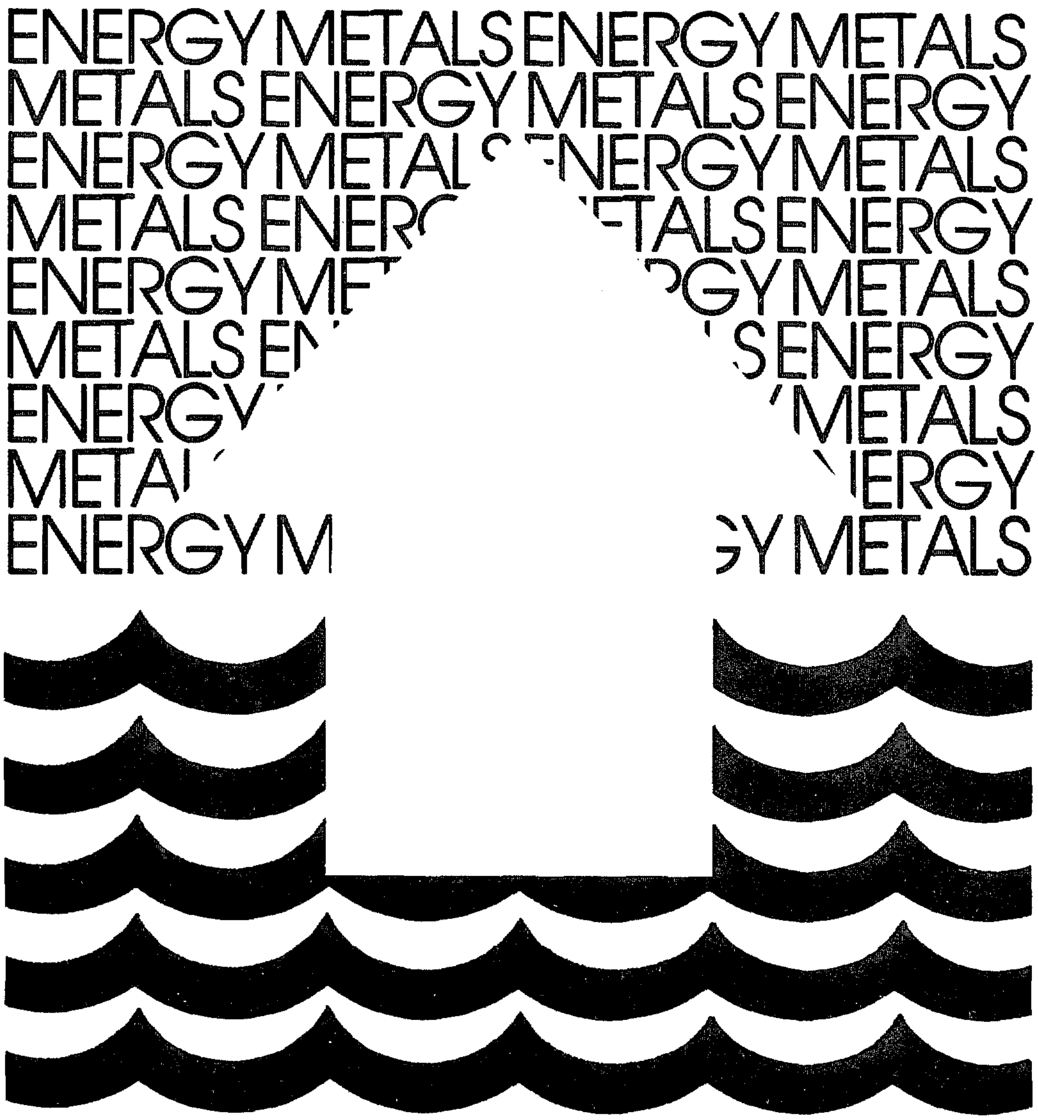

Deep Seabed Mining

Draft Environmental Impact Statement on Issuing an
E[illegible] .icense to Ocean Mining Associates

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1984

Deep Seabed Mining

Draft Environmental Impact Statement

Prepared by:
Office of Ocean and Coastal Resource Management
Ocean Minerals and Energy Division
2001 Wisconsin Avenue, N.W.
Washington, D.C. 20235

May 1984

U.S. DEPARTMENT OF COMMERCE
Malcolm Baldrige, Secretary

National Oceanic and Atmospheric Administration
John V. Byrne, Administrator

National Ocean Service
Paul M. Wolff, Assistant Administrator

DESIGNATION: Draft Environmental Impact Statement (DEIS)

TITLE: Deep Seabed Mining Exploration License

ABSTRACT: This DEIS is prepared pursuant to the Deep Seabed Hard Mineral Resources Act (P.L. 96-283, "The Act") and the National Environmental Policy Act of 1969 (NEPA) to assess the impacts of issuing a deep seabed mining exploration license to Ocean Mining Associates (OMA). Exploration by OMA will be authorized by license from the National Oceanic and Atmospheric Administration (NOAA) for ten years in the Pacific Ocean equatorial high seas, roughly between Central America and Hawaii. OMA proposes to use acoustic data, photography, satellite navigation, and to sample by means of grab samplers, dredge baskets, box cores, and gravity corers to delinate its exploration area. The worst case potential for impact involves loss of 54 kg of benthic biomass, from the seafloor three miles deep in the Pacific Ocean. OMA's exploration activities will provide better understanding of environmental impacts of deep seabed mining and ultimately to reduce dependence on and impacts of land based mining, and will provide a reliable source for nationally strategic metals.

No onshore activities or equipment tests are authorized by issuance of the exploration license.

LEAD AGENCY: U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
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COMMENTS: The draft of this environmental impact statement was filed with EPA on May 18, 1984. Comments are due by July 13, 1984. A public hearing on the DEIS will be held in Room B100, 2001 Wisconsin Avenue, N.W., Washington, D.C. 20235, on July 3, 1984 at 9:00 a.m.

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EXECUTIVE SUMMARY

The National Oceanic and Atmospheric Administration (NOAA) has prepared this environmental impact statement (EIS) pursuant to Section 109(d) of the Deep Seabed Hard Mineral Resources Act ("the Act"), NOAA regulations implementing the Act (15 CFR Part 970, Deep Seabed Mining Regulations for Exploration Licenses) and Section 102(2)(c) of the National Environmental Policy Act of 1969 (NEPA). The Act authorizes the Administrator to issue licenses for exploration and permits for commercial recovery of manganese nodules in the deep seabed, subject to appropriate terms, conditions, and restrictions (TCRs).

Under Section 4(5) of the Act, exploration means:

(a) any at-sea observation and evaluation activity which has, as its objective, the establishment and documentation of -

(i) the nature, shape, concentration, location, and tenor of a hard mineral resource; and

(ii) the environmental, technical, and other appropriate factors which must be taken into account to achieve commercial recovery; and

(b) the taking from the deep seabed of such quantities of any hard mineral resource as are necessary for the design, fabrication, and testing of equipment which is intended to be used in the commercial recovery and processing of such resource;

NOAA proposes to issue an exploration license subject to TCRs (15 CFR 970.500) for a period of ten years to carry out exploration activities as set forth in an application for a deep seabed mining license submitted to NOAA by Ocean Mining Associates (OMA). This EIS assesses the potential environmental impacts of issuing an exploration license to OMA and of alternatives to issuance of the exploration license.

The license activities will take place in the area between the Clarion - Clipperton fracture zones in the Northeast Equatorial Pacific Ocean, between Central America and Hawaii. These activities would assist OMA in delineating its exploration area for manganese nodules, which are fist-sized concretions of manganese and iron minerals that occur on the sea bottom in areas of low sediment deposition around the world. Manganese nodules are rich in four strategic metals -- nickel, cobalt, manganese, and copper. Nickel, currently supplied to the United States chiefly from land-based mines in Canada and New Caledonia, is used for high-temperature alloys used in aircraft. Cobalt, imported mainly from Zaire, is used in the electrical industry for permanent magnets. Manganese, which is supplied to the United States by Brazil, Gabon, South Africa (expected to be our major source in the future), and Australia, is essential to the production of steel. Copper, in which the United States is nearly self-sufficient, is used mainly in electrical equipment. If commercially feasible, nodule mining can provide an increasingly important domestic source for these strategic metals as foreign producers retain more of their domestic output (and therefore export less) in the years ahead.

OMA submitted two applications for exploration licenses pursuant to NOAA regulations in early 1982, which are now consolidated into one application. The areas applied for were in conflict with other deep seabed applications filed with NOAA. By January 1984, OMA and three other applicants filed amendments that resolved these conflicts; OMA set forth approximately 156,000 km^2 included in its amended submission.

This EIS summarizes the findings of NOAA's programmatic environmental impact statement (PEIS) of September 1981, then assesses issues related to issuing the OMA license. OMA's proposed activities as set forth in its exploration plan are designed to delineate further the extent and distribution of nodules, the topography of the seafloor, including obstacles, and properties of seafloor sediments in order to establish an area for commercial recovery from the larger exploration area. Specifically, OMA proposes to use acoustic data, photography, satellite navigation, and samples by means of grab samplers, dredge baskets, box cores, and gravity corers to delinate its exploration area. The worst case potential for impact involves sampling with dredge baskets and the resultant loss of 54 kg of benthic biomass, about one millionth of that in OMA's license area. Sampling impacts could also be caused by the other two U.S. applicants contemplating this type of sampling and by the French and Japanese consortia should they sample in this manner. Japan has announced its intention to test a hydraulic mining system around 1990. Although these activities appear to have no potential for significant environmental impact and would not normally require preparation of an EIS, Section 109(d) of the Act nonetheless requires that NOAA prepare this EIS to assess the impacts of issuing any license.

NOAA's environmentally preferred alternative is to issue, rather than delay or deny issuing, the exploration license to provide better understanding of environmental impacts of deep seabed mining and to reduce the reliance on and impacts of land based mining. This conclusion is consistent with the purposes of the Act and reduced dependence on foreign sources of strategic metals.

No endangered species are expected to be affected by OMA's proposed activities. Based on consultation with other Federal agencies and the opportunity for public review and comment, NOAA's proposed TCRs provide for OMA:

1) to report any endangered species that it observes;

2) to report and protect cultural resources, such as shipwrecks, that it discoveres in the license area; and

3) provide a monitoring plan and environmental baseline information in accordance with NOAA Technical Guidance Document (TGD) at least one year in advance of any proposed equipment test, so that a supplement to this EIS can be prepared on the proposed activities.

