agencies whether the NSF ocean data policy could serve as the basis for development of a government wide ocean data policy. NSF has convened two meetings of agency experts to consider this question, This effort could result in a draft ocean data policy presented to each of the interested agencies for their review and adoption by the beginning of the 1988 fiscal year.[22]

Funding

Since fiscal year 1980, the base funding for NODC[23] and NGDC[24] has diminished in real dollars. At the same time, the workloads of both centers have increased, Estimates indicate that the digital data storage requirements for NODC will triple in the next 5 years and will double for NGDC.

Based on general operating budgets for some national data centers and funds spent for data collection operations by the Federal agencies, it is estimated that funds for storage are less than 1 percent of the funds spent on data collection. Some estimate that this proportion should be in the range of 5 to 10 percent. In contrast, the geophysical prospecting data industry commonly invests 10 to 200 percent of the costs of collecting marine data in processing and archival ;[25] the actual percentage varies depending on the cost of data acquisition—about 200 percent in the Gulf of Mexico where costs are low and 10 percent in less accessible regions such as the Beaufort Sea. As a result of chronically low funding, national data centers have been able to preserve only a small fraction of the collected data, and many important data sets have been lost.

Some fraction of this loss is likely due to the data collector and primary user not planning for or considering secondary use. But funding agencies must also bear some responsibility for ensuring that data are properly preserved and maintained. An appropriate amount of data management money should be included in grants—and not at the expense of funding for the research that collects the data.

---

[19] For example, an informal working agreement specifies that the Bureau of Land Management require its contract researchers to provide all data for archival in NESDIS centers (1978) and that the National Science Foundation require that appropriate data collected by researchers working under NSF Ocean Sciences sponsorship be provided to NESDIS centers as part of contract fulfillment (1 982).

[20] For example, Marine Geological and Geophysical Data Management Agreement, NOAA and USGS, April 1985; and Geological and Geophysical Data Dissemination Agreement, MMS and NOAA, May 1985. Other interagency understandings (with NSF, NOS, and DOD) are rooted in policy, precedent, and unilateral instruction but are not spelled out in formal interagency agreements.

[21] As part of planning for data management activities in support of the Tropical Ocean Global Atmosphere Study (TOGA) and the World Ocean Circulation Experiment (WOCE).

[22] L. Brown, National Science Foundation, pers. com. to Richard Vetter, OTA contractor, Apr. 13, 1987.

[23] NODC funding: Fiscal year 1982 ($4.5 million), Fiscal year 1983 ($4.6 million), Fiscal year 1984 ($4. 1 million), Fiscal year 1985 ($4.1 million), Fiscal year 1986 ($3.8 million), Fiscal year 1987 ($3.6 million.

[24] NGDC funding: Fiscal year 1980 ($3.1 million), Fiscal year 1981 ($3.1 million), Fiscal year 1982 ($3.1 million), Fiscal year 1983 ($3.0 million), Fiscal year 1984 ($2.8 million), Fiscal year 1985 ($2. 7 million), Fiscal year 1986 ($2.6 million).

[25] Carl Savit, western Geophysical Company, pers. com. to Richard Vetter, OTA contractor, Nov. 25, 1986,

According to NGDC, "If funding agencies abdicate their responsibility for the processing of data to a stage usable by others and the long-term preservation of the data, they have in fact created a burden for the scientific community and create the possibility of non-productive and redundant collections of data. "[26] When secondary usage is not planned for, it either takes large expenditures to "reconstitute' the data, or the data never become available to the secondary user.[27]

[26] M. S. Loughridge, "Frontiers in Data Storage, Retrieval, and Display, *Proceedings of the Marine Geology and Geophysics Data Workshop, Nov. 5-7, 1980* (Boulder, CO: National Geophysical and Solar-Terrestrial Data Center, 1980), p. 145.

[27] A simple library function can prevent data duplication. NGDC has a data base called GEODAS (Geophysical DAta System) which identifies where data have been collected and by whom. The new user is then faced with copying and converting the data.

SURVEY AND CHARTING EFFORTS

NOAA's National Ocean Service (NOS) and the USGS Office of Energy and Marine Geology are the civilian organizations with primary responsibilities related to acquisition and processing of bathymetric and geologic data within the U.S. EEZ. While source data should be archived in a national database (NGDC), the evaluation of data quality and processing of the data into maps and charts, digital or analog, is a responsibility which must continue as a part of the NOS and USGS missions. Effectively, NOS and USGS produce the Federal assessment of the best geographic depiction of these data. It is important that both agencies acquire the capability to establish and maintain these data sets in digital form. Without such efforts each individual user would have to judge data quality and process a myriad of data sets which would be a costly endeavor.

In 1984, USGS and NOAA signed a Memorandum of Understanding[28] to conduct joint mapping and survey efforts in the EEZ. Funds appropriated to USGS and NOAA have been increasingly reprogrammed to support this research over the last 3 years. Total EEZ exploration funds in the Federal agencies were $9 million in 1984, $12 million in 1985, and about $16 million in 1986 (table 7-l). Eighty percent of the money for EEZ exploration is within USGS and NOAA budgets; the GLORIA and multi-beam survey programs consume virtually all of this funding.

[28] Cooperative program for bathymetric survey by NOAA and USGS, signed by both J. Byrne and D. Peck, April 1984.

Table 7=1.-Funding for EEZ Programs

Agency	Fiscal year (million dollars) 1984	1985	1986
Department of Commerce:			
National Oceanic and Atmospheric Administration	1.0	4.4	[a] **5.0**
Department of the Interior;			
U.S. Geological Survey	4.7	5.1	8.4
Minerals Management Service	2.7	1.8	1.6
Bureau of Mines	0.3	0.2	1.2
Total funding	8.7	11.5	16.2

[a] A SeaBeam system was purchased for an additional $2 million.

SOURCE: Office of Technology Assessment, 1987

USGS: The GLORIA Program

The USGS GLORIA mapping program is intended to provide a complete and broad overview of the U.S. EEZ (see ch. 4). Currently, about 30 percent of the EEZ[29] has been surveyed with GLORIA. At the present rate, the entire U.S. EEZ will be covered by the end of 1996, The time lag between surveying and publication of maps is about 1 ½ years.[30] USGS intends to distribute GLORIA data to the public through NGDC; however, none has yet been archived. All of the swath data are digital and stored on magnetic tape. These data must be combined with navigational information to be of full value.

29 About one million square nautical miles.

[30] To date, the EEZ off the west coast (California, Oregon, Washington), in the Gulf of Mexico, and off Puerto Rico/U. S. Virgin Islands has been mapped. The *West Coast Atlas was* published in March 1985 on the second anniversary of the EEZ declaration, The *Gulf of Mexico Atlas will be* published in August 1987.

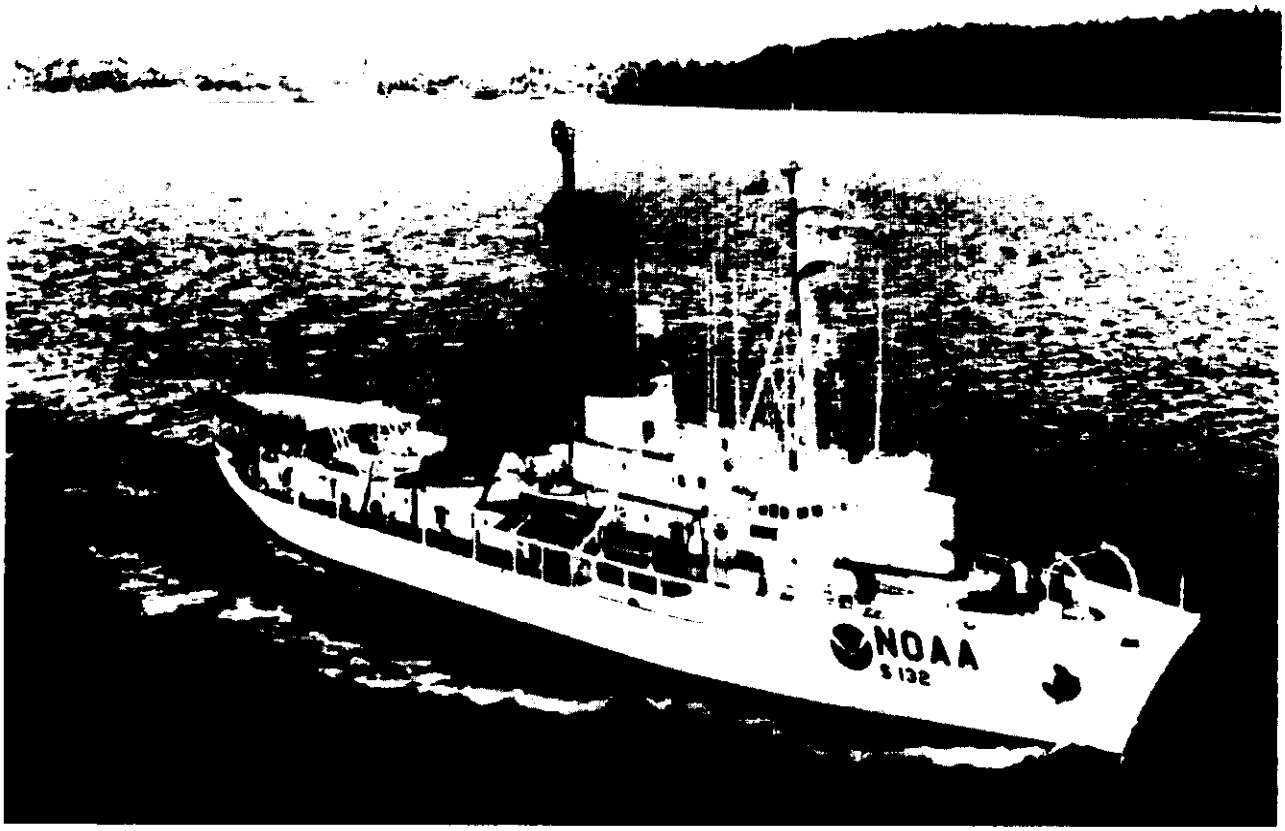


Photo credit: National Oceanic and Atmospheric Administration

The NOAA ship *Surveyor* is equipped with the Sea Beam system for detailed bathymetric mapping of the EEZ.

