Deep Seabed Mining

Report To Congress

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
December 1989

UNITED STATES DEPARTMENT OF COMMERCE
The Under Secretary for
Oceans and Atmosphere
Washington, D.C. 20230

DEC 28 1989

Honorable Thomas S. Foley
Speaker of the House of Representatives
Washington, D.C. 20515

Dear Mr. Speaker:

I am pleased to submit the Deep Seabed Mining Report of the National Oceanic and Atmospheric Administration to the Congress in compliance with Section 309 of the Deep Seabed Hard Mineral Resources Act (P.L. 96-283).

Sincerely,

John A. Knauss

Enclosure

THE ADMINISTRATOR

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Honorable Dan Quayle
President of the Senate
Washington, D.C. 20510

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Deep Seabed Mining

Report To Congress

Prepared by:
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Ocean Minerals and Energy Division
1825 Connecticut Avenue, N.W.
Washington, D.C. 20235

December 1989

U.S. DEPARTMENT OF COMMERCE
Robert A. Mosbacher, Secretary

National Oceanic and Atmospheric Administration
John A. Knauss, Administrator

TABLE OF CONTENTS

EXECUTIVE SUMMARY

The National Oceanic and Atmospheric Administration (NOAA) activities related to the implementation of the Deep Seabed Hard Mineral Resources Act (Public Law 96-283, the Act) in fiscal years 1988 and 1989 are described in this fifth report to the Congress. Efforts during these years have been directed toward research in support of future regulatory decisions, focussing on continued environmental studies. NOAA also worked on the publication of final regulations for future deep seabed mining commercial recovery operations under a NOAA permit. Revisions which reflected international conflict resolution, were processed for three U.S. mining licenses. NOAA designated a joint deep seabed mining environmental reference area and announced a proposed provisional impact reference area.

A major area of NOAA'S activity has been directed toward environmental studies to support future regulatory decisions. The focus of these studies has become the nature, magnitude and significance of mining impact on seafloor marine life. We expect this to continue to be a primary area of NOAA's attention as it further pursues environmental studies pursuant to section 109 of the Act. NOAA has continued to consult with other mining nations to establish a network for exchange of information on environmental research efforts and regulatory measures to protect the environment. It also maintains an information base for seabed mining which includes an extensive marine minerals

bibliography, as well as data bases for ferromanganese and placer deposits.

Proposed and supplemental proposed commercial recovery regulations were issued by NOAA in 1986 and 1987, respectively. Final regulations were issued on January 6, 1989. Promulgation of these regulations was designed to encourage orderly planning and the development of technology by providing a clear regime early for both industry and government planning purposes.

Consultations among the United States, Belgium, Canada, the Federal Republic of Germany, Italy, the Netherlands, the United Kingdom, and the USSR produced agreements on the resolution of all remaining site overlaps in August 1987. In March and April 1988, NOAA announced approval of amendments to exploration licenses issued to Ocean Minerals Company, Ocean Management, Inc., and Ocean Mining Associates (licenses USA-1, 2 and 3, respectively) to reflect these agreements.

Ocean Mining Associates (OMA) identified an area within its license site, USA-3, which it was willing to make available for scientific study and environmental monitoring. OMA was joined in this effort by contributions of adjacent areas from the Kennecott Consortium (USA-4) and Ocean Minerals Company (USA-1). NOAA recognized this expanded area as a potential provisional interim preservational reference area (PIPRA) in implementation of section 109 of the Act and noticed its designation in November 1988. OMA also identified an area within its mine site scheduled

to be mined early, which it has proposed to be used for the monitoring of benthic impact during mining operations. NOAA noticed this area in September 1988 as a proposed provisional impact reference area (PIRA).

During the two years covered by this report, licensees' activities have been directed toward evaluation and integration of data obtained through conflict resolution. Analysis of this data has further contributed toward delineation by the consortia of prime areas or subareas that will be selected as the focus of future mining efforts. Equipment development, technical and economic studies have continued. As summarized above, three of the consortia have identified adjacent areas within their mine sites for a combined environmental preservational reference area, and a second area has been offered by one of the consortia as a provisional impact reference area. In addition to these efforts the consortia have actively continued to monitor mineral markets and associated economic, technical, legal and political developments affecting mining.

CHAPTER I

INTRODUCTION

Purpose and Scope

This fifth biennial report to the Congress, submitted pursuant to section 309 of the Deep Seabed Hard Mineral Resources Act, describes deep seabed mining activities conducted by the National Oceanic and Atmospheric Administration (NOAA) during fiscal years 1988 and 1989.

This chapter contains an overview of the nature of the resource and the status of industrial activities. NOAA's activities in implementation of the Act are addressed in Chapter II.

Activities included in this report relate to: NOAA's research activities in support of future regulatory decisions, publication of commercial recovery regulations, designation of environmental reference areas, and activities under four exploration licenses and license revisions.

Activities reportable under the Act but not yet having occurred include: permit issuance or denial, environmental damage from mining activities, and civil and criminal proceedings.