The Environmental Protection Agency (EPA) is developing a general National Pollutant Discharge Elimination System (NPDES) permit for all vessels operating under NOAA exploration licenses.

No onshore processing activities are proposed in OMA's application.

Based on the foregoing analysis and information, NOAA has tentatively determined that the exploration proposed in OMA's application cannot reasonably be expected to result in a significant adverse effect on the quality of the environment (15 CFR 970.506). This determination is necessary before NOAA may issue a license for deep seabed mining exploration activities.

This EIS also summarizes NOAA's environmental research since 1981 concerning unresolved issues in the PEIS.

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I. B. Site-Specific Considerations 4

I. Introduction

1.A Purpose and Need for Action

The National Oceanic and Atmospheric Administration (NOAA), in consultation with the U.S. Environmental Protection Agency (EPA), the Secretary of State, and the Secretary of the Department in which the Coast Guard is operating, has prepared this draft site-specific environmental impact statement (EIS) pursuant to Section 109(d) of the Deep Seabed Hard Mineral Resources Act (the Act) and 102(2)(c) of the National Environmental Policy Act (NEPA). This site-specific EIS assesses the potential environmental impacts of the site delineation and other exploration activities proposed in the application of OCEAN MINING ASSOCIATES (OMA) for issuance of an exploration license under the Act. The EIS does not assess the impacts associated with at-sea mining equipment tests. Such tests will be prohibited under the license until NOAA has prepared a supplemental site-specific EIS incorporating additional environmental and technological data submitted by the consortium to NOAA, and NOAA has modified OMA's license to authorize tests in accordance with appropriate terms, conditions and restrictions.

This site-specific EIS will:

1) describe the area in the eastern North Pacific Ocean where OMA proposes to conduct exploration activities;
2) describe the type of activities that will be conducted under the exploration license; and
3) assess the environmental impacts expected to be associated with these exploration activities.

This EIS fulfills the requirement of Section 109(d) of the Act to prepare an EIS prior to issuing an exploration license.

In September 1981 NOAA published a Final Programmatic Environmental Impact Statement (PEIS) that described the results of the Deep Ocean Mining Environmental Study (DOMES), a five-year project designed to examine potential effects from nodule mining, and assessed the foreseeable environmental impacts from the exploration for manganese nodules under a license and the commercial recovery of the nodules under a permit. The area of main commercial interest described in the PEIS is shown in Figure 1. Also shown within this area is the smaller area that encompasses the area as applied for in license applications and that is the subject of this EIS. In accordance with the intent of the Council on Environmental Quality's (CEQ) NEPA regulations, and the administrative procedures outlined in the PEIS, this EIS focuses solely on the specific major action, i.e., the issuance of a site-specific exploration license. This site-specific EIS "tiers" off the broader PEIS by summarizing the PEIS analysis and incorporating the major discussions by reference, then covering issues specific to the license application. However, to make it clear to the reader that the exploration activities described in this EIS eventually will lead to commercial recovery, a comprehensive summary of PEIS issues associated with commercial scale recovery is included as Appendix 1. For a more detailed discussion of the technology and environmental aspects, the reader is referred to the PEIS which is available to all interested persons from the NOAA, Ocean Minerals and Energy Division (N/ORM1), Room 105, 2001 Wisconsin Avenue, N.W., Washington, D.C. 20235 [Telephone: (202) 653-8257].

I.B Site-Specific Considerations

NOAA is aware of the potential complications from publicly disclosing the precise locations of the requested U.S. license areas,

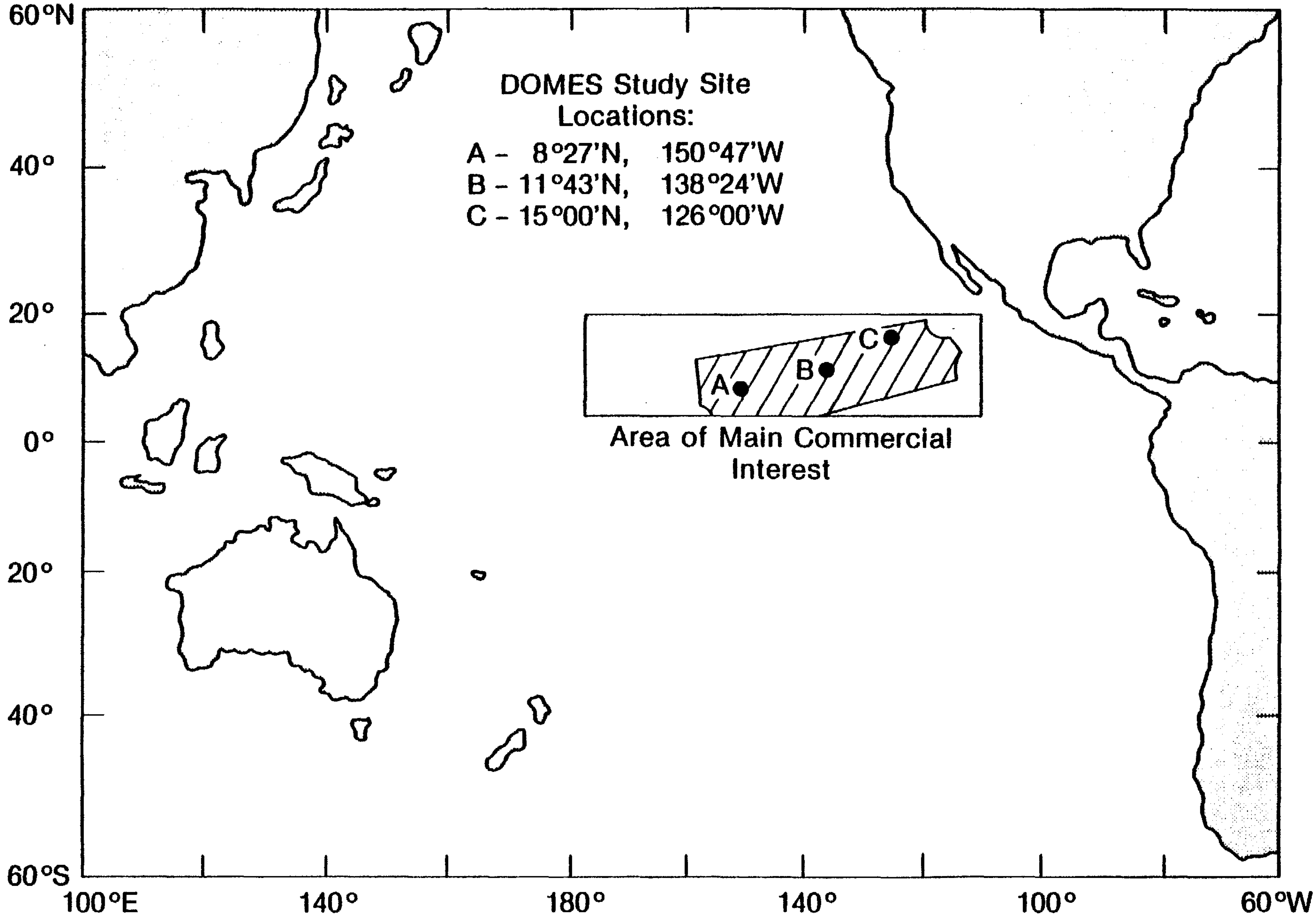

Figure 1. Area discussed in EIS in relation to original area of main commercial interest (i.e., the DOMES area).

through the EIS process, prior to the public disclosure of areas to be requested by other nations from the Law of the Sea Preparatory Commission.

The objectives of NOAA, in considering how to prepare this EIS, are both to avoid the adverse foreign affairs and commercial consequences NOAA believes would result from premature disclosure of the U.S. site coordinates (or other information from which site location can be derived) and to meet our NEPA obligations. With these objectives in mind, NOAA has reviewed the site-specific confidential information provided by OMA, and has determined that, except for site coordinates, use of confidential information at this time is not necessary to meet either the requirements of NEPA or NOAA's own related decision-making needs.

As to the coordinates themselves, NOAA believes it is necessary to include them in the record on a confidential basis for internal decision-making purposes. However, on the basis of OMA's request for their confidential treatment and NOAA's preliminary conclusion that the coordinates are likely to be exempt from disclosure pursuant to the Freedom of Information Act (5 U.S.C. 552) or the Trade Secrets Act (18 U.S.C. 1905), NOAA is placing the coordinates and a map of the proposed site in a confidential appendix which will not be distributed to the public.

NOAA has prepared a separate EIS for each of four license applicants. In each of these EISs, NOAA's approach has been to use a single area as the "affected environment". The area is large enough to include all proposed U.S. sites, and presumably also includes large portions of all Final Settlement Agreement sites (i.e., those sites agreed upon among consortia which have filed applications in the Federal Republic of Germany, France, Japan, United Kingdom and U.S. to resolve area conflicts) but the area described is still considerably smaller than the DOMES area characterized in the PEIS. The site-specific data in this EIS were acquired from the public domain, including non-confidential data in all U.S. applications for NOAA licenses for exploration. As a result, the "affected environment" chapters in each applicant's EIS are identical. However, the applicants' descriptions of their areas, while compatible with the PEIS description, do differ slightly from each other owing to the fact that the sites do not coincide.

Although NOAA has already stated in the PEIS and license regulations that the proposed exploration activities have no potential for significant environmental impact, NOAA has taken a "worst case" approach by characterizing in some detail the proposed exploration activity that would be likely to disturb the seafloor the most (such as basket samplers). This activity, if carried out, would be carried out in the applicant's proposed license area (around 156,000km^2 in area) which is located in the "affected environment."

NOAA intends to provide the additional site-specific data as soon as possible. Thus, when the Preparatory Commission situation is resolved, NOAA will reconsider the need for confidentiality and whether to supplement each EIS. In any event, should any licensee propose at-sea testing during the license phase, NOAA must supplement the EIS with test details and site-specific baseline data, including those acquired specifically for the test, prior to authorizing the test. NOAA expects that the test location would be public information at that time, and NOAA will independently evaluate the need for confidential treatment of any other information.