USGS considers the GLORIA program a ' 'showcase' success and is committed to its completion. However, recent budget cuts will at least delay if not permanently inhibit the project. The Office of Energy and Marine Geology had a budget of $24 million for marine geology in 1986. This is the total EEZ expenditure within USGS, which includes $18 million for salaries and overhead. The entire operating expenses budget of this office is spent on the GLORIA survey (see table 7-l). Only modest funds are expended on other activities, e.g., analyzing mineral contents of vibracores.[31] All Geological Framework studies were discontinued in 1982, also because of budget constraints. USGS has a contract through 1991 with the British Institute of Oceanographic Sciences (IOS) which operates the GLORIA equipment. If USGS cannot meet the terms of the contract, a significant financial penalty will be imposed and USGS could lose the GLORIA system. Although the United States is developing similar technologies, no system with the swath width of GLORIA will be available in the foreseeable future if the current system is returned to IOS.

[31] USGS estimates that two people spend 20 percent of their time analyzing mineral core samples. At this rate, the backlog of 1,000 cores will take 10 to 15 years to complete; plans to procure more cores from areas identified as economically promising based on this initial screening have been discontinued due to lack of funds.

NOAA: The Bathymetric Mapping Program

The National Ocean Service of NOAA is producing very detailed bathymetric maps of the EEZ using multi-beam or swath echo-sounders in conjunction with precise navigational positioning (see ch. 4). A bathymetric map can be constructed within 6 months of collecting multi-beam data, in striking contrast to the years needed to produce maps and charts manually. Individual field surveys

are typically processed in 3 weeks or less, provided no major system problems are encountered. Two mapping systems developed by the General Instrument Corp. are the Sea Beam system and the Bathymetric Swath Survey System (BS^3) used aboard ships of the NOAA fleet. A more modern version of BS^3 called Hydrochart II is now available from General Instrument. Japan has deployed the first system. NOAA intends to use Hydrochart 11 or its equivalent on the U.S. east coast and to upgrade BS^3 to the same system. Swath data are now classified (see the last section in this chapter).

NOAA has operated multi-beam survey ships since the mid to late 1970s. The EEZ swath mapping program began in 1984 and covered about 150 square nautical miles. During 1985, about 1 ½ ship-years were logged covering about 6,400 square nautical miles. In 1986, approximately 2 ship-years completed another 14,000 square miles. By the end of 1986, NOS had 3 ships in operation acquiring swath data, and about 1 percent of the total U.S. EEZ had been mapped. NOS staff estimate that it will take about 143 ship-years to survey the entire EEZ and that about 150,000 reels of magnetic tape will be required to store the entire set of original data. To date, about 6,000 magnetic tape reels of swath data have been recorded and stored. The storage problem is significant though not insurmountable. NOS is currently evaluating the possibility of using optical disk technology for long-term storage of EEZ bathymetric data. NOAA intends to archive all original data as a source database for use by other researchers. NOS will process the data into two gridded data sets:

1. Metric data in the UTM (Universal Transverse Mercator) projection to construct bathymetric maps, and
2. English (feet or fathom) data in the Mercator projection to construct nautical charts.

Both gridded data sets will be processed into digital graphics for use in electronic chart systems and the construction of map and chart hard copy graphics.

In conjunction with the swath data, other ancillary data are collected by ships. These data include 3.5 and 12 kilohertz underway bottom-profiling systems and surface weather observations .[32]

Since 1980, the budgets for mapping, charting, and geodesy programs in NOAA have shrunk 10 to 20 percent (unadjusted dollars). Ship support funds also have been reduced over this period. Currently, EEZ multi-beam efforts represent about 10 percent of the NOAA surveying and mapping activities. Bathymetric surveys are not a line item in the NOAA budget; the level of effort increases at the expense of traditional mapping and charting activities.[33] NOAA is increasing multi-beam survey efforts in 1987 to 418 sea-days at a cost of about $6.1 million .[34,35] Eventually, NOAA plans to apply similar technologies within nearshore regions using experience gained with the offshore systems.

[32] More detail on the NOS bathymetric mapping program may be found in the report of the December 1984 EEZ Bathymetric and Geophysical Survey Workshop, NOAA, March 1985.

[33] Three ships formerly assigned to charting now do mult i-beam surveys.

[34] Estimated from cost of ship-days in 1984-86.

[35] Appropriated $1, 1 million for an additional multi-beam system.

OTHER DATA COLLECTION PROGRAMS

The National Oceanic and Atmospheric Administration

In addition to the extensive program of bathymetric mapping using multi-beam systems (described above), NOAA collects and synthesizes biological, chemical, and physical characteristics of the ocean environment. Through NESDIS, NOAA controls the major data centers for EEZ data (NGDC and NODC).

The National Ocean Service

General Physical Oceanography Programs.—NOS is the major NOAA group systematically collecting physical and geological data from the EEZ. In addition to the relatively recent swath mapping program, NOS collects and maintains tidal data along the U.S. coastline. NOS has funded the development of a state-of-the-art database management system for much of these data as part of its ‘ ‘next-generation water level measurement system. ” Insufficient funds have been provided to put

all of the old data into this system, and some old strip charts and hand tabulations continue to be used. NOS also maintains wave data, but there is now no adequate archival system. Within the NOS Office of Oceans and Atmospheric Research, the Sea Grant Program and the two regional laboratories[36] collect data as well. These efforts tend to be more in the mode of exploratory short-term data collection rather than multi-year systematic surveys.

The Strategic Assessment Branch.—The Strategic Assessment Branch (SAB) of the NOAA Office of Oceanography and Marine Assessment conducts comprehensive, interdisciplinary assessments of multiple resource uses for the EEZ to determine marine resource development strategies which will benefit the Nation and minimize environmental damage or conflicts among users .[37]

SAB is producing a series of four regional atlases (see figure 7-1) whose maps combine the physical, chemical, and biological characteristics of resources and their environments with their economic, environmental quality, and jurisdictional aspects. The four atlases cover:

- the U.S. East Coast;
- the Gulf of Mexico;
- the Bering, Chukchi, and Beaufort Seas; and
- the U.S. west coast and Gulf of Alaska.

The maps cover a range of topics on physical and biological environments (geology, surface temperatures, aquatic vegetation . . .), more than 300 species of living marine resources (invertebrates, fishes, birds, mammals . . .), economic activities (population distribution, seafood production . . .), environmental quality (release of oil and grease discharge, bacteria . . .), and jurisdictions (political boundaries, environmental quality management areas . . .). In addition, each map is also in digital form in a computer data system with supporting software that provides the capability to prepare composite maps for combinations of species, life history, etc.[38] This capability may be used by visiting investigators.

About 200 copies of the U.S. East Coast Atlas of 125 maps were published in 1980.[39] The ***Gulf of Mexico Atlas (163*** four-color maps) was printed in 1985; the *Bering,* ***Chukchi, and Beaufort Seas Atlas (127*** maps) will be printed late in 1987. The ***West*** *Coast and* ***Gulf of Alaska Atlas is*** scheduled for 1988 publication.

A ' 'national" atlas of 20 maps on the health and use of coastal waters of the United States is also being produced. The first five maps published were: ***Ocean Disposal Sites, Estuarine Systems, Oil Production, Dredging Activities,*** and NOAA's *National Status and Trends Program.* Future maps are scheduled on hazardous waste sites, marine mammals, fisheries management areas and other similar topics.

Other SAB activities include an economic survey of outdoor marine recreation, a national coastal pollutant discharge inventory, a national estuarine inventory, a national coastal wetlands database, and a shoreline characterization.

National Marine Fisheries Service

The work of the National Marine Fisheries Service (NMFS) is done by 5 regional offices, 4 fisheries research centers, and 20 laboratories. The NMFS mission is: 1) to carry out national and international conservation and management of living marine resources, 2) to encourage the utilization and development of U.S. domestic fisheries and fisheries resources, and 3) to conduct bioenvironmental and socioeconomic research. Work that results in the production of EEZ oceanographic data is largely carried out by the laboratories of the four fisheries centers. Some NMFS data are made available to and become part of the NODC archives.

The NMFS has an automatic data processing Telecommunications Long-Range Plan, initiated in 1981. Currently, there is active interaction between the Seattle and Miami centers and among the North East Region laboratories. The Office of Management and Budget has approved funds to provide for a major upgrade of the system during fiscal years 1988 and 1989. Most of the "traffic" consists of data on catch efforts, socioeconomic fac-

[36]The pacific Marine Environmental Laboratory and the Atlantic Oceanographic and Meteorological Laboratory.

[37]C.N. Ehler D .J. Basta, T, F. LaPointe, and M .A. Warren, "New Oceanic and Coastal Atlases Focus on Potential EEZ Conflicts, " Oceans 29 (3), 1986, pp. 42-51.

[38]Two examples are shown in ch. 6, figures 3 and 4.

[39]Now out-of-print.

Figure 7-1.— Regional Atlases of the EEZ

Four atlases prepared by the Strategic Assessment Branch of NOAA depict environmental, economic, and jurisdictional information useful for **regional assessment** of **EEZ resources.**

SOURCE: National Oceanic and Atmospherlc Administration.

Underway Geophysics Collected in the EEZ

As the concentration of these ship tracks shows, a significant amount of geophysical information has been collected in the EEZ; however, much more mapping, sampling, and resource assessment remains to be done.

Source: National Geophysical Data Center, National Oceanic and Atmospheric Administration

tors, and administrative matters. NMFS biological-environmental data (i. e., oceanographic data) are mainly of regional interest and are shared within a region by more conventional means, such as direct exchange of "hard" or paper copy.

The National Geophysical Data Center

The mission of the National Geophysical Data Center (NGDC) is "to acquire, process, archive, analyze and disseminate solid earth and marine geophysical data . . .; to develop analytical, . . . and descriptive products; and to provide facilities for World Data Center A. '[40] Its Marine Geology and Geophysics Division (one of four divisions) covers most of the work of interest to the EEZ. The archives of this Division include some 10 million track miles of marine geophysical data, about 25 percent of which is in the U.S. EEZ. About half of the requests for data come from private industry. The next largest requesting groups are academia and the Federal Government.

Funding for NGDC activities has declined slightly from fiscal year 1981 through fiscal year 1987 while its archives and responsibilities have steadily increased. Future projections suggest an increase in data storage requirements of 600 percent (presuming only high-density magnetic tapes are used for storage) from fiscal years 1986 to 1992.

NGDC data are processed and made available to a worldwide community of clients through series of 'Data Announcements' on topics ranging from

[40] The World Data System A was established as part of the International Geophysical Year 1956-57 to foster data exchange between countries. World Data System A coordinates information from "free' world countries; World Data System B, from Soviet bloc countries.

common depth point seismic reflection data for specific regions of the U.S. continental shelf, to core descriptions for special areas, to high-resolution seismic reflection data, to magnetic and gravity data, to the latest data sets from the deep sea drilling project, to ice-gouge data. These announcements provide users with detailed information on the characteristics of the particular data set being offered, including related data sets, costs, and available formats.