The Resource

Manganese nodules are small, irregular, fist-sized concretions of manganese and iron minerals that are found on the

bottom of many of the world's oceans and lakes. They were first discovered during the 1873-76 oceanographic voyage of the HMS CHALLENGER but remained scientific curiosities until their value as a potential mineral resource was realized in the late 1950's. Although 79 elements have been identified in Pacific Ocean nodules, only four are of strategic and economic importance: manganese, copper, nickel, and cobalt. In spite of the worldwide occurrence of nodules, their population density on the seafloor and the concentrations of the value metals are highly variable. Main commercial interest therefore focussed on an area in the east-central Pacific Ocean (Figure 1) that contains a higher concentration of high-grade nodules than other surveyed areas. The nodules in this area have a high average percentage of the value metals, especially nickel (approximately 1.3 percent nickel, 1.1 percent copper, 0.2 percent cobalt, 25 percent manganese). This 13 million km^2 area--commonly known as the Clarion-Clipperton Fracture Zone--was the subject of NOAA's five-year Deep Ocean Mining Environmental Study (DOMES) and so is also referred to as the DOMES area. The DOMES study formed the basis for many of the scientific findings in NOAA's Deep Seabed Mining Final Programmatic Environmental Impact Statement (September 1981). The DOMES area has been estimated to contain from 3.6 to 13.5 billion metric tons (dry weight) of nodules--an apparently enormous resource for the future.

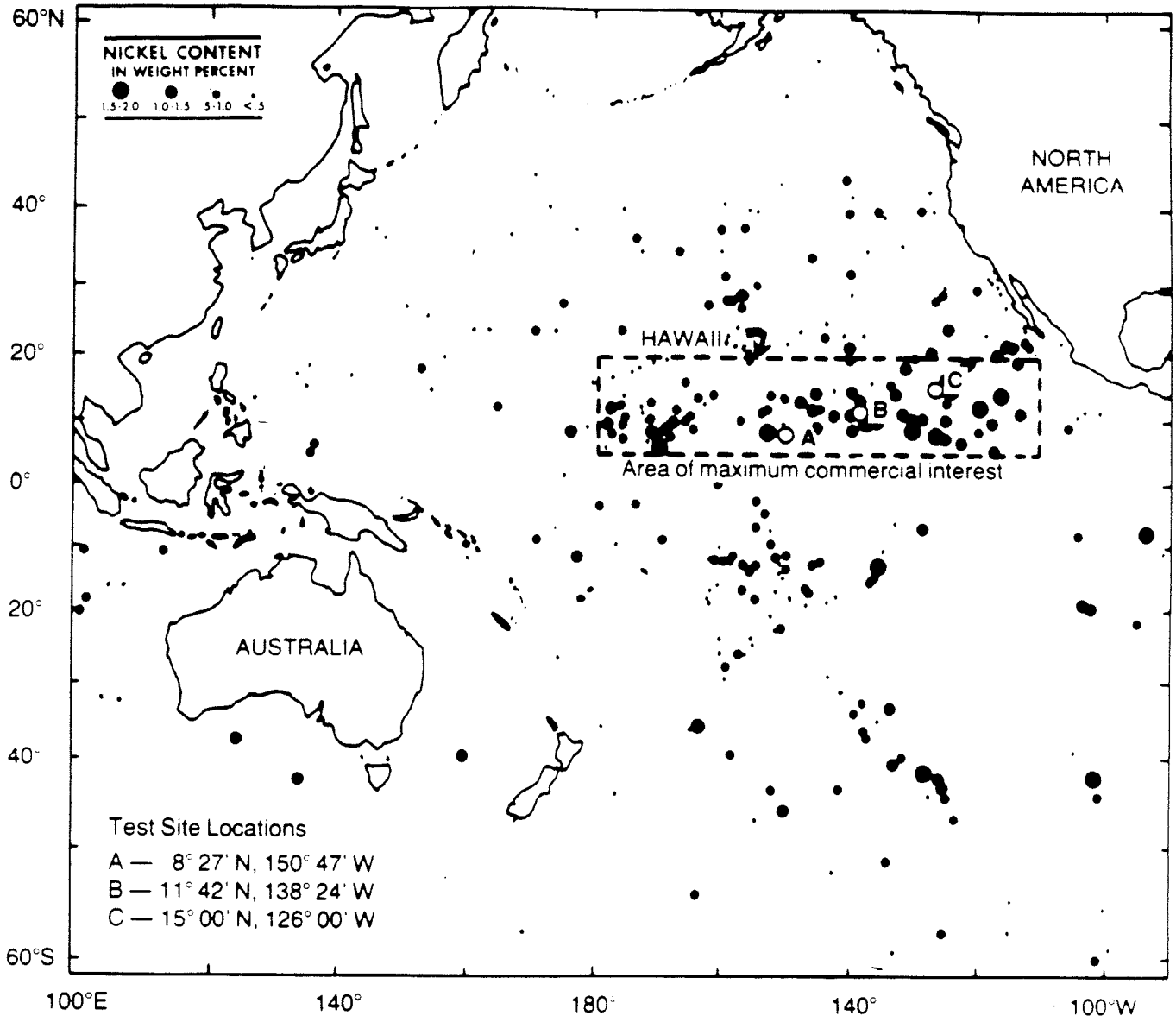

Figure 1 --Area of manganese nodule maximum commercial interest and high nickel concentration in nodules with DOMES test site locations (Horn, Horn, and DeLach, 1972).

The National Interest

The United States is dependent on foreign sources for two of the strategic metals found in manganese nodules: cobalt and manganese. Cobalt, which we import primarily from Zaire and Zambia, is used for the high-temperature alloys necessary in the aerospace industry. Manganese, imported primarily from Australia, Brazil, and South Africa (which has been projected as our major source in 10 to 20 years), is required in the steel industry. Nickel, used mainly in stainless steel and other high temperature steel alloys, is supplied by Australia and Canada. Copper, in which the United States is nearly self-sufficient, is used mainly in electrical equipment.

Dependence on foreign sources of metals can lead to uncertainties in supply ranging from cost instability to supply disruption. In addition to the possibility of political instability, foreign producers may retain more of their domestic output as they acquire their own capability to manufacture finished products. Also, as the sources of supply become more restricted, the ability of the mines to meet world demand can become a factor in determining both supply and price.