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II. Alternatives

The alternatives available to NOAA, involving the issuance of an exploration license, include:

1) issue the license (the proposed action);

2) delay issuing the license; and

3) deny issuance of the license.

NOAA's PEIS determined that the initial license phase exploration activities -- which are the subject of this site-specific EIS (Section IV) -- have no potential for causing significant environmental impacts (15 CFR 970.701(a)). The at-sea mining system tests -- which will be addressed in a subsequent site-specific EIS with additional environmental data gathered by industry during these initial exploration license activities -- were also judged to have no potential for causing significant environmental impacts because of the short duration of the tests. Terms, conditions and restrictions (TCRs) will be issued with the license to ensure the protection of the environment and to assess the adequacy of NOAA's previous prediction of no significant environmental impacts from site delineation or testing activities. The proposed TCRs are in Appendix 8.

Issuance of the license could be delayed until a better understanding of the environmental effects is developed -- through NOAA research or monitoring of at-sea equipment tests - or until U.S. site coordinates are made public after the identification of all international sites with the Preparatory Commission. This, however, would be a disadvantage to U.S. applicants who require site tenure in order to proceed with the expense of detailed exploration needed to lead to the development of mines, and would delay the acquisition of the additional environmental data needed for predicting future mining impacts. Monitoring of the at-sea mining system tests, which NOAA expects to take place at publicly-disclosed locations in the Clarion - Clipperton area, will also provide this needed information.

Denying the issuance of the license would prevent the development of the seabed mining industry, would not be environmentally advantageous because it would prevent or delay indefinitely the development of a better understanding of the environmental effects, and would necessitate continued reliance on land based mining and an increased dependence on foreign sources of strategic metals. This alternative also would be inconsistent with two of the purposes of the Deep Seabed Hard Mineral Resources Act, i.e., "to establish ... an interim program to regulate the exploration for and commercial recovery of hard mineral resources of the deep seabed by United States citizens;" and, "to encourage the continued development of technology necessary to recover the hard mineral resources of the deep seabed."

NOAA's preferred alternative is to issue the license subject to proposed TCRs (Appendix 8). NOAA has certified OMA's application as eligible for license issuance pursuant to the requirements of NOAA's regulations. Before the license is issued, the Act (105(a)) in summary requires NOAA to determine that the exploration activities: 1) will not unreasonably interfere with the freedom of the high seas; 2) will not conflict with any international obligation of the U.S. established by treaty or convention; 3) will not create a situation which may lead to a breach of international peace and security involving armed conflict; 4) cannot reasonably be expected to result in a significant adverse effect on the quality of the environment; and 5) will not pose an inordinate threat to the saftey of life and property at sea. The analysis and information in this EIS supports a determination by NOAA that the exploration proposed in the application cannot reasonably be expected to result in a significant adverse effect on the quality of the environment (15 CFR 970.506).

In addition to alternatives to issuance of the exploration license, the PEIS also identified three issues associated with licensing where several alternative approaches to each issue have environmental consequences: environmental monitoring; the proximity of mine sites to each other; and, stable reference areas (PEIS, pages 131-135). Because the majority of activities conducted during exploration have no potential for significant impact and no monitoring is required, environmental monitoring is a license phase issue only in relation to mining system tests. Because of the nature of the initial exploration activities, i.e., site delineation only, the only monitoring required at this stage will be for fulfilling the requirements of the NPDES general permit (see Section VI.A) and for reporting the sighting of any endangered species and the discovery of cultural materials such as shipwrecks. Mitigation is also not appropriate at this stage since there is not expected to be any significant adverse environmental effects during either site delineation or at-sea equipment test mining activities (PEIS, pages 102-109). However, the proposed TCRs would impose on the licensee a continuing responsibility to conduct operations to assure protection of the environment and so as not to create a significant adverse effect on the environment; and NOAA has authority to amend the TCRs and to modify or suspend license activities to avoid significant adverse environmental effects.

The proximity of mine sites, although largely a permit phase concern, will be examined during the license phase. As exploration activities progress and mining system test sites and potential commercial mine sites are delineated, the alignment of these sites will be evaluated in the context of NOAA research to determine if proposed site spacing is a problem. Research results from ongoing projects may provide insight into minimum safe spacing. The areas subjected to mining system tests during exploration will be small and the alignment of these test sites is not expected to produce any significant adverse environmental effects.

The establishment of stable reference areas (SRA) will not occur at least until the time of issuance of a commercial mining permit. However, research required to develop criteria to be used in selecting sites for SRA is currently being funded by NOAA based on recommendations of the National Research Council (See Appendix 2). The development of a scientific basis for designating SRA is environmentally preferred over allowing their designation on a random basis.

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III. AFFECTED ENVIRONMENT OF APPLICATION AREAS 17

III. A. Upper Water Column and Atmosphere 17

III. B. Lower Water Column and Seafloor 25

III. Affected Environment of Application Areas

As was explained in the Introduction, the description of the Affected Environment in each of the four EISs prepared by NOAA is identical. The description includes a summary of the DOMES baseline data found in the PEIS followed by the non-confidential data from the applications of each consortium. Not all of the DOMES parameters were measured by the consortia as part of their pioneer effort (some measured other parameters; some monitored tests in other oceans). However, all parameters will be measured in the future, prior to mining system tests, when it is important to augment the DOMES findings. The majority of the consortia data are taken directly from the license application submitted by Ocean Minerals Company (OMCO)[1/] and, unless otherwise identified, should be credited to that applicant. Additional data were provided by the Kennecott Consortium (KCON), the Ocean Management, Inc. consortium (OMI), and the Ocean Mining Associates consortium (OMA). The license area applied for by each consortium is situated between the Clarion and Clipperton fracture zones and lies entirely within the larger 13 million km^2 area studied during DOMES (Figure 2). The area of the Clarion - Clipperton fracture zone outlined in Figure 2 is 4.6 million km^2. The total area applied for by all U.S. applicants lies within this area and is 648,000 km^2, approximately 14% of the total Clarion - Clipperton area and 5% of the DOMES area characterized in the PEIS.

III.A Upper Water Column and Atmosphere

The Clarion - Clipperton area is under the influence of the Northeast Tradewinds for most of the year. Eastern Pacific tropical storms and cyclones are most frequent in late summer and early fall.

1/ Because of the volume of data presented as figures and tables in OMCO's application, they have been referenced in this section as Table or Figure 7-A, B, etc., and attached to the EIS as Appendix 7.

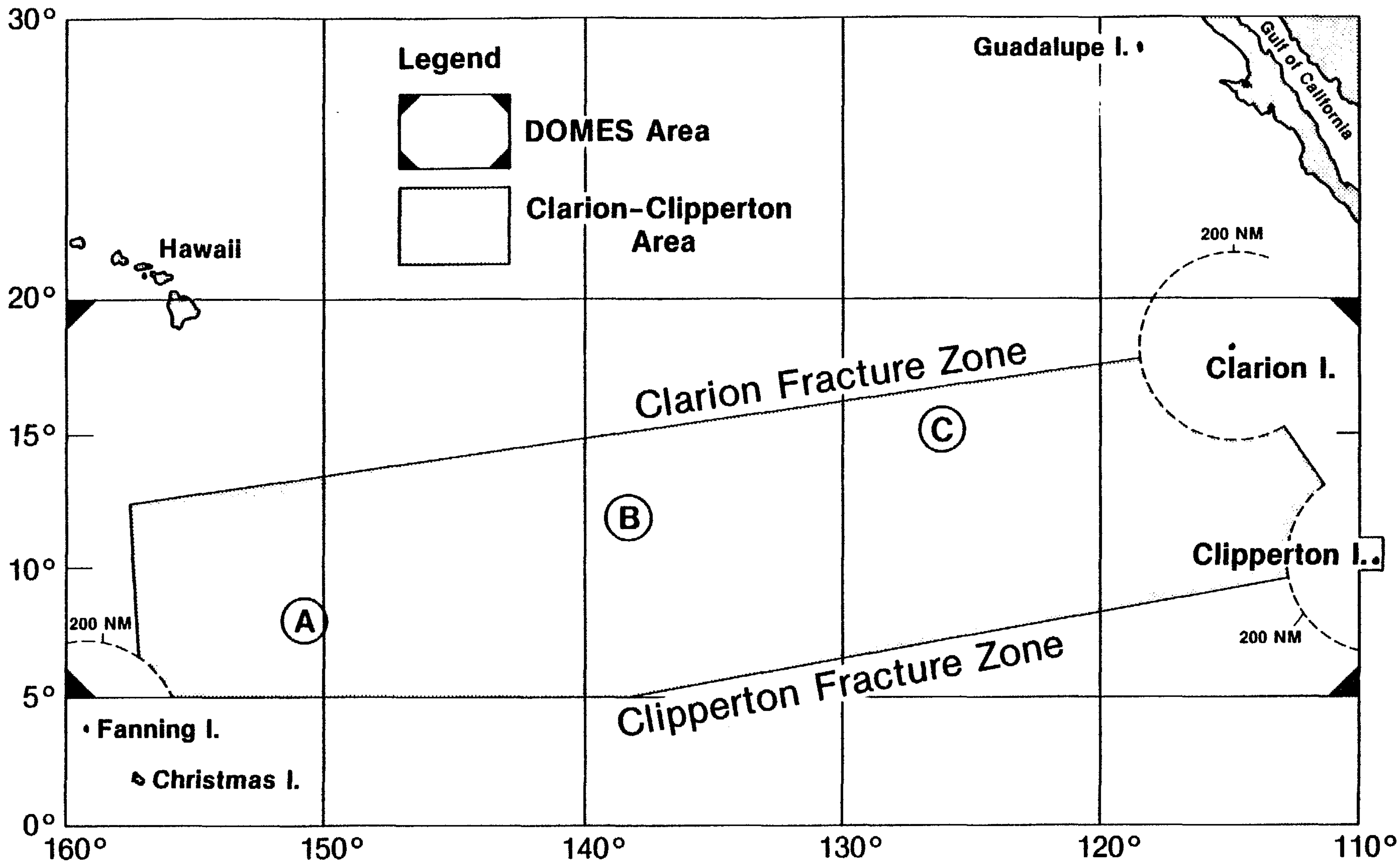

Figure 2. Clarion-Clipperton Area Discussed in EIS (which includes all license areas applied for in U.S.) in relation to eastern section of DOMES area with Sites A, B, C.