The Marine Geology and Geophysics Division has two interactive systems for accessing worldwide marine geophysical data and geological data in the sample holdings of the major U.S. core repositories. Using software developed by the Division, a user can specify geographic area, type of geophysical measurement, sediment/rock type, geologic age, etc., and receive inventory information at a computer terminal. First operational in June 1978, these two systems are used primarily by Division personnel, but there has been experimental use at remote terminals by the staffs of Scripps Institution of Oceanography and other core repositories under data exchange agreements with NGDC and other Federal agencies. NGDC hopes to make three other data sets similarly accessible for users:

1. multi-beam echo-sounder data from NOS and other collecting institutions,
2. side-looking sonar data, and
3. digital multi-channel seismic reflection data if demand and funding warrant.

NGDC staff states that most users of Division data do not need "on-line"[41] access; NGDC typically satisfies most inquiries by performing tailored searches of the data for the requestor.

Types of EEZ data held by NGDC are Marine Geological Data Bases, Bathymetry and Marine Boundary Data Bases, and Underway Geophysical Data. In terms of numbers of reels of data stored and in rates of acquisition in bytes[42] per year, the Underway Geophysical Data sets dominate the NGDC inventory (97 percent). Most of the data sets are collected in digital form and stored on magnetic tape.

[41] Interactive access to the data.

[42] One byte is the amount of computer memory used to store one character of text.

Marine Geological Databases.—There are four major categories in the geological databases: Marine Core Curator's (MCC), Marine Minerals (MM), Digital Grain Size (DGS), and Miscellaneous Geology Files (MGF).

- All of the data sets are digital, aggregated, and stored on magnetic tape except for the MGF. The amount of MGF data stored is on 20 reels of magnetic tape. The sum of the other categories is about 14×10^6 bytes, half of which are DGS data. All sets combined are on 23 reels of magnetic tape.
- The average delay between sampling and reporting is 10 years for DGS and MGF data and 2 and 5 years respectively for MCC and MM data. All four categories are provided on request.
- All data are acquired from academic or government laboratories ranging from 90 percent academic for MCC to 90 percent government for DGS. The sum of the acquisition rates for MCC, MM, and DGS is about 140 kilobytes per year (100 kilobytes per year for GDS) with MGF acquiring about 1,000 stations per year.
- Future uses are expected to increase by about 1 percent per year for MCC and GDS, 2 percent per year for MM, and 5 percent per year for MGF.

Problems Handling Geological Data.—Marine sediment and hard-rock analyses present unique data management challenges. Unlike bathymetry, for example, data volume presents no real obstacle to geological data storage and retrieval. The problem lies in the descriptive, free-form, nonstandard nature of the data. There are nearly limitless varieties of analyses performed on sediment and hard-rock samples, each analysis requiring suitable documentation to make the data usable. Decisions must be made as to which types of analyses merit creation of a database and, for each type of data selected, which analyses or measurements should be stored. These decisions require input from the marine geological scientific community to be combined with data management practices to produce databases that satisfy user requirements. The nonstandard form of marine geological data also makes compilation of data very labor-intensive. Much of the data must be hand encoded from descriptive data reports and other sources and entered into the

computer, in contrast to geophysical data which are collected digitally in a relatively uniform manner.

Bathymetry and Marine Boundary Databases.—There are four kinds of data sets included in this category: NOS Hydrographic Surveys (NOS/HS), NOS Multi-beam EEZ Bathymetry (NOS/MB), Gridded Global Bathymetry (GGB), and Marine Boundary (MB).

- The most valuable EEZ data sets in this group are those from the National Ocean Service. All NOS hydrographic surveys that are available in digital form are archived and merged into an accessible database at NGDC. All four data sets (except NOS/MB) are collecting data, are all in digital form, and all are unedited. NOS/MB data are aggregated, and NOS/HS data are reformatted to be accessible by location. (The NOS/MB data are "on hold' as a result of classification.) All data sets are on magnetic tape.
- The time lag for reporting NOS/HS data is about 2 years. All but the NOS/MB data are made available to others on request.
- The NOS/HS data are acquired at about 42 megabytes per year from the NOS. GGB was a one-time data acquisition from academic and DoD sources.
- Annual increases in uses for NOS/HS and MB data are estimated at 5 percent and GGB at 15 percent. (There is no EEZ multiple-beam bathymetry on file at NGDC because of data classification, and no acquisition is planned. NGDC does plan to index the location of survey tracklines so that operators of multi-beam systems can avoid duplication.)

Problems with Bathymetric and Boundary Data. —Transmission of survey data between NOS and NGDC has been irregular over the years, primarily because the digital versions of surveys have not been important to the nautical charting effort at NOS. Over the last 3 years, NGDC has made a consistent effort to obtain and catalog a large backlog of surveys stored at NOS headquarters. Availability of other bathymetric data sets depends *on* DoD classification policies. Marine boundary data are available, though they need to be centralized to be readily accessible. NGDC has the U.S. EEZ boundary points (produced by NOS) and the outer continental shelf lease area boundary points (produced by USGS). NOS is compiling and distributing a detailed set of boundary points for the U.S. coast; these data have not been submitted to NGDC.

Underway Geophysical Data.—Four kinds of underway data are included in this category: Underway Marine Bathymetry (MB), Underway Marine Seismic Reflection (MSR), Underway Marine Magnetics (UMM), and Underway Marine Gravity.

- About 25 percent of the Underway Geophysical Data are taken in the EEZ. Data are increasing in all sets. Except for MSR, most of the data are in unaltered digital form stored on magnetic tape. The MSR data are 45 percent on paper, 40 percent on microfilm, and 15 percent on magnetic tape. While 85 percent of the MSR data are analog, the MSR digital archive alone totals about 3,000 reels of low-density tape. The remaining 3 digital sets total about 5 million records on 10 high-density reels, about half of which are MB.
- The average delay from sampling to reporting for all sets is about 5 years, All data are made available upon request.
- The combined rate of accumulation of data for all sets is about 100 megabytes per year.
- Future use for all sets is estimated to increase at about 25 percent per year.

Problems and Successes with Underwa$_y$ Data. —An internationally accepted format for underway geophysical data is in general use. Flow of data to NGDC has been good from the Minerals Management Service, U.S. Geological Survey, Scripps Institution of Oceanography, Hawaii Institute of Geophysics, Lamont-Doherty Geological Laboratory, and the University of Texas at Austin. Other institutions' performances in submitting data have been spotty because they have not practiced centralized long-term data management. A considerable amount of data from some institutions has been lost or dispersed in laboratories.

The National Oceanographic Data Center

The mission of the National Oceanographic Data Center (NODC) is to acquire, archive, manage, and make oceanographic data available to secondary users. NODC has served in this capacity since

Photo credit: W. Westermeyer

Marine analysts examine instrumentation aboard the dredge *Mermentau.*

its formation in 1961 and probably now has the world's largest unclassified collection of oceanographic data.

About 95 percent of the EEZ data obtained are in digital form, the rest is in analog form. All of the data are stored on magnetic tape and comprise about 650,000 stations, equivalent to about 135 reels of magnetic tape or about 4 gigabytes. The time-lag from sampling to reporting ranges from 1 to 5 years. The rate at which data are acquired is about 650 megabytes per year, due mainly to inputs from a few high data-rate devices such as current meters.

NODC has been pivotal in the development of several data management activities that involve data that is entirely, or at least mainly, taken in the EEZ:

Outer Continental Shelf Environmental Assessment Program (OCSEAP).—OCSEAP is a comprehensive multi-disciplinary environmental studies program initiated by BLM to provide environmental information useful in formulating Alaskan oil and gas leasing decisions. Starting from a modest $100,000 data collection program in 1975, OCSEAP had assembled by the end of 1984 over 2,500 data sets covering more than 100,000 stations and consisting of more than 4 megabytes. During the early stages of this program, a great deal of effort was devoted to the development of data formats and codes that would support the needs of investigators and be compatible for preprocessing and converting to digital form prior to submission to NODC.

National Marine Pollution Information System (NMPIS).—NMPIS is essentially an annually updated catalog of thousands of marine pollution-related projects carried out or supported by dozens of Federal agencies. The catalog includes types of projects, types of data and/or information covered, geographic distribution, quantity of data/information, means of access, costs, and principal contacts.

Marine Ecosystems Analysis (MESA) Project.—MESA is a cooperative program between NOAA and the Environmental Protection Agency (EPA) to conduct baseline marine environmental measurements primarily in the New York Bight, New York; and Puget Sound, Washington, areas. This program, which began in 1978 and completed its data collection phase by 1983, resulted in more than 2,000 marine environmental data sets consisting of over 200,000 stations. NODC now holds these data in appropriate files in the National database.

Strategic Petroleum Reserve/Brine Disposal Program.—This NOAA program began in 1977 to provide assessment information to the Department of Energy (DOE) on environmental effects of brine discharge into the Gulf of Mexico. Baseline marine environmental measurements from monitoring efforts at discharge sites consisting of over 87,000 stations have been archived by NODC.

California Cooperative Fisheries Investigations (CALCOFI).—The CALCOFI program, largely supported by the State of California, makes oceanographic observations in conjunction with fisheries studies at a grid of stations in the California Current region off the California coast. Begun in 1949, this program has produced physical/chemical oceanographic data consisting of more than 370 data sets of over 16,500 stations which are now held by NODC.

New Efforts Underway at NODC Involving EEZ Data.—A cooperative agreement has been

signed between NOAA's National Ocean Service (NOS) and NODC to develop an Alaska regional marine database in Anchorage, Alaska, at the Office of Marine Assessment Ocean Assessment Division. NODC and NOS are both providing copies of their data holdings in the Alaska EEZ region and will provide routine updates every six months. Database maintenance will be done in Anchorage, and a full database copy will be available at the Ocean Assessment Division there and at NODC.

Consideration is being given to creating Level II satellite data sets for the EEZ at NODC. While massive global satellite data archives are available from the Satellite Data Services Division of the National Climatic Data Center, investigators require easier data access than is now possible. NODC is presently archiving and distributing data from the U.S. Navy Geodetic Satellite which provide full EEZ coverage as part of the satellite Exact Repeat Mission.

Prototype Coastal Information System Using a Personal Computer.—In 1986, NOAA developed a prototype coastal information system for the Hudson-Raritan Estuary. The system is designed for use by regional planners, environmental specialists and managers, and citizen groups with access to an IBM compatible personal computer. Information is accessed by file directory, menu, and glossary and provides output as map sections and vertical profiles with a wide variety of properties ranging from temperature through water depth.