The establishment of a domestic deep seabed manganese nodule mining industry would provide the United States with: (a) a stable supply of strategic metals important to the economy at competitive prices, (b) a reduced annual balance of payments deficit, (c) increased investment in a basic industry,

(d) regional employment benefits, and (e) continued leadership in new ocean technologies.

The presently depressed level of world metal markets has dimmed prospects for commercial mining in the near term. Nevertheless, nodule mining appears to be competitive with new sources of these metals and so must remain an option for United States industry in the decades ahead.

Mining Consortia

The domestic deep seabed mining industry presently includes four multinational private sector consortia with U.S. members (Figure 2) which were issued exploration licenses by NOAA in 1984. The United Kingdom and the Federal Republic of Germany each have also issued licenses, for additional areas under their own respective domestic seabed mining legislation, to different ones of these multinational consortia. There are also three national consortia presently developing their own deep seabed mining capabilities: the French consortium, AFERNOD; the Japanese consortium, Deep Ocean Resource Development Company (DORDCO); and the USSR's Yuzhmorgeologiya. The Federal Republic of Germany also issued one license to the wholly-German consortium AMR. In addition to these eight consortia, each of which has been involved in a wide spectrum of nodule mining research and development activities, exploration is being conducted by India and the Republic of Korea.

Fig. 2 Deep seabed mining consortia involving United States firms and parent companies, including dates of consortia formation, as set forth in applications filed with NOAA in February 1982, and subsequently amended, showing NOAA license identification.

Nation	USA-1 Ocean Minerals Company (OMCO) (11/77)	USA-2 Ocean Management Inc. (OMI) (5/75)	USA-3 Ocean Mining Associates (OMA) (10/74)	USA-4 Kennecott Consortium (KCON) (1/74)
United States	Cyprus Minerals Co. (Cyprus Mining Co.) 50% Lockheed Missiles & Space Co., Inc. (Lockheed Corp.) 37.528% Lockheed Systems, Co., Inc. (Lockheed Corp.) 12.472%	Schlumberger Technology Corp. 24.67%	Essex Minerals Co. (USX Corp.) 25% Sun Ocean Ventures Inc. (Sun Co.) 25%	Kennecott Utah Copper Corp. (a U.S. Corporation owned by R.T.Z.) 52%
Belgium			Union Seas, Inc. a U.S. corporation (Union Miniere) 25%	
Canada		INCO, Ltd. 25.11%		Noranda Exploration, Inc., a U.S. corporation 12% (Noranda Mines Ltd.)
Italy			Deep Sea Systems, Inc. U.S. corporation (ENI/Italy) 25%	
Japan		Deep Ocean Mining Co., Ltd. (DOMCO-19 Japanese Companies) 25.11%		Mitsubishi Corp. 12%
United Kingdom				R.T.Z. Deep Sea Mining Enterprises, Ltd. (Rio Tinto-Zinc) 12% Consolidated Gold Fields, PLC 12%
West Germany		AMR 25.11% (Preussag A.G., Salzgitter A.G., Metallgesellschaft A.G.)		

December 1989

Overview of Industrial Activity

All of the NOAA-licensed consortia, prior to enactment of the Act, had already conducted extensive seafloor studies, as well as at-sea technology testing, as long ago as the early 1960's, so all license activities are designed to augment what they already know. License activities presently consist primarily of the analysis and integration of exploration data received from other consortia as a result of conflict resolution of overlapping claims, as well as the continued monitoring of technological developments, economic assessments and other planning activities for future development of the operators' respective sites.

Although further mining system tests may be authorized under the license, no additional tests are presently planned by the licensees.

A discussion of specific activities conducted by each licensee over the last two years is presented in Chapter II.

Technology Presently Contemplated for Mining

The first generation mining technologies under consideration by the United States consortia are all hydraulic type systems. Hydraulic systems, using either submerged centrifugal pumps or air lift systems, will recover nodules in a seawater slurry and pump them through a pipeline from a seafloor collector to a mining ship on the ocean surface. The hydraulic collector likely will sweep the bottom in nearly adjacent swaths; each swath may

be up to 20 meters (65 feet) wide. One consortium's collector will be self-propelled. The other collectors probably will be towed across the seafloor by the mine ship. Both types of systems have been tested by the consortia and monitored by NOAA.

In addition to the nodules, bottom water, sediment, and some macerated benthos will be drawn into the collector. Most of this extraneous material will be ejected at the seafloor; however, some of this material will be transported up the pipeline and, after separation from the nodules, discharged at the sea surface. The two activities, ejection near the seafloor and sea surface discharge, are the twin perturbations toward which NOAA has addressed most of its environmental effects research. Direct collector contact, while having an environmental impact, will affect a relatively small area and is unavoidable if nodules are to be mined.

CHAPTER II

IMPLEMENTATION OF THE DEEP SEABED HARD MINERAL RESOURCES ACT

Deep Seabed Mining Environmental Research Program

The major area of NOAA's efforts under the Deep Seabed Hard Mineral Resources Act has been the continuation of environmental studies to support future regulatory decisions. NOAA's environmental research efforts have focussed toward determining the biological effects of the accelerated sedimentation that would result from deep seabed mining operations. The following is a brief description of the environmental research conducted since 1987 or currently in progress.

Scripps Institution of Oceanography (SIO) was funded to examine the degree of faunal recovery in the mining tracks 11 years after complete removal of the fauna, and to conduct a critical sediment dose experiment. The critical dose experiment will evaluate experimental faunal sensitivity to acute burial by determining the depth of resedimentation necessary to provide measurable mortality on benthic fauna.