Oceanroutes, Inc. assembled detailed weather and sea-state statistics for OMCO for three sites within the Clarion - Clipperton zone which are representative of OMCO's application area. Each of these three sites - designated I, II, and III - is at a location close to DOMES Sites C, B, and A, respectively. Table 7-A shows a summary of the annual statistics characterizing the wind and the sea and swell conditions for the three sites. Prevailing winds have an easterly component during all months. Predominant swell direction is from the east to northeast due to the influence of the tradewinds. Tropical cyclones usually occur within the Clarion - Clipperton zone from May through November with maximum occurrence likely during July, August, and September (Table 7-B). OMCO Site I - in the vicinity of DOMES Site C - has the highest frequency of occurrence of storms among the three sites (Table 7-C). Knowledge of the tropical storm source region (Figure 7-A) and the historical corridors for cyclone tracks (Figure 7-B) allows an estimate of storm formation to site impact time to be calculated.

Surface currents in the eastern tropical Pacific (Figure 3), from north to south, are the westward-flowing North Equatorial Current, the eastward-flowing North Equatorial Countercurrent, and the westward-flowing South Equatorial Current. These currents are relatively shallow (500 m or less) and vary markedly in speed with depth, location, and season.

Surface current measurements in the vicinity of OMCO's three study sites were taken during DOMES. Measurements during August, September, and October, 1976 at DOMES Site A in the North Equatorial Countercurrent showed the mean current direction to be eastward at an

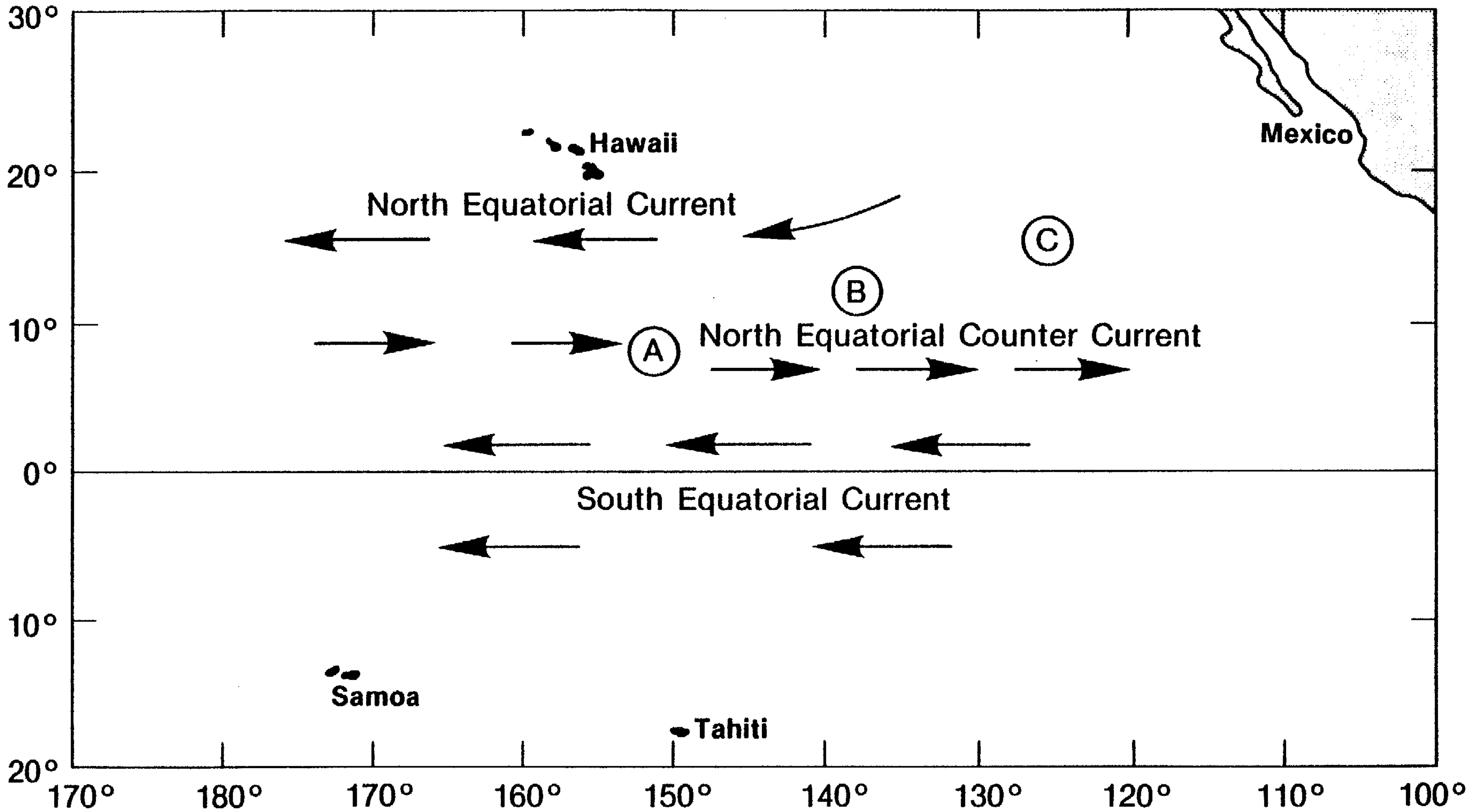

Figure 3. General surface circulation scheme in the Eastern Tropical Pacific, with DOMES site stations A, B, C (Ozturgut *et al.*, 1978).

average speed of 20 cm/s at 20 m depth. The speed of 10 cm/s recorded at 100 m remained nearly constant to the maximum 300 m depth of current meter deployment where a speed of 12 cm/s was recorded.

Measurements at DOMES Site B during March and April 1976, showed the mean current direction to be eastward with the speed of 3 cm/s at 20 m increasing to almost 20 cm/s at 200 m and 300 m.

Measurements at DOMES Site C, located within the westward-flowing North Equatorial Current, showed a previously undetected subsurface current flowing in the opposite direction to the surface flow. The current at 20 m was westward at 17 cm/s; however, the mean current at 200 m and 300 m was toward the east at about 6 cm/s.

Seasonal variations also occur in the velocity of the currents. For example, during 1976 the North Equatorial Current fluctuated from a velocity of 5 to 30 cm/s in the spring to 5 to 15 cm/s in the fall.

The thermal structure of this area of the tropical Pacific Ocean is characterized by a well-defined surface mixed layer overlaying a strong permanent thermocline. Temperature decreases with depth, reaching about 4.5°C at 1000 m, and exhibits very small seasonal changes. The mean mixed layer depth measured at all stations during DOMES was 36 $\pm$ 32 m during the summer and 55 $\pm$ 18 during the winter. The thermocline extended to a depth of 150 $\pm$ 31 m in summer and to 130 $\pm$ 18 m in winter.

The salinity in the surface mixed layer showed very little seasonal variation, with a mean value of 34.3 ‰ for summer and winter. The dissolved oxygen concentrations in the mixed layer are near saturation. During DOMES, oxygen concentrations just below the mixed layer were above saturation (400 - 500 ug-at/l) in certain locations because the bulk of the phytoplankton were located at these depths. An oxygen minimum zone, with concentrations as low as 1 ug-at/l, was found between 300 m and 500 m depth.

Data collected by OMCO during exploration cruises show the average mixed layer depth to be 35 $\pm$ 10 m during April and 45 $\pm$ 15 m in September. Surface water temperature was 25° - 27°C. Figure 7-C shows the distributions of salinity, temperature, and dissolved oxygen as measured by OMCO at a representative site in the vicinity of its application area. A maximum salinity of 34.7 °/oo was found within the thermocline and a minimum of less than 34.3 °/oo at the base of the thermocline. A second salinity maximum (about 34.7 °/oo) occurred between 200 and 400 m. Dissolved oxygen concentrations decreased through the thermocline, reaching a minimum zone between 200 and 400 m where concentrations of 1 umol/l were found. These data collected by OMCO are within the ranges observed during DOMES at Sites B and C.

OMI's application reports surface water temperature values of 26° - 27°C for its application area.

Suspended particulate matter (SPM) in the DOMES area was most abundant in the surface waters with an average concentration of 30 $\pm$ 18 ug/l in the upper 300 m. Below the thermocline, concentrations were uniformly very low (7-12 ug/l) with a slight increase near the bottom (10-14 ug/l) being indicative of a weak nepheloid layer. DOMES did not analyze for trace metals in suspended particulates.

OMCO used free-floating sediment traps to collect particulate matter from the upper water column. Particles from these traps were analyzed for organic carbon and nitrogen (Table 7-D) and for Mn, Zn, Cu, Cd, Ni, Fe, and Al (Table 7-E).

Nutrient concentrations in the mixed layer are low because of uptake by phytoplankton and because the thermocline inhibits vertical nutrient transport. OMCO analyzed seawater samples for inorganic nutrients (Table 7-F) and for dissolved trace metal concentrations and particulate trace metal content (Tables 7-G and 7-H). The seawater trace metal analyses indicated that although dissolved manganese concentrations decreased slowly with depth, there seemed to be little relationship with the dissolved oxygen concentrations of the water column. Data used in the PEIS (PEIS, pg. 27, Landing and Bruland, 1980) for a sampling site 700 nautical miles north of the DOMES area, however, show a total dissolvable manganese concentration maxima at the surface and at the lower boundary of the oxygen minimum zone (800 - 1500 m). OMCO data show an increase in manganese concentrations in the suspended particles at the top of the oxygen minimum zone.

The average surface chlorophyll a value of 0.12 mg/m^3 measured at the DOMES sites is typical of the low values for phytoplankton standing crop in subtropical ocean waters. The average daily primary production for summer and winter was 133 $\pm$ 62 mg C/m^2/day.

Standing stocks of micronekton, zooplankton, and neuston varied seasonally from 3 to 8 g/m^2 with the higher values typical during the winter. Macrozooplankton were found in highest concentrations in the upper 150 m. The lowest concentrations were found in the oxygen minimum zone and below 900 m.