Problems with NODC Data.—Data quality is a continuing concern for both NODC and researchers using NODC data. To address this issue, a series of 'Joint Institutes' between NODC and various research laboratories has been initiated. These institutes are located on-site at the laboratories. Data are collected, pre-processed, and checked for quality by the program's principal investigator(s) or their staff(s) before being provided to NODC for archival. One such "Joint Institute" for subsurface thermal data from the Tropical Ocean Global Atmosphere Study (TOGA) program is now operating at the Scripps Institution of Oceanography, and others are planned, depending on resources, for other programs at the University of Hawaii and the University of Delaware.

Another problem is the large number of organizations collecting marine environmental data in varying formats, employing various levels of quality control. This situation makes it both expensive and difficult to manage resulting data to the satisfaction of an equally large user community. NODC does not have financial or staff resources to routinely reformat and uniformly quality control every data set received for archival.

U.S. Department of the Interior

Minerals Management Service

The Minerals Management Service (MMS) carries out programs to implement the EEZ proclamation through its Office of Strategic and International Minerals. The programs include: formulating a mineral leasing program for non-energy minerals; establishing joint Federal-State task forces in support of preparation of lease sale EISs through cooperative agreements; providing support for data-gathering activities of other Federal and State agencies and universities; and developing regulations for prospecting, leasing, and operations for Outer Continental Shelf/EEZ minerals.

The MMS administers the provisions of the Outer Continental Shelf Lands Act (OCSLA) through regulations codified in Title 30 of the Code of Federal Regulations. The regulations govern permitting, data collection and release, leasing, and postlease operations in the outer continental shelf. The regulations prescribe:

- when a permit or the filing of a notice requires geological and geophysical explorations to be conducted on the outer continental shelf; and
- operating procedures for conducting exploration, requirements for disclosing data and information, and conditions for reimbursing industry for certain costs.

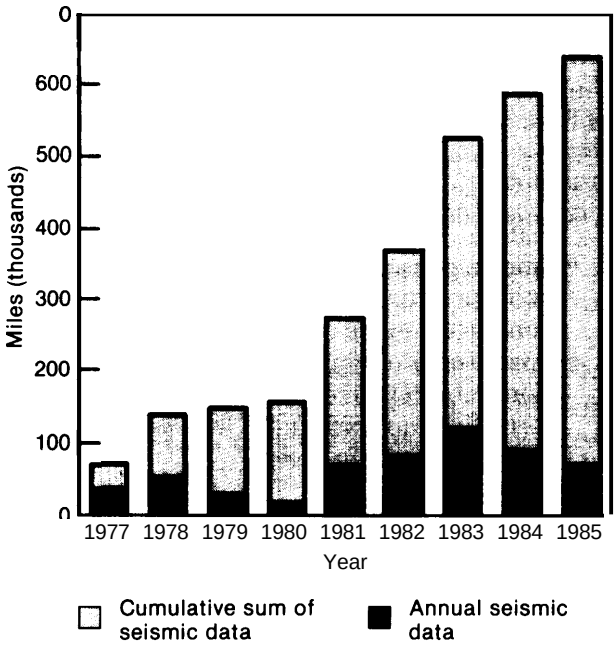
Prior to 1976, common depth point (CDP) seismic data were primarily acquired by the government through nonexclusive contracts or as a cost-sharing participant in group shoots. As the cost of

acquiring these data increased, the concept of obtaining the data as a condition of permit was developed. Starting in 1967, the MMS has reimbursed industry permitters for reproduction costs of acquired CDP seismic data. Recent costs for such data have averaged about $600 per mile. The MMS now holds about 1 million miles of such data, of which about 260,000 miles was acquired before fiscal year 1976 and could continue to be held as proprietary indefinitely. Data acquired after 1976 are held as proprietary by the petroleum industry for a period of time. MMS is about to propose a rule increasing the hold on such geological data from 10 to 20 years. Additionally, the agency is considering prohibiting the release of any geophysical data until the new rule goes into effect .[43] The effect of this new policy would be to shut off most industry-collected data from reaching the public for another decade. Approximate amounts of CDP data remaining in MMS archives for the years 1977 through 1985 are shown in figure 7-2.

Ninety-five percent of the CDP data are collected in digital form, with the remainder analog. Of the portion stored by MMS, 95 percent are stored on Mylar film with the remainder on magnetic tape. Except as noted above, none of the data are available to the general public. Industry is the source of all of the data and MMS expects future acquisition rates to continue at about the same rate as the past few years. These data are acquired as a condition of offshore geological and geophysical permits issued under the terms of the OCSLA. There are no problems obtaining the data, so long as MMS has the funds to reimburse the permittee for the duplication costs. MMS also collects physical oceanographic data, which accounts for about 25 percent of the MMS Environmental Studies program. These data are obtained by MMS contractors; MMS contracts now specify that data obtained under contract are to be provided in digital form to the NODC.

[43] T. Holcomb, NOAA/NGDC, Apr. 24, 1987, and D. zinger, MMS Reston, Apr. 27, 1987, personal communications to OTA.

Figure 7-2.—MMS Seismic Data



SOURCE: Office of Technology Assessment, 1987.

U.S. Geological Survey

The U.S. Geological Survey (USGS) is the dominant civilian Federal agency that collects marine geological and geophysical data. USGS conducts regional-scale investigations aimed at understanding and describing the general geologic framework of the continental margins and evaluating energy and mineral resources. About 60 percent of the EEZ data collected are in digital form. The ‘ ‘raw’ field data are usually stored for some lengthy period for possible direct access. About two-thirds of the data must be merged (aggregated) with other data (usually navigation data) in order to be of value. The total amount of EEZ data collected to date is stored on about 50,000 reels of magnetic tape and is being accumulated now at about 200 reels per year. The time lag from collection to reporting is about three years for publication in a scientific journal and about one year for a seminar or an abstract at a meeting.

Future acquisition of EEZ data is expected to increase approximately 10 percent per year, mainly because new equipment allows more information to be collected per ship mile. In the past, all USGS data were copied and sent to NGDC. This policy continues except for digital seismic data; only summaries of these data are sent. NGDC then an-

nounces the availability of such data sets and, if demand warrants, the data are then sent to NGDC.

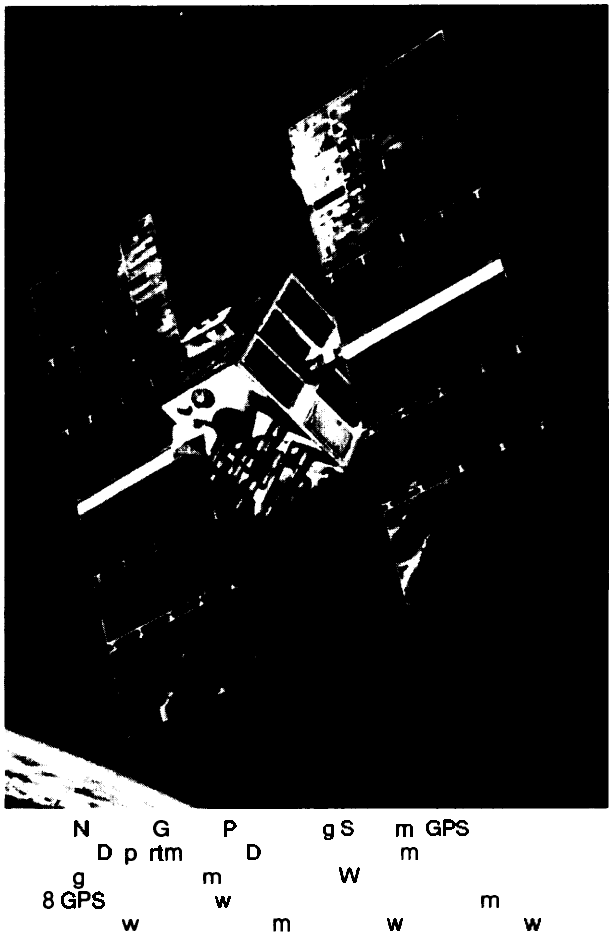
Bureau of Mines

While the Bureau of Mines (BOM) does not actively collect and archive EEZ data, BOM is a prime user of information collected by other groups. Programs related to the EEZ include development of technologies that will permit recovery of mineral deposits from the ocean floor, studies of beneficiation and processing systems, economic analyses of mineral extraction, and assessment of worldwide availability of minerals essential to the economy and security of the United States.

National Aeronautics and Space Administration

The National Aeronautics and Space Administration (NASA) flies a number of satellites carrying sensors (passive and active) that measure many ocean surface properties including temperature, color, roughness, and elevation. From these measurements, a-number of important properties of the ocean can be estimated, including biological productivity, surface wind velocity, bottom topography, and ocean currents. All of these satellites obtain some small but significant percentage of their data while over the EEZ. The bulk of the ocean program data archived by NASA is located at the National Space Science Data Center at the Goddard Space Flight Center, Greenbelt, Maryland, and at the NASA Ocean Data System centered at the Jet Propulsion Laboratory, Pasadena, California. Scientific analysis of the data is performed by researchers at the two laboratories and at universities around the country.

Both laboratories are currently collecting EEZ-related data. About 80 to 100 percent of the data are digital with spatial scales of hundreds to thousands of yards and temporal scales of hours to days. Most of the data are stored in raw form on 27,000 reels of high-density magnetic tape. The time lag between data sampling and reporting is between one and two years; these data are available to



others. NASA acquires data at the rate of about 10^{12} to 10^{13} bytes per year, which is expected to increase significantly in the future.

NASA has developed pilot data management systems that have successfully demonstrated concepts such as interactive access to data previewing and ordering. These programs allow users to actually view the data available; the programs will not be fully operational before the early 1990s.

The "NASA Science Internet" (NSI) program was created in 1986 to coordinate and consolidate the various discipline-oriented computer networks used by NASA to provide its scientists with easier access to data and computational resources and to assist their inter-disciplinary collaboration and communication. NSI is managed by the Information

Systems Office within NASA's Office of Science and Applications. The Ames Research Center in Sunnyvale, California, is responsible for technical implementation of NSI. NSI services include consolidating circuit requests across NASA disciplines, maintaining a database of science requirements, disseminating information on network status and relevant technology, and supporting the acquisition of network hardware and software.

Science networks with the NSI system include the Space Physics Analysis Network, the Astronomy Network (Astronet), the network for the Pilot Land Data System, and the network planned for the earth science program. Currently, these networks support approximately 150 sites accommodating 2,000 scientists. Growth in use has been 20 to 40 percent each year across all science disciplines. NSI will coordinate links between NASA networks and networks of other agencies as well, such as NOAA, USGS, and NSF.