The field work for this project requires the unique technological capability of precision sampling and experimental manipulations: sampling within the 2-meter wide mining tracks, emplacement of 40 fenced areas 60 cm in diameter and injection of sediments at four treatment levels, and sampling near the center of the fence 7-10 days later. The SIO's Remote Underwater

Manipulator (RUM III) was upgraded in 1987 to provide the necessary capability to conduct these experiments. Originally SIO's Deep Tow system and RUM III were to be used with the Ocean Research Buoy System which was to be modified with funds from a frequent user so that it could be towed to the study area, DOMES Site C. When the funding did not come through, the decision was made to use the RUM III directly from the surface ship for the first time. This required two test cruises in December 1988 and May 1989. The first test indicated that modifications both on the RUM and on the surface vessel were necessary. After the modifications, during the second test RUM was deployed successfully several times. A final test cruise was run in November 1989 to field test the new corers, other electronic equipment and the positioning system. The field work for this project will be conducted in May 1990.

NOAA also is in the process of evaluating the suitability of a site within the areas of the U.S. licensees to be designated as a Preservational Reference Area (PRA). The preservational reference areas are stable reference areas unaffected by mining activities and similar to the mining sites so that they can effectively serve as controls. The physical information and data on the variability of deep-sea fauna suggest that the site being considered by NOAA as a PRA will be biologically similar to the mining sites. However, certainty of this assumption requires additional direct observations on benthic fauna and other parameters. A contract was awarded to SIO to evaluate the

composition of the benthic fauna at this site and to investigate its similarity to the mining areas. In September 1989, SIO scientists obtained box core samples of the benthic fauna and deployed current meter and transmissometer moorings. The samples are being processed for macrofauna analysis, and the final report on all data analysis and results will be available in September 1991.

Further research is being undertaken toward characterization of the PRA. A seabeam survey of a large portion of the PRA will be conducted by the NOAA ship SURVEYOR in March 1990 to provide contemporary bathymetric survey data in the PRA. The distribution, identity, and the abundance of epibenthic megafauna from videotapes in the PRA and in the OMA license area are being evaluated under another contract. Another study that will be conducted in the PRA is the mass flux measurements of marine snow which are macro-particle aggregates generally greater than 1 mm in size. Marine snow because of their high settling velocities capture some of the particles they overrun, and thus accelerate the settling of very fine particles such as the sediments resuspended near the seabed by mining. The University of Southern Mississippi scientists will deploy a camera flux system consisting of a sediment trap and camera assembly to obtain the marine flux data. They will also obtain vertical profiles of marine snow abundance in the water column by lowering the marine snow survey camera. The marine snow study will be conducted in January 1990 from a Soviet research vessel YUZHMORGEOLOGIYA.

NOAA also sponsored participation of a deep sea biologist in two cruises of the Federal Republic of Germany's research ship F/S SONNE investigating the environmental effects of mining in the eastern South Pacific. The objectives of this study are to create a large scale disturbance on the seabed and then observe its recolonization over several years. Two reports summarizing the field work (Report on the German DISCOL 1 and DISCOL 2 Expeditions, E.J. Foell, 1989) are available.

NOAA has been seeking and has achieved international collaboration for efficient use of our resources to address environmental issues associated with deep seabed mining. The cooperative study with the Federal Republic of Germany noted above is one of the examples. Also, in September 1989 NOAA signed an agreement with the USSR mining consortium Yuzhmorgeologiya for coordinated at-sea research and exchange of scientists to improve our understanding of the northeastern tropical Pacific Ocean. Under this agreement, three Soviet scientists participated in a NOAA sponsored cruise to the PRA, and U.S. scientists will take part in a USSR cruise in January 1990. Further, NOAA is in the process of establishing an arrangement with the Japanese Metal Mining Agency for cooperation in environmental impact research studies related to deep seabed mining and for mutual environmental monitoring of their mining test. NOAA also has initiated a proposal for collaborative study with France in a seabed mining chronic impact study.

Promulgation of Commercial Recovery Regulations

On January 6, 1989, NOAA published final regulations for deep seabed mining commercial recovery permits under the Deep Seabed Hard Mineral Resources Act. This completes a rulemaking process that has included publication and public comment on an advance notice of proposed rulemaking, a proposed rule and a supplemental proposed rule. The regulations are designed to encourage orderly preparation for the development of technology necessary to recover deep seabed manganese nodules by providing a clear regime now, for industry and government planning purposes, while allowing for changes in regulations, if needed, and deferring detailed decisions on permit-specific terms, conditions and restrictions until the time of permit issuance. The rules also spell out for other interested groups, such as environmental groups and coastal states, how NOAA will address issues of concern to them.

International Conflict Resolution and Revisions to U.S. Mine Site Areas

In 1984 negotiations were concluded that produced an agreement among the United States, Belgium, the Federal Republic of Germany (FRG), France, Italy, Japan, the Netherlands and the United Kingdom (UK) to avoid deep seabed mine site conflicts and to maintain consultations on seabed mining matters of mutual interest. Pursuant to section 118 of the Act, upon the recommendation of the Secretary of State, NOAA subsequently

designated the FRG, France, Italy, Japan and the UK--those parties to the agreement with domestic seabed mining laws--as reciprocating states.

In the summer of 1987 consultations among the United States, Belgium, Canada, the FRG, Italy, the Netherlands, the UK and the USSR produced technical settlements resolving all remaining site overlaps; agreements then were signed among the above governments to implement these settlements. The three affected U.S. licensees subsequently applied to NOAA to amend their mine sites.