DOMES investigations of larval fish distribution and species composition suggest that: 1) the larvae of yellowfin and skipjack tuna occur more abundantly in the neuston layer than in the 1 m to 200 m depths; 2) larvae found between 1 m and 200 m are mainly of mesopelagic species; and 3) very few larval fish occur between 200 m and 1000 m. Studies by Ahlstrom (1971, 1972) showed that over 90 percent of the larvae sampled on the EASTROPAC expedition (1967) belonged to families that are mesopelagic as adults; only 1 percent of the total were epipelagic species such as tunas. Commercially important species of fish such as the bigeye, yellowfin, and skipjack tunas and the striped and blue marlin occur throughout the Clarion - Clipperton area.

OMCO conducted a study of zooplankton and ichthyoplankton distributions in their application area. A total of 166 depth-stratified samples were collected at 23 stations using paired open bongo nets. A floating neuston sampler was also used to collect 44 neuston samples. A complete data set on magnetic tape was submitted to NOAA. An interpretation of this data was also submitted to NOAA in the form of an unpublished manuscript - "Vertical Distribution and Composition of Ichthyoplankton and Invertebrate Zooplankton Assemblages in the Eastern Tropical Pacific" by V. J. Loeb and J. A. Nichols. Of the 22 invertebrate zooplankton taxa identified, copepods, chaetognaths, euphausids, siphonophores, larvaceans, and amphipods were numerically dominant within the upper 100m. Copepods comprised 40 - 71% of the total abundance by day and night within all five depth intervals (Table 7-I). A total of 59 taxa were identified among more than 45,000 captured fish larvae (Table 7-J). Few species of commercial importance were found. Coryphaena sp. (Mahi

mahi or dolphin) were found only in the upper 25m and comprised 0.01% of the total abundance in that depth interval. Scombridae (tuna) were found throughout the upper 100 m, but comprised only 0.09% of the total ichthyoplankton.

In order to supplement the few existing reliable published reports on the abundance of midwater fish, OMCO submitted fish caught in their free fall grab samplers to the University of California, Santa Barbara, for identification. Table 7-K shows a taxonomic account of all the fish retained in the samplers. Based on thousands of grab samples, each sampling about 0.1 m^2 area, OMCO collected 7.2 fish/100 m^2.

Fish caught by rod and reel from the survey vessel were analyzed for heavy metal content. The specimens were frozen at-sea and transported to a laboratory for analysis. Tissues from five organs from fourteen Mahi-mahi, two wahoos, two tuna, and a white-tip shark were analyzed for twelve different metal concentrations. These data will be included in the final EIS.

III.B Lower Water Column and Seafloor

Near-bottom current measurements were made at three sites during DOMES. Single mooring current meters were deployed from April to November 1976 at DOMES Sites A and B and from July to December 1977 at Site C. Mean currents over the record lengths (4 - 6 months) were small and to the northwest at all sites. A mean speed of 2.1 cm/s was recorded at Site A and 5.2 cm/s at Site B. A maximum speed of 24 cm/s was recorded 6 m from the seafloor at Site A. Currents at Site C fluctuated both in average speed and direction. Currents from July to early November were northwest with a maximum speed of 8.8 cm/s recorded

30 m from the bottom. From November to December the direction was almost south with a maximum speed of 6.3 cm/s at 200 m from the bottom.

Estimates of bottom currents made by OMI from photographs and observations during television profiling indicate a velocity of 5 cm/s (no direction was given).

Physical properties of the bottom water were measured during DOMES. Salinity within 300 m of the seafloor was nearly uniform with an average value of 34.7 ‰. Bottom waters were well oxygenated but showed a significant decrease in concentration from west to east across the Clarion - Clipperton area. Mean dissolved oxygen values decreased from 359 ug-at/l at Site A to 332 ug-at/l at Site C. Nutrient concentrations were high while SPM showed a slight increase over its concentration in the upper waters.

Water depth in the Clarion - Clipperton area increases from about 4000 m in the eastern portion to about 5600 m in the deeper northern and western portions and in the fracture zones. Abyssal hills are the dominate features of the seafloor. Sediment distribution is related to water depth, surface water productivity, calcium carbonate solubility, and the presence of volcanic islands. Siliceous oozes and clays are abundant between the Clarion and Clipperton fracture zones. Calcareous sediments, because of their increased solubility with depth, are found in the shallower southern areas and around seamounts.

Topographically, OMCO's application area consists of rolling abyssal hills in water depths that range between 4000 and 5500 m. The axes of the topographic highs trend approximately north - south. The general relief is usually 100-300 m. The abyssal hills are occasionally interrupted by steep fault scarps 5 - 100 m in height and by large seaknolls. Although erosional features appear in some areas, studies of subbottom structure indicate that sediments are accumulating on most of the seafloor. Deepsea clays with minor siliceous biogenic components are the dominant sediment type.

The topography of the Kennecott Consortium (KCON) application area consists of rolling abyssal hills and valleys with a north-south orientation and an average relief of 200 m. Abyssal hills with a 600 m relief are occasionally found. Steep rock scarps with relief of tens of meters are also found. The mean depth increases westward from 4000 m to 4600 m. The sediment consists of a stiff siliceous clay.

The dominant topographic features of OMA's application area are a series of north-south trending ridges. These ridges, with slopes that rarely exceed 10 degrees, have a distance of 1 - 8 km between crests. Fault zones are also present, as evidenced by the many scarps found on the seafloor. Areas of low local relief are few and scattered throughout the site. They are characterized by random occurrences of rocks and boulders. Rocks, boulders, and outcrops of basalt are commonly associated along the flanks and crests of ridges. Pelagic red clay and brown clay are the dominant sediment types; however, three subtypes have also been identified: 1) a surface "ooze" 0.6 cm to 5 cm in thickness; 2) a soft sediment, with some bioturbation, underlies the "ooze" but has a transitional contact with it; 3) a firm, stiff sediment is immediately beneath the surface "ooze" and in sharp contrast with it. This clay, seen while observing the seafloor with underwater television, is sometimes exposed at the surface and is likely to be associated with obstructions on the seafloor.

The application area of Ocean Management, Inc. (OMI) is dominated by extensive areas of flat, smooth seafloor and areas of small-scale abyssal hills. These areas are occasionally interrupted by seaknolls rising 700 m above the seafloor. North-northwest to south-southeast striking topographic features are observed in the western part of the area. Rock outcrops are rare and the sediment cover appears to be regular in this area. Water depths in the entire area range from 4500 m to almost 5200 m.

During DOMES, benthic organisms were surveyed by photography and sampled with box cores, free-fall baited traps, and bongo net tows. The near-bottom macrozooplankton population, comprised mainly of crustaceans, was very low, with fewer than five individuals caught per sample in net tows. Bottom scavengers found in the baited traps included two families of fish (rat-tails and liparids) and large numbers of amphipods (about 50,000 individuals in the 73 samples obtained). Photographic surveys showed that at least 90 percent of the larger, observable epibenthic organisms were sea stars, brittle stars, sea anemones, sea cucumbers, and sponges. Analysis of the box cores revealed that 40 percent of the organisms collected were polychaete worms (underestimated due to sampling problems), 19 percent were tanaids, and 11 percent were isopods. The majority of the remaining organisms were sponges, bryozoans, gastropods, sea cucumbers, sea urchins, bivalves, sea anemones, brittle stars, brachiopods, and miscellaneous non-polychaete worms.

OMCO collected data on benthic epifauna in their application areas during exploration cruises. Basket samplers and 35 mm photographs were used to determine the benthic population. Preliminary results indicate that sea cucumbers provide the majority of the biomass while the numerically dominant megafauna are sea urchins, sea anemones, and brittle stars.

More than 50 species of large invertebrates were collected with the basket samplers (Table 7-L). Echinoderms comprised 38 of these species, with the remainder being mostly mollusks, crustaceans, and cnidarians. The echinoderms showed approximately 12 new species and one new genus. Most of the echinoderms have been reported from other parts of the eastern Pacific Ocean, or from other oceans.

The 35 mm still photographs, taken within 5 m of the seafloor, were analyzed for large epibenthic organisms (Table 7-M). The species identifications of the organisms identified in the photographs were confirmed by comparison with organisms from the basket samplers. Numerically dominant organisms are the sea urchin *Pleisodiadema globulosum* (an echinoderm), the anemone *Actinange* (a cnidarian), and the brittle stars of the genus *Ophiomusium* (echinoderms). The results of Friedman's 2-way analysis by ranks indicate that urchins are significantly more numerous than other benthic organisms. These results compare favorably to the DOMES data obtained at Sites B and C.

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IV. LICENSE ACTIVITY IMPINGEMENT ON THE ENVIRONMENT 33

IV. A. Activities Permissible Under the Act 33

IV. B. Proposed Activities 34

IV. C. Use Conflicts 36

IV. <u>License Activity Impingement on Marine Environment</u>

IV.A Activities Permissible Under The Act

The normal sequence of activities followed by the mining industry in bringing a mine to commercial production consists of prospecting, exploration and development. Prospecting, which is the initial reconnaissance of an area of interest, includes mapping, and taking geophysical, geochemical and oceanographic measurements, as well as random samples of the seafloor. Prospecting is excluded from regulation under the Act (Section 101(a)(2)) as long as it does not significantly alter the surface or subsurface of the seafloor or significantly affect the environment. With the exception of pre-enactment explorers who have applied for a license, exploration - which includes development (Section 4(5)) - is prohibited except under a NOAA license (Section 101(a)). The Act defines exploration to mean:

> "(A) any at-sea observation and evaluation activity which has, as its objective, the establishment and documentation of
>
> (i) the nature, shape, concentration, location, and tenor of a hard mineral resource; and
>
> (ii) the environmental, technical, and other appropriate factors which must be taken into account to achieve commercial recovery; and
>
> (B) the taking from the deep seabed of such quantities of any hard mineral resources as are necessary for the design, fabrication, and testing of equipment which is intended to

be used in the commercial recovery and processing of such resource".

The initial activities to be conducted by OMA in the area under its license consist mainly of surveying and sampling activities and are of the type included under (A) in the definition of exploration. Other activities to be conducted by OMA involve analysis of the data acquired offshore, including marketing evaluations, do not require a NOAA license and are not the subject of this EIS.

IV.B Proposed Activities

The objective of exploration, in general, is to delineate the important features of a target area discovered during prospecting in sufficient detail to permit the evaluation of the area as a mine. The subject is discussed in the Deep Seabed Hard Mineral Resources Act, NOAA's Deep Seabed Mining Final PEIS (Appendix 3, pages 255-258), NOAA's Deep Seabed Mining Final Technical Guidance Document (Section 2.2), and NOAA's Deep Seabed Mining Final Exploration Regulations (15 CFR 970.701).