The West Coast Time Series project converts raw satellite data to ocean chlorophyll concentrations and sea surface temperatures (useful for studies of biological productivity and ocean circulation) in formats agreed to by the scientific user community, and provision has been made for efficient data distribution.

Problems Handling NASA Data.—Users say it is difficult to obtain complete and timely responses to requests for satellite data.[44] This problem appears to be due to lack of funds to develop and operate efficient data archival and distribution facilities for secondary users.

It is currently impossible to get satellite data archives to copy very large data sets—thousands of tapes—so the ' 'archive' is basically a warehouse of information with limited distribution capacity.

U.S. Navy

The U.S. Navy has a global marine data collection program that is among the largest in the world. Data collection by the Navy is not necessarily focused in the U.S. EEZ; therefore it is difficult to estimate how much of the Navy's data relate to the EEZ. The Navy's marine data collection includes bathymetry, subsurface currents, seismic profiles, bottom samples, visibility, some water chemistry and biology, vertical profiles of physical properties (such as temperature, conductivity, and sound velocity), acoustic character, magnetics, gravity, and some side-scan sonar and bottom photography. Most of the data are either classified or under controlled distribution to the Department of Defense or its contractors.

Some data are collected, corrected, and filtered before being archived at the Naval Oceanographic Office; in most cases, the original/raw data are also retained. Analog data are stored in their original form. Most of the data are stored on magnetic tape, some on floppy disks, and some on paper records. Some unclassified oceanographic data are forwarded to NODC, principally through the Master Oceanographic Observation Data Sets, and some unclassified geological/geophysical data, including unclassified bathymetric data, sediment thicknesses, and magnetics are forwarded to NGDC. The Navy is a significant user of unclassified data obtained principally from NODC and from academic laboratories working under Office of Naval Research contracts. Future use of data is expected to remain at about the present level with no particular focus on the EEZ.

Currently, the U.S. Geological Survey's GLORIA data are not subject to classification. NOAA multibeam depth data, however, are sufficiently detailed that they are now classified as confidential by agreement of the National Security Council, and the Navy has recommended that this classification be upgraded to secret. Although the NOS is continuing to collect multi-beam data, the NOS data are being treated as classified (see next section). No Sea Beam data are currently being forwarded to NGDC from any source, and thus no such data are released in response to requests from foreign countries.

The Navy's Office of Naval Research supports a set of unclassified basic research contracts (mainly with academic institutions) that obtain data in the EEZ. Some of these are: Coastal Dynamics (to improve prediction of coastal ocean environmental

[44] This problem was mentioned by many other agencies and educational institutions and is outlined in the 1982 NRC report *Data Management and Computation,* Vol. 1.

conditions), Coastal Transition Zone Oceanography (to advance understanding of upper ocean dynamics in regions influenced by the proximity of a coastal boundary), and Sediment Transport Events on Shelves and Slopes (to understand the underlying physics of and develop a new predictive capability for sediment erosion). Small amounts of unclassified Navy EEZ data are provided to the NOAA national data centers.

State and Local Governments

Most, if not all, coastal States are collecting and/or managing EEZ data. Though a major share of their needs is being met by national centers, most must obtain some data from other sources (industry, academic laboratories, and their own facilities).

To determine the amount and characteristics of EEZ data being collected and/or managed by coastal States, OTA sent questionnaires to the State geologists (members of the Association of American State Geologists) of the 23 coastal States. Sixteen replied. Analysis of the responses revealed that:

- Roughly 75 percent of State data exist in analog form. Only one (the Oregon Department of Geology and Mineral Industries) collects most of their data in digital form. Approximately 80 percent of the data are stored on paper only.
- The most usual time lag between sampling and reporting was 1 year, ranging from 1 month to 3 years.
- Without exception, those who have data make it available to others. Most of this activity is in response to individual requests.

Problems Handling State Data.—Even where State digital data sets exist, transfer to other users has been difficult because of lack of a standard format. The greatest need expressed by the States is for the establishment of a system to insure a regular exchange of information and to encourage the coordination of activities on local, regional, and national levels.

Academic and Private Laboratories

The academic laboratories vary widely in size, scope, and sophistication. They range from the 10 major oceanographic institutions which are members of the Joint Oceanographic Institutions[45] to the hundreds of smaller coastal and estuarine laboratories. Many of them maintain their own data archives. Those undertaking research sponsored by the NSF Division of Ocean Sciences and and/or located near the five NODC liaison offices (at Woods Hole, Massachusetts; Miami, Florida; La Jolla, California; Seattle, Washington; and Anchorage, Alaska) routinely provide their data to NODC and/or NGDC. About 20 percent of NODC's present archive has come from the academic and private laboratories and recently the annual percentage acquired from them is even greater—42 percent in 1985 and 35 percent in 1986. NODC staff credit the National Science Foundation's Ocean Sciences Division's ocean data policy as a contributing cause to this increase.

Academic and private laboratories respond to the ''market place'' in their handling of unclassified oceanographic data. Thus, the solution to data management problems lies with those who control the market, mainly the Federal agency sponsors of academic research. Effective processing of data collected on academic ships may depend on inclusion of funds in the research project specifically for the purpose of data reduction. In NSF, the Division of Ocean Sciences budgets for this activity, but the Division of Polar Programs does not.

Some of the smaller laboratories have minimal involvement in either using or producing EEZ data. Networks for regional data exchange would help to alleviate this barrier.

Industry

Private industry has been a relatively minor source of data for the national archives, amounting to only 4 percent of the total NODC data. However the present annual percentage for NODC increased abruptly to 6 percent in 1985 and then to 14 percent in 1986. NODC staff attributes this increase to recent practices by some government agencies contracting for oceanographic survey work (e.g., MMS) to specify that unclassified data be provided to data centers.

[45] Scripps institution of Oceanography, Woods Hole Oceanographic institution, University of Washington, University of Miami, Lamont-Doherty Geological Observatory, Texas A&M University, University of Rhode island, Oregon State University, Hawaii Institute of Geophysics, and the University of Texas.

OTA surveyed 10 industrial organizations (primarily geophysical firms) actively collecting and/or utilizing EEZ data, with these results:

- About 75 percent of the companies contacted collect all or part of the EEZ data that they use, and almost all of the data are digital. Predominately, the stored data are unaltered and on magnetic tape.
- One major geophysical prospecting company far outstripped the combined total of stored data by all other companies—10^{14} bytes—amounting to a total of about 2 million reels of magnetic tape. The other companies ranged from a few reporting hundreds of reels of magnetic tape to the remainder utilizing only a few tens of reels.
- Most of the companies make their data available only through purchase. A few reported providing data to national data centers, especially those collecting data for a Federal agency under contract.
- Estimates of future increase or decrease of use were highly variable and were indicated as being sensitive to future economic conditions, particularly in terms of variability of costs of EEZ resources (e. g., oil).

Problems Handling Industry Data.—Government agencies frequently replicate data that private companies have "in-house. Such duplication of efforts is extremely costly. Some industry spokespersons believe that Federal survey programs are unfairly competitive with industry surveys. On the other hand, private industry often retains details related to their surveys as proprietary information. Federal access to details creates an awkward situation in that once survey data are in Federal hands, they can be accessed by others through the Freedom of Information Act. A centralized index of industry surveys similar to the NGDC GEODAS (Geophysical DAta System) system is needed so researchers will know what private sector data exist, thereby avoiding potential duplication.

CLASSIFICATION OF BATHYMETRIC AND GEOPHYSICAL DATA

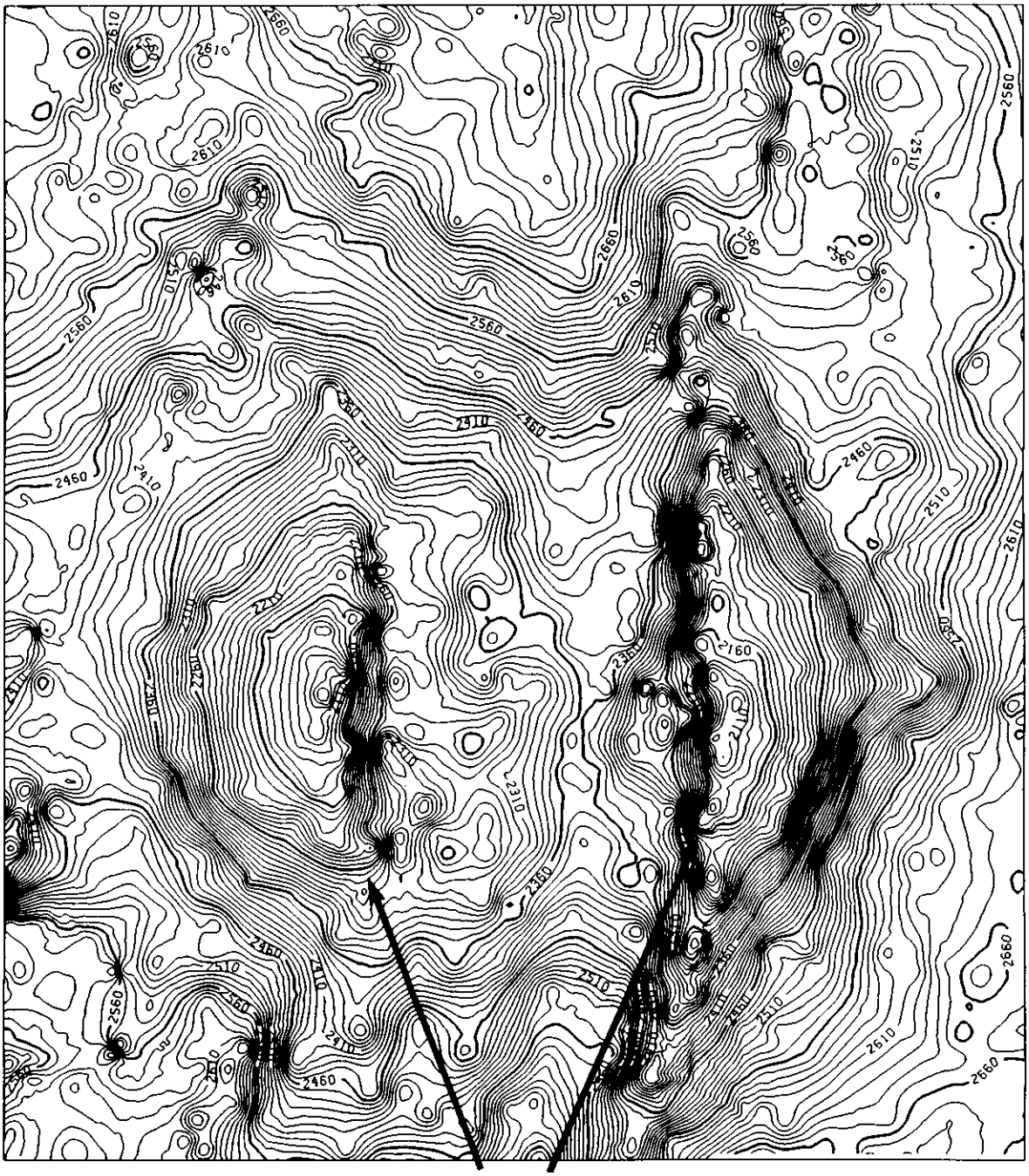
Multi-beam mapping systems, e.g., Sea Beam and the Bathymetric Swath Survey System—BS^3, can produce bathymetric maps of the seabed many times more detailed than single beam echo sounding systems (figure 7-3, for example). This new generation of seabed contour maps approaches—and sometimes exceeds—the accuracy and detail of land maps and provides oceanographers a picture of the deep ocean floor not available a scant decade ago. Prior to 1979, before the first NOAA research vessel ***Surveyor*** was equipped with Sea Beam, the U.S. oceanographic community only had available low-resolution bathymetric maps that were suitable for navigation and general purposes but lacked the detail and precision needed for science.