In March and April 1988 NOAA noticed approval of adjustments to the license area boundaries and changes in the sizes of three of the operating areas to reflect this conflict resolution. The affected licenses were USA-1 (issued to Ocean Minerals Company, OMCO), USA-2 (issued to Ocean Management, Inc., OMI), and USA-3 (issued to Ocean Mining Associates, OMA). Kennecott Consortium's (KCON) license area was not affected by site overlaps and remained unchanged. The total area of all four U.S. revised sites is 496,651 km^2. The original and amended operating area of each licensee's site and increase or decrease in size as a result of these amendments is as follows:

Licensee	Original Area	Final Area	Change
OMCO (USA-1)	165,533 km^2	168,841 km^2	+3,308 km^2
OMI (USA-2)	135,100 km^2	112,500 km^2	-22,600 km^2
OMA (USA-3)	156,060 km^2	150,310 km^2	-5,750 km^2
KCON (USA-4)	65,000 km^2	65,000 km^2	None

Amendments to these operating areas were accomplished by modifications of license terms, conditions and restrictions, as well as relinquishment and revision. Exploration strategies, the proposed schedule of activities and other basic plan elements were not affected. Figure 3 shows the final configuration of the U.S. areas in relation to the foreign areas in the Clarion-Clipperton Zone.

Provisional Interim Preservational Reference Area (PIPRA)

In accordance with the Deep Seabed Hard Mineral Resources Act and considering the National Academy of Science's recommendations and NOAA's final mining regulations for commercial recovery, NOAA is in the process of evaluating the suitability of a site within the Clarion-Clipperton Fracture Zone as a Provisional Interim Preservational Reference Area (PIPRA). Preservational reference areas are stable reference areas unaffected by mining activities and representative of the environments to be mined. Such areas are "control" sites which can be referred to as questions arise during monitoring of mining impact. They may be selected provisionally prior to application for a commercial recovery permit. They are considered interim in the sense that they can serve the purpose of preservational areas until areas are designated internationally.

The center portion of this site was originally proposed by Ocean Mining Associates (OMA, license USA-3) and identified by them as "Ashkhabad South," in honor of the Soviet city in which

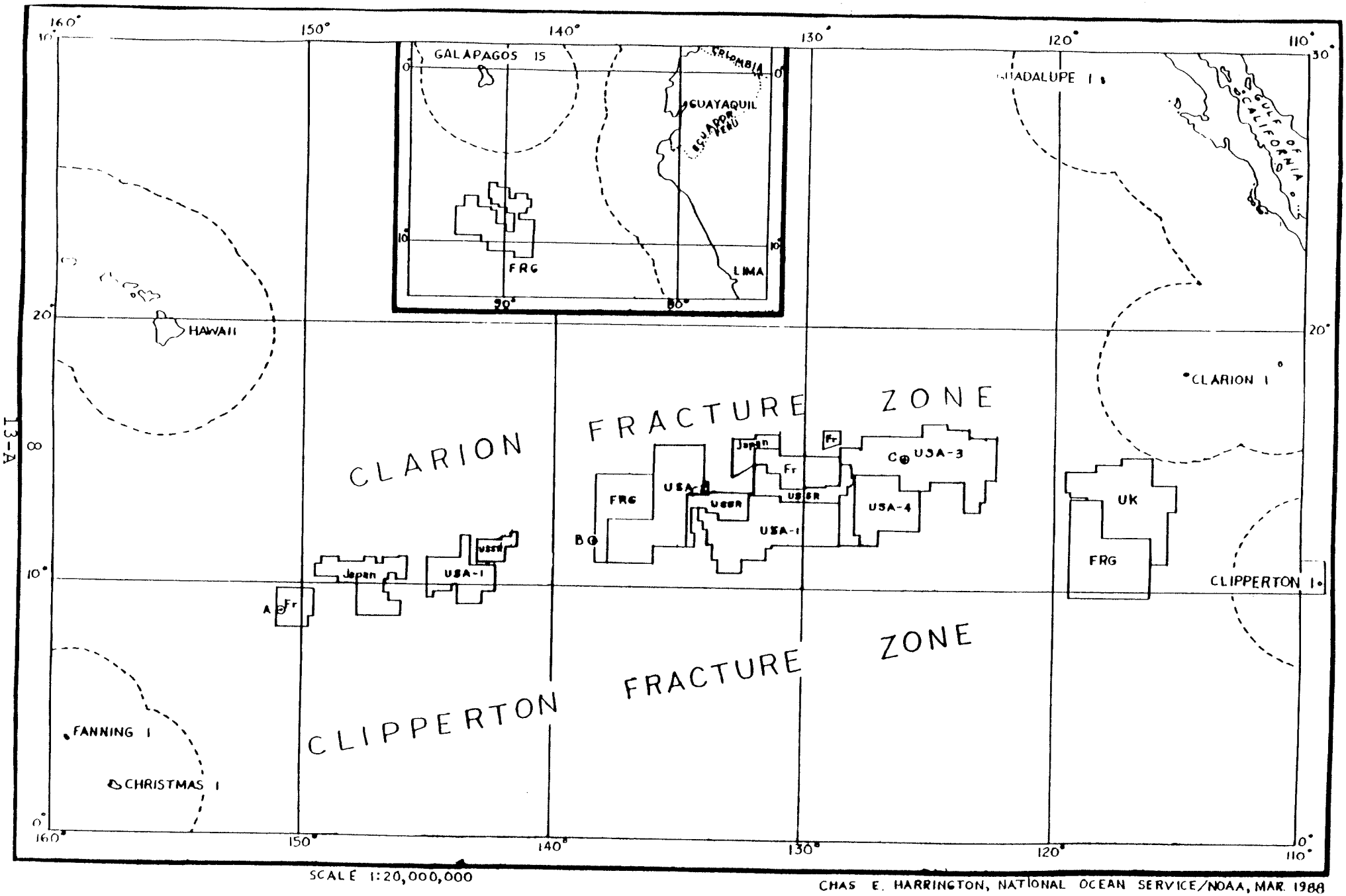

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Figure 3. Deep Seabed Mining Operating Areas

the constructive notion of deep seabed mining stable reference areas was born. Because of concern that mining in the adjacent areas could affect the core of this reference area, the area subsequently was enlarged with contributions from the neighboring U.S. licensees, Ocean Minerals Company (license USA-1) and Kennecott Consortium (license USA-4), as well as additional area from OMA. The proposed PIPRA now totals 15,157 km^2 in area. NOAA noticed this expanded PIPRA in November 1988.