OMA's proposed activities are designed for further evaluation and development of the resource and the development of market strategies and financial planning. Much of the work planned for the 10 year license period will build on earlier findings during about 20 years of pre-enactment exploration and engineering development. These activities have been judged by NOAA to have no potential for significant environmental impact [CFR 970.701(a)] and would normally not require an EIS; however, the Deep Seabed Hard Mineral Resources Act requires an EIS on each license NOAA considers issuing.

OMA recognizes that new information, as developed, will dictate the course of future plans and so urges NOAA not to consider as inflexible the plan now proposed.

The proposed activities are categorized by OMA as those relating to the development of the resource and those dealing with other complementary activities such as market assessment and financial planning. The main category of activities pertinent to this EIS are those dealing with the resource and its environment. The location, concentration, and quality of nodules will be examined as will physical conditions that may affect the recovery of those areas of nodules selected for potential mining. Environmental data also will be acquired in accordance with license TCR so that adequate environmental baseline data are available at least one year prior to mining system testing.

Technology development, including at-sea testing of mining equipment and onshore processing tests, will, unless NOAA is advised otherwise, be delayed until commercial recovery permits are applied for or are issued.

Cruises to obtain a better definition of the nodule resource and the physical environment will occur throughout the 10 year license term.

Nodule sampling will be carried out with boomerang grab samplers, wire lowered coring devices, dredge baskets, or snatch samplers rigged to wire lowered instrument packages. Box coring also will be conducted, mainly for sediment samples.

Wire lowered TV and photographic equipment will be used to determine nodule population variability as well as nodule size. Wire lowered acoustic equipment also will be used for the same purpose.

Macrotopographic (large scale topography) mapping of the entire license area will be accomplished to characterize its general relief and topographic fabric. A Raytheon Finite Amplitude Depth Sounder (FADS) or its equivalent will be used. Potential obstacles to mining, in regions otherwise appearing to be mineable, will be delineated by wire lowered side-looking sonar.

Other standard oceanographic measurements will be obtained. For example, geological characteristics of the upper few meters of seafloor will be identified by use of a wire lowered sub-bottom profiler. Seafloor engineering properties (shear, adhesion, plasticity) will be measured by in-situ testing. Current sensors may be deployed.

IV.C Use Conflicts

OMA requires each vessel operating under its control to enter data in the ship's log relating to any ship sightings and activity in their exploration area. OMA's application, which contains a summary of all sightings recorded in over 10 years of exploration (Appendix G of OMA application), indicates a total of 50 sightings, only 1 of which was a fishing vessel. No known instance of actual or potential use conflict has been encountered during their exploration activities. Neither the Department of Defense nor the U.S. Coast Guard expressed any concern over potential use conflicts during their review of OMA's application.

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V. ENVIRONMENTAL CONSEQUENCES 39

V. A. Exploration Activities 39

V. B. Endangered Species 41

V. C. Cultural Resources 43

V. Environmental Consequences

V.A Exploration Activities

The mine site delineation activities (Section IV.A) to be conducted by OMA during its exploration license are of the type judged by NOAA to have no potential for significant environmental impact (15 CFR Section 970.701(a)). These activities, which do not include at-sea equipment tests, will consist of sampling and remote sensing to collect environmental baseline data, to collect information on the topography, sediments, and nodule location and abundance, and to collect small quantities of nodules.

The "worst case" potential for environmental impact during exploration activities would, excluding testing, occur from seafloor sampling with basket samplers. Basket samplers, also called chain bag dredges, vary from a fraction of a m^3 to several m^3 in volume and are generally designed to be dragged along the seafloor while the vessel is underway (Society of Mining Engineers, Mining Engineering Handbook, Vol. 2, pg. 20-86, 1973). The small quantities of nodules collected in this manner could be used for onshore testing of collector system components in OMA's seafloor simulation facility. Some quantities could also be used in further onshore processing development tests. However, because OMA presently has a supply of nodules in storage, from the 1978 mining system test, which could be used for these purposes, the need for a large amount of additional nodules is unlikely at this time. The collection of large quantities of nodules (e.g., 10,000 to 20,000 tonnes) needed for the operation of a large scale pilot plant would only be obtained in conjunction with further at at-sea testing of a scaled down version of a commercial recovery system. This is not discussed here since such tests would be addressed in a supplement to this site-specific EIS.

Impacts caused by this basket sampling occur through contact of the sampler with benthic organisms and by the small plume generated by disturbance of the sediment. The worst case impact situation would require about 100 dredge samples to be taken to obtain a total of 90 tonnes of nodules. The meter wide sampler towed for an hour at 0.5 m/s for each of 100 separate samples would affect a total area of about 0.2 km^2.

$$1 \text{ m} \times 1 \text{ hr.} \times 60\text{s/min.} \times 60 \text{ min./hr.} \times 0.5 \text{ m/s} \times 100 = 180{,}000 \text{ m}^2 \cong 0.2 \text{ km}^2$$

The average benthic biomass in the Clarion - Clipperton zone based on DOMES is 0.3 g/m^2 (PEIS, pg. 46). Each dredge sample would therefore result in the mortality of about 0.5 kg of benthic organisms while 100 samples would cause about 54 kg of mortality.

$$1800 \text{ m}^2 \times 0.3 \text{ g/m}^2 = 540 \text{ g} = 0.54 \text{ kg}$$

$$100 \times 0.54 = 54 \text{ kg of biomass}$$

The sediment pushed aside during sampling could also smother the organisms in an area roughly the width of the sampler. No significant "rain of fines" should occur because of the short duration of each operation and the small area disturbed by the sampler mouth. The fact that the action of the basket sampler disturbs less sediment than the mining collector indicates that sampling also has no potential for significant adverse impact. NOAA has already determined that the action of the mining collector during test mining has no potential for significant adverse impact (PEIS, Pages 100-108); therefore, NOAA considers the effect of basket sampling in this area to be insignificant.

It should be noted that it is not uncommon for deep sea benthic sampling for research purposes to commonly tow a dredge for distances of one kilometer, thus affecting 1000 m^2 (assuming a 1 meter dredge mouth opening).

In considering the worst case environmental impact, one must recognize that the impact discussed above might also be cauded by the other two U.S. applicants contemplating sampling of that type (the third U.S. applicant does not intend to sample). In addition, the two French and Japanese consortia might sample in similar fashion. Japan has announced its intention to test a hydraulic mining system around 1990 at the completion of its National Project in deep seabed mining. NOAA does not know the location of the proposed French and Japanese sites but they are likely to be in the larger DOMES area (Figure 1) or, possibly, in or near the smaller area shown (Figure 2). Therefore, 1.0 km^2 (5 x 0.2 km^2) may be affected within the 4.6 million km^2, <u>if</u> the Japanese and French sites fall within the area defined in Figure 2. Otherwise, the relative amount of area affected will be much smaller, if the two sites fall within the larger DOMES area.

Should OMA decide to conduct at-sea mining system tests under this license, NOAA will prepare a supplement to this site-specific EIS. The additional baseline data and the mining system characteristics that OMA is required to submit to NOAA at least one year prior to any scheduled tests will enable NOAA to be better able to address the environmental consequences of the tests in the supplemental EIS.

V.B Endangered Species

Section 7 of the Endangered Species Act (P.L. 95-632) requires Federal agencies to insure that any action authorized, funded, or carried out by them does not jeopardize the continued existence of listed species or destroy or modify the critical habitat of any endangered or threatened species. Section 7 also requires all Federal agencies to consult with the Department of the Interior (Fish and Wildlife Service) and the Department of Commerce (National Marine Fisheries Service) when any of their actions may affect endangered species. A biological opinion is then issued by each agency indicating whether the action is likely to jeopardize a species or adversely modify its critical habitat.

NOAA, in preparing the proposed regulations for the issuance of deep seabed exploration licenses, recognized that license activities might affect threatened or endangered species or their designated critical habitat. Since a total of 17 endangered or threatened species of marine mammals and turtles could inhabit the DOMES area or transportation corridors leading to possible onshore process plant locations (Appendix 8, PEIS), NOAA requested a Section 7 consultation and biological opinion from the Fish and Wildlife Service (FWS) and the National Marine Fisheries Service (NMFS). The biological opinions prepared by each office stated that the implementation of the regulations is not likely to jeopardize the continued existence of any endangered or threatened species or destroy or adversely modify any of their critical habitats. The basis for their respective opinions is the fact that the regulations contain sufficient provisions to allow NOAA to protect these species and to meet its responsibilities under the Endangered Species Act.

One of these protective provisions is the requirement for NOAA to continue, prior to the issuance of a license, their consultations with other Federal agencies. Copies of the license applications were distributed to pertinent Federal agencies, including the FWS and NMFS for review of the proposed site-specific activities. No additional Section 7 consultation was required at this stage because no "may affect" situation exists for the listed species or their critical habitats. Following their reviews, both agencies indicated that the exploration licenses should be issued to the applicants.

NOAA's TCRs also contain a provision for the licensee to report any endangered species that it observes (see Appendix 8).

V.C Cultural Resources

The U.S. Department of the Interior's National Park Service (NPS) has reviewed the license applications from the perspective of its responsibilities under the National Historic Preservation Act (16 U.S.C. 470 et seq.) to protect cultural resources on the Outer Continental Shelf and the deep seabed. In its review letter to NOAA, NPS mentioned that compliance with NEPA requires consideration of cultural resources in the DOMES area. This area of the Pacific Ocean has experienced a large volume of ship traffic and ship loss throughout history. Since the deep sea is an excellent environment for the preservation of shipwrecks and their contents, the NPS suggested that NOAA's regulations require the miner to notify NOAA if the miner encounters any cultural resources during exploration or commercial operations. NOAA in turn will apprise NPS of any such discoveries. Accordingly, NOAA's license phase TCRs contain a provision for notification if any shipwrecks or other cultural artifacts are encountered.