Some marine geologists and geophysicists consider the development of multi-beam mapping systems to be their profession's equivalent of the invention of the particle accelerator to a physicist or the electron microscope to a biologist. Now that the technological threshold for sensing the intricate details of the landforms beneath thousands of feet of ocean water has been overcome, oceanographers believe that tremendous strides can be made in exploring the seabed and understanding the processes occurring at great ocean depths.

The convergence of two advanced technologies—multi-beam echo sounders and very accurate navigational systems—provides the basis for extremely detailed maps of the seabed that are spatially accurate in longitudinal and latitudinal position on the earth's surface as well as precise in determining the depth and landforms of the undersea terrain. Multi-beam systems, when used in conjunction with the satellite-based Global Positioning System, can produce charts from which either surface craft equipped with the same shipboard instruments or submarines with inertial navigation and sonar systems can navigate and accurately position themselves.[46] If geophysical information, e.g., gravity and magnetic data, is superimposed over the mapped region, its value for positioning and navigation is further enhanced. A 1987 workshop of Federal, private, and academic representatives

[46] R. Tyce, J, M iller, R. Edwards, and A. Silver, "Deep Ocean Pathfinding-High Resolution Mapping and Navigation, " *Proceedings of the Oceans* '86 *Conference* (Washington, DC: Marine Technology Society, 1986), pp. 163-168.

Figure 7-3.—Map of the Surveyor Seamount Straddling the Juan de Fuca Ridge Produced With Sea Beam Bathymetry



The contours depict water depth in meters. The split in the mountain was caused by seafloor spreading. This map shows only 2 percent of the data (about 400,000 data points) obtained by Sea Beam. The detailed features obtained with Sea Beam encouraged scientists to study this area more closely; evidence of recent volcanism has unexpectedly been found.

Source: National Oceanic and Atmospheric Administration

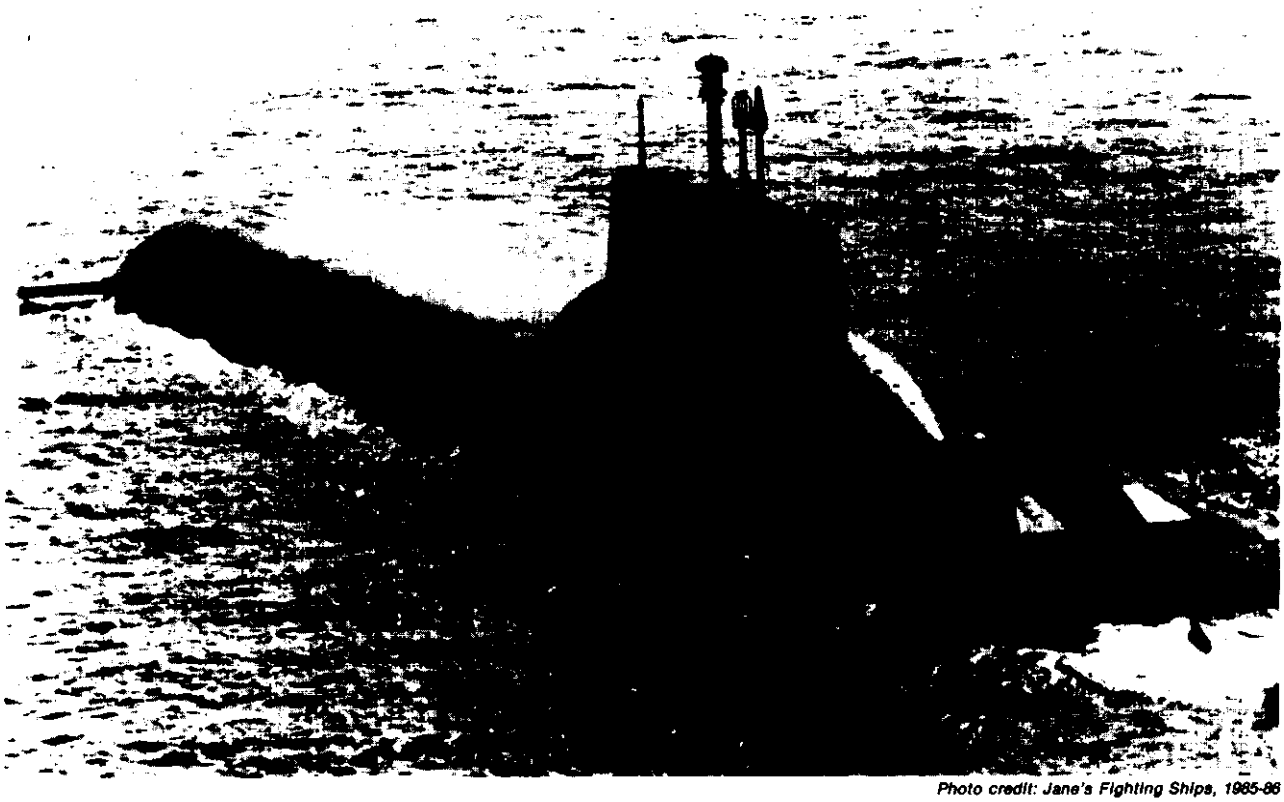


Photo credit: Jane's Fighting Ships, 1985-86

A *Typhoon* class submarine can operate in any ocean of the world and still have her main targets within range.

concluded that NOAA should acquire geophysical data that would not hinder the timely acquisition of the bathymetric data.[47] Classification stymied NOAA's effort to form a cooperative arrangement with industry and academia. Thus, to date, NOAA has not acquired gravity or magnetic data.

While the capability to identify subsurface terrain features and accurately determine their position is a boon to scientists seeking to locate and explore geological features on the seafloor, it presents a potentially serious security risk if used by hostile forces. Because of the security implications, the U.S. Navy, with the concurrence of the National Security Council's National Operations Security Advisory Committee, initiated actions to classify multi-beam data and restrict its use and distribution.

Modern undersea warfare requires that submarines, once submerged, remain submerged to avoid detection. When submarines operate globally, this long-term submergence presents significant navigational problems. Inertial guidance systems and other navigational gear must be occasionally updated with precise locational information if the submarine's position is to be determined accurately. One means for doing this is by fixing terrain features on tie ocean bottom and triangulating within them to determine the vessel's position. With detailed' bathymetric maps and precise geodesy, modern acoustical detectors and onboard computers are capable of precisely fixing a submarine's position without having to surface and risk detection. Little imagination is needed to understand the security implications of high-resolution bathymetry. Bathymetric data may also affect other aspects of undersea warfare, including acoustical propagation and mine warfare countermeasures.

In 1984, NOAA centered its bathymetric data collection in the NOAA ships Surveyor (equipped

[47]The OTA Workshop on Data Classification was held Jan. 27, 1987, at Woods Hole Oceanographic Institute, under the auspices of the Marine Policy and Ocean Management Center.

with a Sea Beam system) and the ***Davidson*** (equipped with BS[3]) and announced long-range plans to systematically map the U.S. EEZ. NOAA's plans for comprehensively mapping the EEZ at a high resolution—depth contours of 10-20 meters, and geodetic precision of 50-100 meters—have been challenged by the Navy, and the two agencies have since entered into protracted negotiations in search of a workable solution, but in the summer of 1987 significant problems remained unresolved .48

Marine scientists and private commercial interests are concerned that the Navy may classify NOAA bathymetric and geophysical data. Whenever data classification is at issue, the reasons for the security restrictions themselves are considered sensitive, thus opportunities are limited for public review of the need and extent of restrictions or for consultation to identify possible compromises to balance security risks and scientific needs. In general, both the oceanographic community and private industry have not been involved in the negotiations between NOAA and the Navy to the degree that the non-government interests believe they should be, given their stake in the outcome of the classification decision. Even some scientists within NOAA feel alienated from the process.

Earlier Reviews of Data Classification

In 1985, the Director of the White House Office of Science and Technology Policy requested that the National Academy of Sciences (NAS) review the National Security Council's position that public availability of broad-coverage, high-resolution bathymetric and geophysical maps of the EEZ would pose a threat to national security; NAS was asked to explore plausible means to balance national security concerns with the needs of the academic and industrial communities. In the course of its study, the NAS Naval Studies Board found it impossible to "quantify" national security benefits gained from classification or the possible benefits that could be realized by the U.S. scientific and industrial users if such data were to be freely available to the public.

Because of the difficulty it encountered in evaluating the benefits and risks associated with classifying bathymetric and geophysical data, the Naval Studies Board restricted its inquiry to whether the unrestricted release of accurately positioned, high-resolution bathymetric data could result in any new and significant tactical or strategic military threats. It did not assess the needs of the oceanographic and geophysical research community for the data, nor did it assess the ocean mining industry's need for such surveys. The Naval Studies Board concluded that "map matching, i.e., locating one's position by matching identifiable features on the seafloor by using precise bathymetry from broad regional coverage, could afford potentially hostile forces a unique and valuable tool for positioning submarines within the U.S. EEZ.