All along, NOAA has been considering these proposals in the context of the applicable provisions in its final regulations. One of the regulations' criteria for selecting a PIPRA is that it be located in a portion of a permit area tentatively determined: to be non-mineable, not to be scheduled for mining during the commercial recovery plan, or to be scheduled for mining late in the plan. The areas contributed meet this criterion, according to the plans of the relevant licensees. Further, estimates of the size of a benthic plume produced by commercial mining reveal that an approximately 20 km x 20 km center core within the PIPRA would very likely be free of impact from mining plumes. This criterion is further assured by the present approach of a joint PIPRA, with the contributions from three licensees. A joint PIPRA offers the added benefit of greater efficiency for future joint studies and monitoring. Such an arrangement for the joint monitoring of a PIPRA is unrelated to the requirement for each permittee to monitor an impact area with respect to its own mining operation.

NOAA believes that this expanded deep seabed mining environmental reference area (Figure 4) also is similar in environmental character to that of the surrounding license sites. This would fulfill the remaining criterion in the regulations. Moreover, this core area of 400 km^2 would be large enough to permit sampling of the local variability in the benthic community structure.

In view of the above, NOAA has preliminarily determined that the proposed area should be designated as a PIPRA. NOAA intends to review and obtain additional data to validate this.

Environmental and resource data for the area contributed by each licensee have been received by NOAA. These data include bathymetry, sediment characteristics, video tapes and photographs of epibenthos, nodule coverage and composition. NOAA will continue to acquire and analyze licensees' data. NOAA also intends to acquire additional information on the water column, the benthic community and other parameters independent of licensees' data. Initial efforts for this purpose are described in the above section on environmental research. Assuming the environmental characteristics of the area are confirmed to meet the criteria of 15 CFR 971.602(d), it will be conclusively designated a PIPRA wherein studies will continue.

Provisional Impact Reference Area

In May 1988 Ocean Mining Associates (OMA) submitted a request to NOAA for consultation on early designation of a