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VI. MONITORING 47

VI. A. National Pollutant Discharge Elimination System (NPDES) Permit 48

VI. B. Monitoring Plan 48

VI. Monitoring

The Deep Seabed Hard Mineral Resources Act requires each licensee "to monitor the environmental effects of the exploration and commercial recovery activities in accordance with guidelines issued by the Administrator...". Because the majority of activities that are conducted during exploration have been deemed by NOAA to have no potential for significant environmental impact, no monitoring of exploration activities (other than the NPDES monitoring requirements of EPA) will be required unless a consortium desires to test mine under a license. If so, the proposed TCRs require that a monitoring plan be submitted by the consortium no later than one year prior to the initiation of tests and be concurred in by NOAA. This plan will be evaluated by NOAA in relation to the baseline information collected by the consortium that is submitted with the monitoring plan, as well as the DOMES data and newly developed research results. Collection of baseline information will be generally in accordance with the Technical Guidance Document (NOAA, 1981b) and concurred in by NOAA. The license TCRs will be modified prior to mine tests to incorporate the monitoring plan and any special conditions required as a result of baseline data submission. Because no test mining is anticipated during the next few years, plans for monitoring - currently unneeded by NOAA - have not yet been developed in detail, although all consortia have recognized in their applications their responsibility to monitor environmental effects. NOAA expects discussions to begin with any consortium wishing to test mine, several years prior to initiation of these tests. The TCRs indicate the essential elements of the plan; details will depend upon test plans as well as environmental baseline findings.

VI.A National Pollutant Discharge Elimination System (NPDES) Permit

Because the Act specifically states that discharges from a vessel engaged in commercial recovery or exploration shall be subject to the Clean Water Act (P.L. 92-500, as amended), each licensee must obtain an NPDES permit. The Environmental Protection Agency, which issues these permits beyond state waters, is developing a general permit for vessels or other floating craft subject to the Deep Seabed Hard Mineral Resources Act and has indicated its intent to process such a permit coincidentally with NOAA's processing of license applications. Such a permit will cover all vessels under a mining license, apply to routine vessel discharges (e.g., deck drainages, sanitary wastes, domestic wastes) and be valid for five years. Discharges under this general permit are to be monitored monthly. If a consortium wishes to test mine, the NPDES general permit will be modified for that consortium to address impacts from the surface and benthic plumes.

VI.B OMA's Monitoring Plan

OMA's application contained no firm plans for at-sea equipment tests under the exploration license. Two at-sea tests have already been conducted. In 1970, tests were conducted on the Blake Plateau and, in 1978, further tests were conducted near DOMES Site C. The former test was monitored by the Lamont-Doherty Geological Observatory (Roels et al., 1973). The latter test was monitored by NOAA (Ozturgut et al., 1980) and provided the basis for NOAA's assessments of potential environmental impacts from mining. Further assessments of benthic impact and recovery at Site C will be available in the near future following the analysis of the box cores and other data obtained during the NOAA-OMA site revisit in June 1983. OMA states clearly (pg. F-13 of application) that they will submit further details on at-sea tests and monitoring plans prior to testing within time frames and formats established by NOAA. A suite of measurements, such as salinity, temperature, nutrients, and currents in the upper water column will be made consistent with those used during DOMES, although improvement in methodologies may result in modifications to DOMES techniques. Similarly, measurements will be made in the near-bottom water column, including suspended particulate concentrations, benthic impact, sedimentary characteristics, currents, and topography. Post-test environmental data will be collected, as necessary.

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VII. ONSHORE 53

VII. Onshore

Ocean Mining Associates has not selected a location for its processing facilities. Process plant siting will be delayed until a commercial permit is applied for or issued, unless NOAA is otherwise notified. The process development plan submitted with the application however, does not foresee building a pilot-plant in the United States. Most of the process research has been accomplished in overseas facilities and it is expected that the additional research will be conducted under contract at the existing facilities. If a prototype plant were to be built in the United States, OMA would submit the required environmental and test data to NOAA for the preparation of a supplemental EIS. No alternatives or mitigation strategy will be considered at this time.

Section 307(c)(3)(A) of the Coastal Zone Management Act (P.L. 92-583, as amended) requires that all Federal licenses and permits for activities that affect the land or water uses in the coastal zone be consistent with approved state coastal zone management programs. However, because OMA will not conduct any onshore processing activities in the United States, there should be no effect on any coastal area and no consistency certification is needed from the applicant at this time.

VIII. LIST OF PREPARERS

The following people contributed to the preparation of this EIS. Special thanks are due to Shirley Pippin and Nancy Edwards who orchestrated the word processing effort and its many drafts. Although not listed below, many other individuals critically reviewed early drafts and their suggestions for improving the document are greatly appreciated.

NAME	TITLE, PROFESSIONAL SUMMARY, YEARS OF RELEVANT EXPERIENCE	ROLE IN EIS PREPARATION
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IX. LIST OF PERSONS, ORGANIZATIONS, AND AGENCIES TO WHOM EIS SENT

The Draft Site-Specific EIS was sent to the following International, Federal, State and local agencies, industry, interest groups, and individuals.

Federal Officials and Agencies

Senate

Committee on Commerce, Science, and Transportation

Committee on Energy and Natural Resources

Committee on Environment and Public Works

Foreign Relations

House

Committee on Merchant Marine and Fisheries

Committee on Interior and Insular Affairs

Committee on Foreign Affairs

Environmental Protection Agency

Department of the Interior

Department of Defense

Department of State

Department of Commerce

Department of Labor

Department of Transportation (U.S. Coast Guard)

Department of Justice

Department of the Treasury

National Science Foundation

Federal Trade Commission

General Accounting Office

National Advisory Committee on Oceans and Atmosphere (NACOA)

Special Interest Groups

American Mining Congress

Center for Law and Social Policy

National Ocean Industries Association

Sierra Club

Conservation Foundation

Natural Resource Defense Council

Oceanic Society

National Wildlife Federation

States (Office of the Governor)

Hawaii

California

Florida

Oregon

Washington

Embassies

United Kingdom

Federal Republic of Germany

France

Japan

Italy

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Brian Hoyle - (Department of State)

Jean Louis Hyacinthe - (Embassy of France)

Balu Jasani - (Federal Emergency Management Agency)

Kent Keith - (Hawaii Department of Planning & Economic Development)

Lee Kimball - (Citizens for Ocean Law)

William Lavelle - (NOAA - Pacific Marine Environmental Laboratory)

Allen Magnuson - (Texas A & M University)

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Appendix 1

Summary of PEIS Issues

1. Background

NOAA's Final PEIS, required by the Act, was prepared to assess the potential marine and onshore environmental impacts of mining, transportation, and processing of manganese nodules and alternative strategies for managing those impacts. Four U.S.-based, multi-national consortia (Table 1) have expressed their main commercial interest in mining manganese nodules (and subsequently applied for exploration licenses) within a 13 million km^2 east-west belt in the east central Pacific Ocean (Figure 1). In addition, three foreign companies have also applied for exploration licenses in their own countries under their respective domestic legislation: Association Francoise pour L'Etude et la Recherche des Nodules (AFERNOD) - France; Deep Ocean Mining Company, Ltd. (DOMCO) - Japan; and, Arbeitsgemeinshaft Meerestechnisch Gewinnbare Rohstoffe (AMR) - a West German partnership of Preussag A.G., Salzgitter A.G., and Metallgesellschaft A.G.. This area was the focus of a NOAA research effort (Deep Ocean Mining Environmental Study or DOMES) that included the collection of environmental baseline data and the monitoring of pilot-scale mining tests. The DOMES project and related research efforts formed the basis for the environmental impact analyses in the PEIS. The scope of the PEIS was limited to the impacts expected from first generation mining technology, that is, methods expected to be used by industry on a commercial scale during the late 1980's through the 1990's. It was intended to be comprehensive in order to reduce the amount of information required in the site-specific EISs. Should new technology be developed, operations outside the DOMES area be undertaken,

Table 1. 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.

Nation	Kennecott Consortium (KCON) (1/74)	Ocean Mining Associates (OMA) (10/74)	Ocean Management Inc. (OMI) (5/75)	Ocean Minerals Company (OMCO) (11/77)
United States		Essex Minerals Co. (U.S. Steel) 25% Sun Ocean Ventures Inc. (Sun Co.) 25%	Sedco, Inc. 25%	AMOCO Ocean Minerals Co., (Standard Oil Co. (Indiana)) 30.669% of OMCO Lockheed Systems, Co., Inc. (Lockheed Corp.) 6.329% of OMCO Lockheed Missiles & Space Co., Inc., (Lockheed Corp.) 38.64% of OMInc.
Belgium		Union Seas, Inc. a U.S. corporation (Union Miniere) 25%		
Canada	Noranda Exploration, Inc., a U.S. corporation 12% (Noranda Mines Ltd.)		INCO, Ltd. 25%	
Italy		Samim Ocean Inc., U.S. corporation (ENI/Italy) 25%		
Japan	Mitsubishi Corp. 12%		Deep Ocean Mining Co., Ltd. (DOMCO-19 Japanese Companies) 25%	
Netherlands				Ocean Minerals, Inc. (OMInc., a U.S. corp.) 63.002% of OMCO -Billiton B.V. 48.68% of OMInc. (Royal Dutch/Shell Group) -BKW Ocean Minerals 12.68% of OMInc., (Royal Boskalis Westminister N.V.)
United Kingdom	Kennecott Corp., a U.S. corporation (Sohio/BP) 40% R.T.Z. Deep Sea Mining Enterprises, Ltd. (Rio Tinto-Zinc) 12% Consolidated Gold Fields, PLC 12% BP Petroleum Dev., Ltd. 12% (The British Petroleum Co., p.l.c.)			
West Germany			AMR 25% (Preussag A.G., Salzgitter A.G., Metallgesellschaft A.G.)	

or at-sea processing of nodules be initiated, a supplement to the PEIS or a new PEIS may be required.

2. Marine Impacts

The principal potential impacts on the marine environment are those associated with mining activities, offshore processing, transportation to port, and the offshore disposal of wastes from onshore processing plants.

First generation mining technology as described in the PEIS will recover nodules from the deep seabed by means of a collector which is pulled or driven along the seafloor (See Figure 4). The nodules are then pumped via a pipe to the mine ship and transferred to the ore carrier for transport to the onshore processing plant. Collector action will result in adverse environmental impacts through direct disturbance of benthic biota in its path and through the creation of a benthic plume of fine-grained suspended sediment which will affect biota beyond direct contact. In addition, a surface plume will be generated by the discharge of bottom water, sediment, and nodule fragments over the side of the mine ship.