While the Naval Studies Board supported the Navy's position with regard to classifying and controlling "processed' survey data, it did not favor classifying raw data until they are processed into a form that provides full geodetic precision and large area coverage. As a further measure, the Board suggested that each processed map be reviewed for distinctive navigational features that would make it valuable for precise positioning and that the sensitive data be "filtered' as necessary to permit its use in unclassified maps. The Board further recommended that the sensitive data be made available on a classified basis to authorized users and that raw data covering a limited area be released without security restrictions for the pursuit of legitimate research .[49]

A second review of the Navy's data classification policy regarding multi-beam data was also undertaken by the National Advisory Committee on Oceans and Atmosphere (NACOA) at the request of NOAA in 1985. NACOA generally supported the Naval Studies Board's conclusions, and found the national security argument for classifying high-resolution bathymetric data made by the Navy more "compelling' than the counterargument made by the academic community for free exchange of scientific information.[50] NACOA therefore rec-

[48] Letter from Anthony J. Calio, Administrator, NOAA, to Rear Admiral John R. Seesholtz, Oceanographer of the Navy, Feb. 3, 1986; and reply from Seesholtz to Calio, Mar. 14, 1986. An extensive exchange of correspondence followed between Calio and Seesholtz through Nov. 6, 1986.

[49] Naval Studies Board, *National Security Implications of U.S. Exclusive Economic Zone Survey Data,* (Washington, DC: National Research Council, Mar. 25, 1985), p. 6.

[50] National Advisor, Committee on Oceans and Atmosphere, *NACOA Statement on the Classification of Multibeam Bathymetric Data* (Washington, DC: National Advisory Committee on Oceans and Atmosphere, Jan. 17, 1986), p. 4.

ommended that only "controlled selective dissemination' of NOAA's multi-beam data be allowed.

Analyzing the two public reports of the Naval Studies Board and NACOA, OTA found that neither group, in reaching its conclusions, appears to have fully weighed the risks, costs, and implications of withholding most high-quality bathymetric maps from the academic community and the private sector. Furthermore, neither report seems to acknowledge the extent that multi-beam technology has proliferated throughout the world among the academic, commercial, and government entities of both friendly and potentially hostile nations. As multi-beam survey data becomes more widely available, secure navigation is possible without NOAA data. Many foreign countries, including the Soviet Union, are now operating multi-beam survey systems. Additionally, there has been no restriction placed on data produced by U.S. academic research vessels operating Sea Beam systems. Finally, neither report discusses the possible inconsistency between the restricted use of broad-coverage, high-resolution bathymetry by U.S. scientists and the private sector and the U.S. position regarding international principles of freedom of access for scientific purposes in other nations' EEZs and foreign scientists' access to the U.S. EEZ.

NOAA's Survey Plans—Navy's Response

After the release of the Naval Studies Board and NACOA reports in March 1986 and June 1986 respectively, the positions of NOAA and the Navy on multi-beam classification diverged rather than converged toward a solution. In response to the Navy's opposition to allowing NOAA to proceed with comprehensive unclassified multi-beam coverage of the EEZ that might serve as an atlas of the seabed, NOAA proposed to abandon its comprehensive long-range plan and substitute a series of smaller-scale targets for multi-beam surveys. These smaller-scale targets included:

- specific sites in water depths greater than 200 meters;
- continuous coverage surveys in limited areas of concern, e.g., in estuarine areas and for navigational safety in depths of 200 meters or less;
- widely-spaced reconnaissance swaths over the extent of a seabed feature;
- detailed investigation of areas up to 20 nautical miles square; and
- international waters outside the U.S. EEZ consistent with international law in a manner similar to multi-beam surveys made by the domestic and foreign academic fleets .[51]

The Navy formed a working group to address NOAA's proposal. The working group concluded that:

1. Surveys in waters shallower than 200 meters along the U.S. coastline are particularly sensitive and should be restricted and classified.
2. Bathymetric data on survey sheets that allows positions to be fixed to less than one-quarter nautical mile should be classified secret; therefore, based on tests showing that a significant proportion of NOAA's multi-beam surveys fall into this category, the Navy proposed that all multi-beam data be collected, processed, and held at the secret classification.
3. Navigation and bathymetric data either must be shipped separately to secure onshore facilities, or if combined (which NOAA does to maintain quality control), it must be handled under secret classification.
4. Areas outside the U.S. EEZ that NOAA proposes to survey may still be sensitive since they could pose a threat to allies and therefore should come within the classification scheme.
5. Small "postage stamp" (20 by 20 nautical miles) surveys also should be considered classified. The Navy did allow that accurate and reliable unclassified nautical charts with appropriate contour spacing can be produced from the classified database to support NOAA's nautical charting mission. [52]

The Navy is continuing to work on filtering techniques that would distort (degrade) the shape and/or location of seabed features. Distortion would reduce the usefulness of a survey sheet for vessel positioning but would allow NOAA to distribute survey sheets in unclassified form to all users. Efforts to date have not produced a filter that can

[51] Letter from Anthony J. Calio, Administrator, National Oceanic and Atmospheric Administration, to Rear Admiral John R. Seesholtz, Oceanographer of the Navy, Feb. 3, 1986.

[52] Letter from Rear Admiral John R. Seesholtz, Oceanographer of the Navy, to Anthony J. Calio, Administrator, National Oceanic and Atmospheric Administration, Oct. 6, 1986.

satisfy both the security demands and positional criteria established by the Navy while still providing oceanographers and the private sector with sufficiently detailed information to be useful. The prospects of developing a mutually acceptable filter seem remote.

OTA Classification Workshop

In collaboration with the Marine Policy and Ocean Management Center of the Woods Hole Oceanographic Institution, OTA convened a workshop in Woods Hole, Massachusetts, in January 1987. Academic and government oceanographers and industry representatives who attended delved further into the impacts and dislocations that data classification might impose on user groups. Workshop participants were asked to:

- focus on the costs and risks of classification to scientific and commercial interests,
- relate the loss of information and/or commercial opportunities in the EEZ to the economic and scientific position of the United States,
- consider the consequences of data classification on U.S. foreign policy related to the need for access to other Nations' EEZs for oceanographic research, and
- identify factors that could affect the operational integrity of a Navy classification system.

Costs and Risks to Scientific and Commercial Interests

Marine geologists and geophysicists believe that it is impossible to evaluate what the loss might be to the U.S. oceanographic community as a result of classifying multi-beam data until a sufficiently large area is surveyed and mapped to discover what scientifically interesting features might be detected as a result of high-resolution bathymetry. The relatively small sampling that has been made available to date receives high praise from the academic community and government oceanographers who anticipate significant breakthroughs in understanding the conformation of the seabed if general-coverage multi-beam data are made available from the EEZ.

To advance oceanographic science, some scientists believe that they must be able to detect and characterize individual geological seafloor features with dimensions as small as 100 meters. Only multi-beam mapping systems provide sufficient resolution to achieve that goal in waters exceeding 200 meters in depth, although optical systems and side-scanning sonar can provide useful information about such features. Should broad-coverage, high-resolution bathymetric surveys and geophysical data be either abandoned or excessively restricted, geologists and geophysicists are concerned that they would be denied fundamental information important to their professions, according to those attending the OTA workshop.

Both NOAA's and the National Science Foundation's (NSF) charters require them to share and publicly disseminate scientific data among non-governmental users. Oceanographic data collected under the aegis of NSF's Division of Ocean Sciences is required to be made public after two years through a "national repository, e.g., the National Geophysical Data Center (NGDC). As a consequence of classification of multi-beam data, there is a possibility that neither NOAA nor NSF would support or undertake large-scale seabed mapping efforts. NOAA has reserved the option of terminating all multi-beam surveys if it is not permitted to conduct unclassified surveys in the U.S. EEZ and elsewhere. 53 Should NOAA forsake broad coverage multi-beam surveys worldwide, the Navy itself would likely lose a valuable source of strategic and tactical bathymetric data from both the U.S. EEZ and elsewhere that could strengthen the U.S. fleets' operational position.

One anticipated indirect long-term impact that could result from restrictions on the collection, processing, and dissemination of multi-beam bathymetric data is a move away from academic emphasis on marine geology and a slowdown in progress in understanding the seafloor and geological processes. Ocean mining interests foresee setbacks in extensive mineral surveying within the U.S. EEZ if NOAA is restricted in its unclassified mapping program. Some industry representatives believe that seabed mining holds a special position of national importance, and, therefore, even if classification procedures were imposed, ocean miners should be given access to the classified, "undegraded," high-resolution bathymetric data. Yet, while Federal

53 Ibid.

agencies with properly cleared personnel will have access to the multi-beam data, it is uncertain whether or not private firms can have similar access. Some firms can handle classified data, but others cannot. Firms that can access such data would have a significant advantage in the bid process. It remains to be seen as to whether or not industry will tolerate such a disparity.

Since the NOAA mapping program is currently the only one affected by the threat of classification, it remains possible for individuals to contract with domestic and foreign firms to conduct multi-beam surveys in the U.S. EEZ. International law does not preclude the conduct of such surveys within the EEZ. Permission is required only when surveys fall within the Territorial Sea. A West German survey ship has already conducted surveys within the U.S. EEZ in cooperation with U.S. industry. Broad-coverage bathymetric surveys would be expensive, and, given the many other uncertainties facing the domestic ocean mining industry, e.g., unstable minerals markets, high cost of capital, and regulatory uncertainties, it is unlikely that mining ventures would commit the necessary funds to contract for such reconnaissance multi-beam surveys, thus reducing the likelihood that mine sites would be developed successfully. Security restrictions on multi-beam data will affect a number of other undersea activities as well, e.g., submersible operations, modelling, identification of geological hazards, cable and pipe routing, fishing, etc.

Through July of 1987, there were no classification restrictions placed on multi-beam bathymetry collected and processed by the academic fleet. However, the Navy has given no assurances that academic data will not be classified in the future. With the exception of surveys made of the Aleutian Trench in the Pacific Ocean and Baltimore/Wilmington Canyons in the Atlantic Ocean, seldom do academic vessels undertake broad bathymetric coverage; rather, they tend to concentrate on smaller specific units of the seafloor. Most of the surveys made by the academic fleet have been made outside the U.S. EEZ. On the other hand, if funds were made available, it may be possible to mount a cooperative broad-scale mapping effort among at least three world-class oceanographic research vessels in the U.S. academic fleet that are equipped with multi-beam systems to provide high-quality data with atlas coverage.[54]

Impacts on U.S. Economic and Scientific Position

Commercial interests represented at the OTA workshop in Woods Hole suggested that restrictive classification procedures could chill the development of new echo sounding technology, since domestic civilian markets for such instruments would probably disappear. Should this situation arise, foreign instrument manufacturers are likely to displace U.S. firms in international markets, and the predominance established by the United States in the 1950s and 1960s would give way, with the leading edge of acoustical sounding technology (much of which was sponsored by the Department of Defense) being transferred overseas. To some extent, this has already happened. There is also a risk that as other nations allow unclassified multi-beam bathymetric maps to be produced within their EEZ, U.S. ocean mining firms, most of which are multinational, might find it advantageous to locate mining ventures in foreign economic zones and abandon efforts in the U.S. EEZ. At a minimum, classification may drive U.S. firms into multinational agreements in order to acquire needed data within the U.S. EEZ.