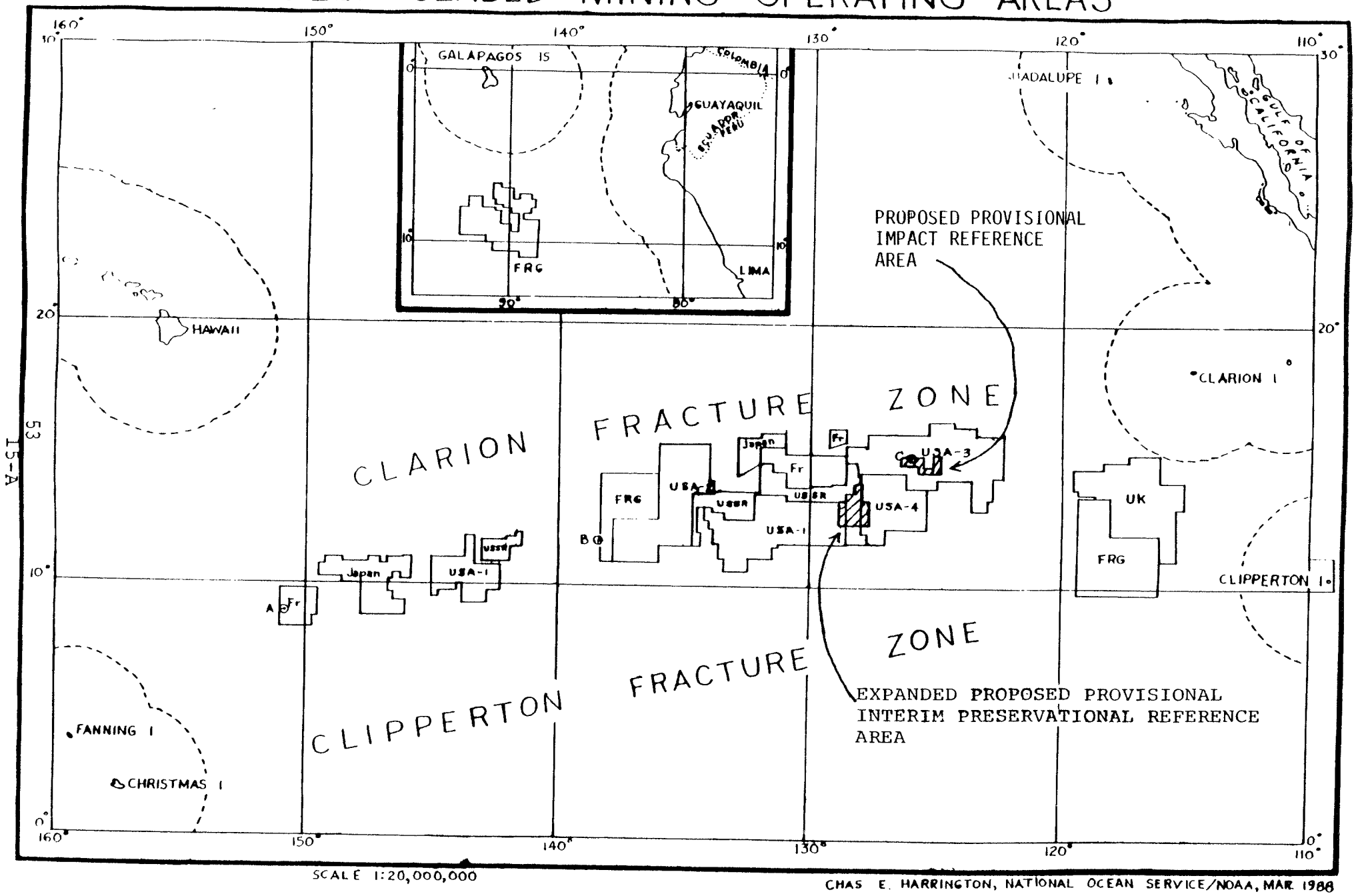

Figure 4. Proposed Benthic Impact Monitoring Areas

Provisional Impact Reference Area (PIRA), an area of approximately 4,629 km^2 within its license site identified by them as "Hennigar's Hook." NOAA announced this proposal in September 1988. This proposed area is tentatively scheduled to be mined early in the permit term. Figure 4 shows the location and configuration of the proposed PIRA and the surrounding license areas. OMA has extensive resource and environmental data collected by them or acquired from other consortia and is making them available to NOAA and the public. Upon determining that the proposed PIRA is representative of the environmental character of OMA's license site, NOAA will make a formal PIRA designation.

OMA made this proposal at this time in the belief that early provisional designation best meets the needs of commercial planning, basic science, and public policy.

Exploration License Activities

In 1984 NOAA issued exploration licenses to four mining consortia:

USA-1 - to Ocean Minerals Company (OMCO)

USA-2 - to Ocean Management, Inc. (OMI)

USA-3 - to Ocean Mining Associates (OMA)

USA-4 - to Kennecott Consortium (KCON)

These actions followed the resolution of originally overlapping site applications by the above consortia and the French and Japanese consortia. Part of their overlap settlement agreement led to the exchange of extensive exploration data

pertaining to relinquished areas. All four consortia are authorized to conduct exploration activities in their respective areas for the 10 year duration of the license.

The terms, conditions and restrictions (TCRs) issued with each license require the licensee to pursue exploration activities in accordance with its approved exploration plan. In order to show that it is following its exploration plan and achieving the major objective of exploration, the ability to apply for a commercial recovery permit by the end of the 10-year license period, each licensee must submit an annual report to NOAA within 90 days of each anniversary date of the license. Annual reports have been received each year from the four consortia.

The information included in the annual reports indicates that in spite of the continued depressed mineral markets and a general reduction in all staff levels, the NOAA licensees have been diligent in each license year in pursuing the activities authorized under NOAA licenses and the accompanying TCRs. Activities and expenditures are explained in a manner which demonstrates to NOAA the evolving ability of each licensee to apply for a commercial recovery permit by the end of the 10-year license period.

USA-1 - Ocean Minerals Company (OMCO)

During the two reporting periods between September 1, 1987, and August 31, 1989, OMCO's license efforts included the following activities.

In April 1988, NOAA published approval of Revision No. 2 to USA-1, which reflected the resolution of site overlaps with the USSR, by amending OMCO's operating area. Four areas originally claimed by OMCO were relinquished to the USSR and two smaller areas were received in exchange. OMCO additionally annexed 3,308 km^2 to the south of the east portion of USA-1.

OMCO performed several data management tasks during the reporting period. Data was integrated from license boundary changes following negotiations with the USSR and data assessment performed toward selecting sites with the highest potential for initial mining operations. Also, work continued on a Nodule Consistency Study to develop a method for identification of potential minesites.

In September 1988, as indicated above, OMCO contributed an area of 3,576 km^2 to a site earlier offered by OMA for use as a deep seabed mining Proposed Interim Preservational Reference Area (PIPRA). OMCO provided environmental data to NOAA early in 1988, and later transmitted similar data for the area that OMCO had received from the French during data exchanges.

Equipment development studies were performed involving review of the technical feasibility of utilizing fiber optics, improved plastics, personnel transportation systems and new

exploration techniques, as well as assessment of new mining operations and navigation techniques. The objective of these studies is to determine the impact that developing technologies may have on design effectiveness of various equipment.

Commercial re-evaluation studies of the metals market and economics affecting the profitability of mining have continued.

NOAA approved a request for Revision No. 3 to USA-1 in September 1988. This amendment revised OMCO's exploration plan by extending the first phase of the work plan to provide a longer period for investment decision. It also reflected a reduction in expenditures in Phase I of OMCO's exploration plan.

USA-2 - Ocean Management, Inc. (OMI)

During the two reporting periods between August 30, 1987, and August 29, 1989, OMI's activities included the following.

OMI has completed a two-year effort to identify a "Prime Area" within its license site which will be given first priority in detailed exploration and eventual exploitation efforts. They have delineated an area comprised of approximately 45,000 km^2 located in the central part of the USA-2 license area. Selection of this Prime Area was based on re-evaluation of the data in OMI's integrated database compiled from extensive exploration work as well as substantial data acquired from third parties with whom data were exchanged pursuant to various conflict settlements. With the conclusion and implementation of the OMI/USSR conflict settlement, an informal agreement had been

reached to exchange data with the USSR. A significant amount of data expected to be received by OMI from the USSR will be on points within this Prime Area, which will eliminate the necessity for further at-sea exploration in this area.