International scientific competition is fierce. This fact is seldom fully appreciated by those unfamiliar with the science establishment. Oceanographers attending the OTA Woods Hole workshop were uniform in their belief that U.S. marine geologists and geophysicists would be put at a disadvantage with their foreign colleagues who may not be limited by data classification. This might tend to lure U.S. researchers to focus their efforts elsewhere in the world where there are fewer constraints on the use and exchange of multi-beam and geophysical data, thus depriving the United States of the benefit of research within its own EEZ.

There was general agreement at the OTA Woods Hole workshop that, if faced with the alternative

---

s+ *The* research *vessel Thomas Washington* operated by Scripps Institution of Oceanography and the research vessels *Robert Conrad* and *Atlantis II* operated by Lament-Doherty Geological Observatory and Woods Hole Oceanographic Institution respectively.

of having high-resolution multi-beam data that has been "degraded" or "distorted" by filters and algorithms, the oceanographic community would prefer to continue using the best "undoctored," unclassified data available even if it were of lower resolution. If the choice of having high-resolution multi-beam bathymetric data over a small area is weighed against broad coverage with filtered data, most oceanographers prefer limited coverage and high-resolution.

Foreign Policy Implications of Data Classification

In proclaiming the establishment of the U.S. Exclusive Economic Zone (EEZ) in 1983, President Ronald Reagan carefully specified that the newly established ocean zone would be available to all for the purpose of conducting marine scientific research. [55] The President's statement reaffirms a long-held principle of the United States that it maintained throughout the negotiations of the Law of the Sea Convention (LOSC): notwithstanding other juridical considerations, nations should be free to pursue scientific inquiry throughout the ocean.

Although signatories to the LOSC granted the coastal states the exclusive right to regulate, authorize, and conduct marine research in their exclusive economic zones, the United States—a non-signatory to the LOSC—continues to support and advocate freedom of scientific access. [56] Thus, although other nations may impose consent requirements on scientists entering their EEZs if they view such surveys as counter to their national interest, the United States has no such restrictions.

While oceanographers are generally pleased with the U.S. open door policy for scientific research in the EEZ, those attending the OTA Woods Hole workshop see potential problems if the Navy establishes precedence for classifying high-resolution bathymetric maps for national security reasons. If the Navy continues to prevail in its position on the sensitivity of multi-beam data, then the United States might find it necessary to prohibit or control the acquisition and processing of similar data by foreign scientists. Such action would, for practical purposes, repudiate the President's announced policy of free access to the EEZ for scientific research.

Should multi-beam bathymetry in the U.S. EEZ be classified, many oceanographers believe that other countries would follow suit or retaliate against U.S. scientists by placing similar restrictions on the collection and processing of data within their EEZs. To date, no foreign multi-beam data has been submitted to NGDC. Other countries are waiting to see how the security issue is resolved within the U.S. The consequences for marine geological and geophysical research on a global scale could be severe as a result of removing a significant portion of the world's seafloor from investigation. The withdrawn areas would include much of the continental margins that are scientifically interesting and may also contain significant mineral resources.

Will Classification Achieve Security?

Although the National Security Council and the Navy may effectively derail NOAA's plans for comprehensive coverage of the U.S. EEZ by high-resolution multi-beam mapping systems, the action in no way assures that such data can not be obtained by a potential hostile through other means. Broad-coverage multi-beam data could be collected and processed by non-government sources, and accurate, unclassified bathymetry could be acquired for strategic and tactical purposes. It is also possible that foreign interests could gather such data and information either covertly under the guise of marine science or straightforwardly in the EEZ under the U.S. policies related to freedom of access for peaceful purposes—although the latter approach might prove politically difficult.

The Navy, on the other hand, considers that any action it may take to gather bathymetric information using its own ships is by definition ***not*** conducting marine scientific research, but conducting "military surveys for operational purposes' which are therefore not subject to coastal State jurisdiction as are civilian scientific vessels gathering the same kind of information. [57] Because the Navy con-

[55] Statement by the President accompanying the proclamation establishing the U.S. Exclusive Economic Zone, Mar. 10, 1983, p. 2.
[56] United Nations Law of the Sea, Part XIII, Sec. 3, Art. 246.
[57] "Navy Oceanography: Priorities, Activities and Challenges," speech presented by Rear Admiral John R. Seesholtz, Oceanographer of the Navy, Center for Oceans Law and Policy, University of Virginia, Charlottesville, Virginia, Oct. 24, 1986.

siders its operations using multi-beam bathymetric systems to be "hydrographic surveying" rather than scientific research, it remains possible for other foreign navies to make the same claim to gain access to the U.S. EEZ for similar purposes.

Over 15 vessels are known to be equipped with multi-beam mapping systems worldwide, not including those of NOAA and the Navy. Multi-beam mapping systems, while expensive to purchase and operate, are not a technology unique or controlled by the United States. Multi-beam technology is shared by France, Japan, United Kingdom, Australia, Federal Republic of Germany, Finland, Australia, Norway and the Soviet Union. (Canada is now in the process of purchasing a system.) While several multi-beam systems were purchased from U.S. manufacturers, other countries, e.g., Federal Republic of Germany (two companies), Finland, and Norway, developed their own systems.

Multi-beam technology is not new. The first Sea Beam unit outside a U.S. Navy vessel was installed on an Australian naval vessel the HMS ***Cook,*** in 1976 and the second on the French vessel ***Jean Charcot*** in 1977. The technology is over 20 years old. While oceanographers are reluctant to consider Sea Beam as "obsolete" or "outmoded, " they note, however, that better technology has been developed and is available in the world market.

Export licenses have been denied to U.S. manufacturers of multi-beam systems for sale to Brazil and Korea for security reasons, but comparable echo sounding equipment is available from foreign sources. U.S. restrictions on the export of multi-beam systems put U.S. equipment manufacturers at a disadvantage. Since foreign multi-beam manufacturers exist, current U.S. policy on technology transfer does not effectively limit the availability of these systems to foreign purchasers. Foreign firms have interpreted U.S. policy to mean that they are not restricted from collecting multi-beam data in the U.S. EEZ. Moreover, operating only within the domestic market, U.S. manufacturers find it difficult to remain competitive.

Private commercial firms have recently announced their intent to enter the multi-beam service market, offering contract arrangements for acquiring, logging and processing high-resolution bathymetric data; and perhaps to recover geophysical data as well. It is apparent that restricting and controlling the acquisition and dissemination of high-quality bathymetric data will become more difficult in the future as its commercial value increases. Just as geophysical surveying firms have been formed to respond to the offshore petroleum industry's need for seismic survey data, so too may bathymetric survey firms respond to an increased demand for multi-beam data. New survey systems that combine wide swath bathymetric measurements with side-scan sonar imagery, e, g., SeaMARC, are also available in the commercial fleet.

Some oceanographers believe that a large amount of unclassified bathymetric data and charts of sufficient precision and accuracy to be used for strategic and tactical purposes are already in the public domain and that much of it may have to be classified if subjected to the Navy's positioning tests. For example, many of NOAA's single-beam surveys that are run with precise electronic control and close line spacing for charting coastal areas and harbor approaches have resolution comparable to multi-beam surveys and are currently in the public domain. A considerable amount of similar commercial data has also been collected and is available for sale. A potential adversary would only need selected data sets to complicate a warfare situation.

The current move to classify bathymetric data is not the first time data restrictions have been imposed on the oceanographic community. From the end of World War II in 1945 to well into the 1960s, some bathymetric data collected in deep ocean areas by the single-beam systems were also classified. One difference between now and then is that earlier surveys were either made by Navy vessels or procured by Navy contract; there was no drain on civilian research and survey budgets, hence little proprietary claim for access to the data could be made by civilian interests.

Observations and Alternatives

Dealing from its position of power regarding security matters, the Department of Defense appears not to have opened the doors of inquiry wide enough to allow adequate involvement of the scientific and commercial communities. Even in its dealings with NOAA, the Navy leaves an impres-

sion among civilian officials that it can maintain its control by not sharing important information germane to the issue, such as technical limits of its requirements. At the same time, the Navy appears to be skeptical about the scope of claims made by civilians on their need to access multi-beam data. Whether facts or perceptions, the current debate is rife with concerns that must be overcome if a mutual solution is to be reached.

While much of the current debate has centered on Sea Beam data because of NOAA's plans to extensively map the EEZ, the Navy has proposed to restrict other multi-beam surveys and geophysical monitoring as well, e.g., magnetic and gravity data. Proposals have been made that NOAA collect geophysical data concurrently with bathymetric data.[58] Such multiple sensing could enhance the scientific usefulness of bathymetric surveys, and it also could increase the usefulness of data for positioning submarines.

Thus far, scientific and commercial interests have resisted the proposed use of mathematical filters to distort the shape and location of subterranean features. One option they have discussed is the establishment of secure processing centers to archive bathymetric and geophysical data. Appropriately cleared researchers could then have access to classified data and secure processing equipment to meet scientific and commercial needs. A similar option would be to allow secure facilities to be located at user installations. A significant amount of classified material is handled by civilian contractors under supervision of DOD. Similar arrangements may be possible with appropriately cleared users of bathymetric/geophysical data. However, a major problem exists in that we are now in a ''digital world, and secure processing of digital data is both expensive (site security) and restrictive (no networking of computers). Universities and firms typically have linked computers and may have to submit to the added expense of additional systems to handle these data. Other innovative means to manage the difficult problems of balancing national security with data access may be possible.

Acceptable resolution of the debate over classifying multi-beam bathymetric data will require more candor and a better exchange of information on all sides of the issue. The Navy appears to have done an insufficient job of communicating its needs and reasons for classification. On the other hand, the scientific community also has had difficulty in articulating its reasons for needing high-resolution bathymetry and in backing them with solid examples. Satisfactory solutions will only come by including in the classification debate those with a stake in the academic and commercial use of bathymetric and geophysical data.

[58] National Oceanic and Atmospheric Administration, *Report of the NOAA Exclusive Economic Zone Bathymetric and Geophysical Survey Workshop*, Dec. 11-12, 1984, p. 2.