OMI's High Speed Exploration System (HSES) was put to sea trials after undergoing a review of component functions and modification of auxiliary equipment. One of the objectives of the deployment at sea was applicability of the HSES to the investigation of microtopography, ocean bottom types and sediment thickness. For this purpose the system was operated on scientific cruises with the German vessel SONNE during a three-month period, and the results obtained were fully evaluated. The system proved highly valuable for measuring microtopography and can be very helpful for environmental research work.

During the reporting period, OMI's Canadian partner undertook a re-evaluation and updating of a 1980/81 Appraisal Study which assessed the economic viability of ocean mining. This updating included a broader strategic exercise which examined the future of various alternative sources of nickel and concentrated on the data within OMI's prime area. All relevant exploration data and assumptions for mining parameters were reviewed and updated, in particular the comparison of the results with corresponding data for alternative (land-based) sources of nickel. Conclusions of the study have indicated an extension of OMI's license term and an amendment to its exploration plan to postpone substantial expenditures.

OMI technical personnel and scientists from the U.S., France and the U.K. participated in research cruises involving several German universities to study the potential environmental impact of seabed mining. Mining activity data relating to OMI's pilot mining test in 1978, as well as relevant photographs, TV-profiles and bathymetric maps were provided to NOAA for environmental assessment.

OMI's legal staff met with representatives of the U.S. and foreign governments to keep abreast of national laws and regulations relating to ocean mining and developments relating to the United Nations Law of the Sea Treaty.

In March 1988, NOAA approved an amendment to USA-2 which relinquished approximately 22,600 km^2 of OMI's operating area in implementation of conflict resolution with the USSR.

USA-3 - Ocean Mining Associates (OMA)

During the two reporting periods between September 1, 1987, and August 31, 1989, OMA's license activities included the following.

New computer capability was acquired by OMA. The staff continued analysis and documentation of data and samples taken in prior years by OMA's service contractor, Deepsea Ventures, Inc. (DVI), or obtained from the public domain or as a result of conflict resolution. This work included kriging and analysis leading to selection of initial subareas within USA-3.

In addition, OMA is developing specifications for the survey systems which will be needed to provide additional data required to select optimal mining strategies within mining subareas.

During the reporting period, OMA identified and proposed to NOAA two environmental reference and monitoring areas within its license site. One area of approximately 8,600 km^2, located in the western portion of USA-3 (Ashkhabad South), has been proposed as a provisional interim preservational reference area (PIPRA). The second area (Hennigar's Hook) of approximately 4,600 km^2, located centrally within OMA's license site, has been offered by OMA as a provisional impact reference area (PIRA). OMA's database has been made available to NOAA. These data were originally collected by DVI and OMA and other commercial sources and integrated by OMA into compatible formats. The contribution of these "preservational" and "impact" areas against which the extent of commercial mining's impact on the benthic community can be compared will provide predictability to both industry and Federal programs.

OMA submitted an application for amendment to its license which reflected a settlement agreement of August 14, 1987, with the USSR. This amendment, which was approved by NOAA on February 26, 1988, reduced the operating area of USA-1 by approximately 5,750 km^2 by modifying the license TCR's to reflect resolution of site overlaps.

The consortium has maintained a program of environmental monitoring and monitoring of mineral markets and associated

economic, technical, legal and political developments. Using the results of these studies, OMA refined its OMA Venture Analysis to reflect current and projected cost and market factors.

Additional activities conducted by OMA during the reporting period included (i) documentation of the legal rights and obligations of OMA in USA-1 under customary international law, U.S. deep seabed mining legislation, the NOAA license, various intergovernmental agreements and overlap settlement agreements to which OMA is signatory; (ii) donation of deepsea survey equipment to NOAA for use in marine mineral environmental programs; and (iii) efforts to obtain international cooperation and coordination of work in environmental research voyages and programs.

In 1988, NOAA received notice of a slight restructuring of OMA's Belgian partner, which was analyzed by NOAA and found to have no effect on OMA's license, USA-3.

USA-4 - Kennecott Consortium (KCON)

Kennecott Consortium (KCON) received its exploration license October 29, 1984, therefore its fifth annual report to NOAA is not due until January 1990. KCON's activities during its third and fourth years included the following.

KCON evaluated and assimilated data received from other consortia as part of the Final Settlement Agreement (resolving site overlaps) into its data base and consolidated its files and data bank into a storage vault in Salt Lake City, Utah.

Approximately 75 tons of nodule samples were reinventoried, replaced into new containers, and moved to a new storage site at Safford, Arizona.

KCON participated in the negotiations between the USSR and the various consortia that were conducted during 1987. These negotiations did not directly involve conflicts with KCON's licensed area. However, to protect its long-term interests KCON was active in those meetings which resulted in KCON being included in a final agreement providing protection for KCON's licensed areas from future USSR claims.

In March 1988, NOAA approved a request from KCON to revise its exploration plan to eliminate the extensive bathymetric/topographic data that KCON had originally proposed to collect in its ten-year plan. KCON acquired a large amount of new exploration data during conflict resolution which, together with previous exploration and development work, eliminated the need for collecting additional data as originally proposed. KCON also requested and was granted a reduction in expenditures to reflect an equivalent credit value of expenditures formerly planned for data acquisition.

During 1988, KCON contributed 2,998 km^2 of its license site to an expanded deep seabed mining environmental reference area in conjunction with OMA and OMCO, and transferred resource and environmental data associated with this area for NOAA's evaluation.

In August 1989, NOAA received notification of a restructuring of the Kennecott Consortium and the sale by the former Kennecott Corporation of its right, title and interest in exploration license, USA-4 to a new Delaware Corporation. This corporate change is currently under review by NOAA.