As a result of DOMES research and monitoring and subsequent research, many of the environmental concerns raised initially about marine mining have been determined to have low probability for causing significant environmental impacts; other concerns appear certain, while others are not yet resolved (Table 2, Appendix 2, shows the updated status of these concerns). Impacts will occur at the sea surface and on the seafloor. The benthic impacts with the potential for significant adverse effects are twofold: organisms in the path of the collector will

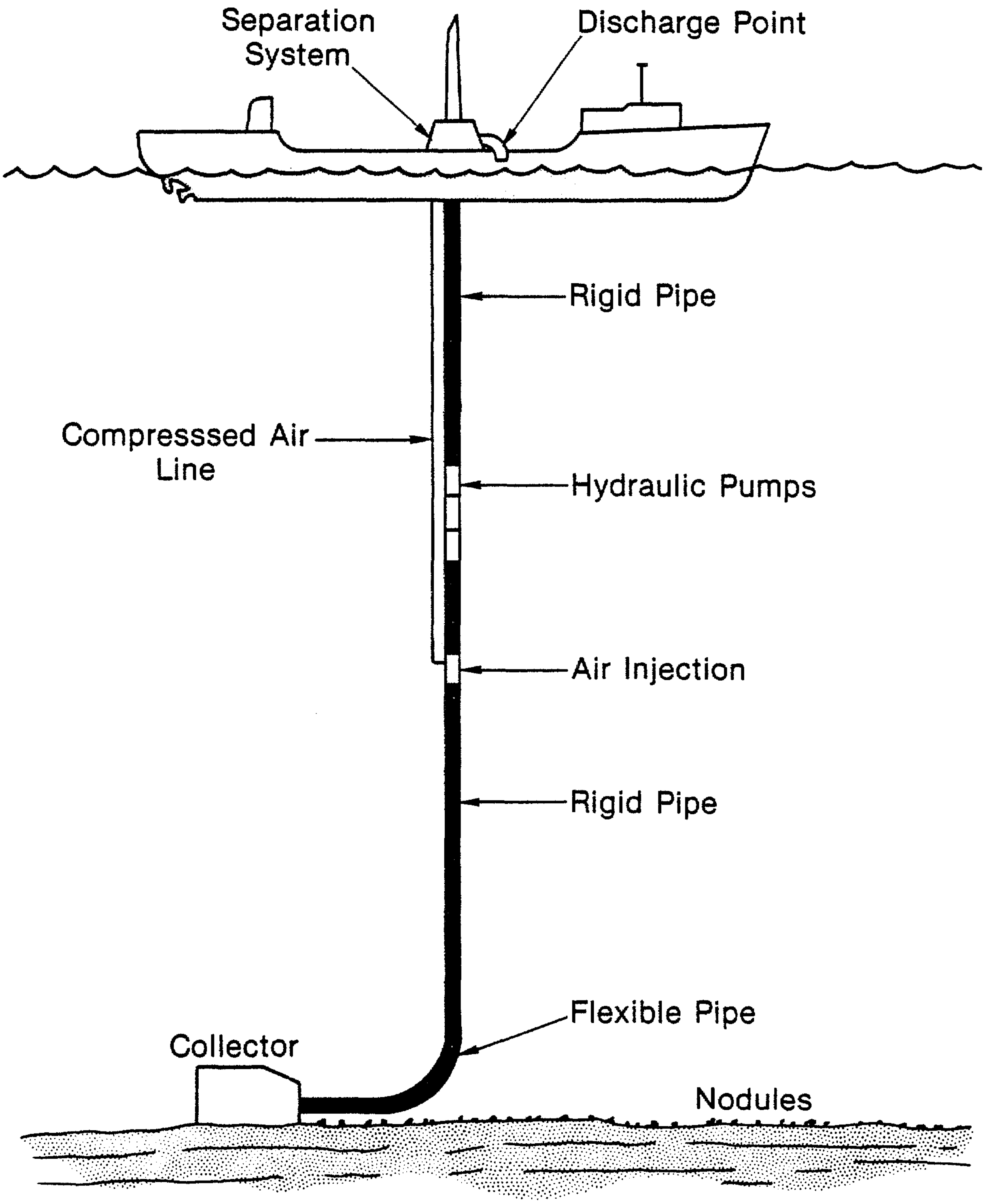

Figure 4. Diagram of the mining system and identification of its major components.

be destroyed; the sediment plume stirred up by the collector may smother smaller benthic animals and dilute their food supply at distances away from the mine site. The only potentially significant environmental impact identified in the PEIS associated with the surface plume is its possible impact on the eggs and larvae of commercially important fish such as tuna and billfish. In addition, at the time the PEIS was issued, it was not known if mining particulates discharged at the surface would accumulate on the pycnocline and cause a reduction in light levels with an accompaning reduction in primary productivity.

Determinations of environmental significance in the PEIS were based on brief periods of pilot-scale mining and on the results of laboratory research and modelling. NOAA will verify or update the conclusions by requiring environmental monitoring of demonstration-scale mining tests if conducted by industry during the license phase.

Offshore processing would be the refining of nodules and the disposal of wastes at sea rather than on land. Because of the technological limitations imposed by ship motion, processing at sea is not expected to occur during first generation mining. If it should be proposed, a supplement to the PEIS will be prepared.

Waste disposal most likely will occur on shore. However, industry may consider ocean dumping or discharge through an ocean outfall. The environmental impacts and the likelihood of receiving the necessary permits for offshore disposal will remain unknown until the exact chemical and physical characteristics of the nodule processing wastes are known. Based on four years of research conducted by NOAA, EPA, the Fish and Wildlife Service (FWS), and the Bureau of Mines (BOM), these wastes are not expected to be toxic.

Nodules will be transferred from the mining ship to ore carriers and transported to port. Any nodules spilled during transfer are not expected to have a significant impact because the nodules appear to be inert in their natural form.

3. Onshore Impacts

Since commercial scale nodule processing has yet to be demonstrated, neither the specific sites where the facilities might be located nor the specific processing technologies can be identified. The exact environmental, socio-economic, and cultural impacts will vary depending on the location of the facilities and the choice of processing technology. The onshore environmental assessment was handled from a generic perspective based upon NOAA-sponsored studies of the various approaches to the metallurgical processing of manganese nodules and geographic areas of the United States where industry may locate. Four major onshore activities have the potential for significant impact: 1) use of port facilities; 2) transportation of nodules from port to processing plant; 3) nodule processing; and 4) waste disposal.

The consequences of the development and operation of the marine terminal include dredging and filling, ship exhaust emissions, water use, and dust. Port-to-plant transportation will likely be done by pipeline, although enclosed conveyors or truck and rail are possible alternatives. Operationally, the nodule processing plant will be similar to a plant designed to process ores mined on land. On-site nodule storage probably will require slurry ponds or specially designed enclosures. Waste disposal presents the greatest environmental concern because of the incompletely known chemical and physical nature of the wastes and the high volume of material. NOAA, EPA, the Fish and Wildlife Service, and the Bureau of Mines presently are conducting research to determine more precise estimates of the characteristics of the wastes, especially if there are any toxic or hazardous components. Disposal will be on land in landfills or tailings ponds.

4. Alternatives

Alternatives for managing nodule recovery and for managing onshore activities were considered in the PEIS and are summarized below:

a. Two types of alternative approaches for managing nodule recovery were considered: approaches other than those established by the Act and approaches for implementing the Act.

Alternatives to the Act include unregulated mining, prohibition of mining, and delay of mining until an LOS treaty enters into force for the United States or the environmental implications are better understood. None of these alternatives to the Act was considered to be NOAA's preferred or the environmentally preferred alternative.

Under the Act, before NOAA can issue a license or permit, it must determine that the proposed activities will not result in a significant adverse effect on the environment. NOAA must issue terms, conditions, and restrictions (TCRs) to assure conservation of the resources, protection of the environment, and the safety of life and property at-sea. Within this framework, nine issues with potential environmental consequences, each with several alternatives, were considered. At the license phase, the issues are: to what extent NOAA should dictate monitoring requirements to industry; the proximity of mine sites to each other; and, what criteria, if any, should apply to the selection of stable reference areas (See Appendix 2, for discussion). NOAA's Technical

Guidance Document (available at the same address as the PEIS) specifies the parameters of concern and encourages industry to develop its own monitoring strategies which will be subject to NOAA review and will form the basis for the monitoring TCRs.

A non-linear alignment of mine sites during commercial mining was recommended. Applications will be reviewed at the license and permit stage for site alignment and benthic research will be conducted to better determine the safe spacing for sites. NOAA has initiated consultations with reciprocating states regarding the establishment of stable reference areas, as required by the Act.

At the permit phase, there are two issues with environmental implications: the proximity of mine sites and technological capability to mine. NOAA must determine if commercial operations can be conducted in harmony with the environment and in accordance with TCRs. Rather than assume the technological capabilities of the applicant, NOAA will conduct its own assessment based on data required on design, component, and operating information submitted with the application and a description of the miner's ability to monitor environmental effects.

Resource conservation issues at the permit phase include: a requirement for a mining pattern on the seafloor; allowing selective mining of the richest zones of the site first; and, requiring retention of manganese tailings from three-metal operations (recovery of Cu, Co, Ni). NOAA will defer a decision on the mining pattern until license phase test mining has been observed. No pattern will be required during the test mining. Selective mining of the richest zones of a site will be allowed if it is part of a logical long-range plan which will not preclude future exploitation of the remaining resource. Alternatives for manganese utilization include letting the world market determine its fate, requiring a four-metal operation, or establishing a means for manganese tailings to be saved. No environmentally preferred alternative is obvious at the programmatic level; however, NOAA's preferred alternative is to establish a means for the manganese not to be rendered unavailable for possible future use.

An issue with international implications involves the development of criteria to use in designating reciprocating states. NOAA prefers establishing specific criteria, including continued consultations on environmental issues and research.

b. Three alternatives exist for NOAA involvement in managing onshore activities: 1) NOAA would only review onshore processing technology and potential impacts with no role in the siting or permitting process; 2) NOAA would act as lead agency for review of environmental impacts, prepare EISs, and work informally with other Federal agencies, and state and local governments to facilitate obtaining the necessary permits; and, 3) the designation of NOAA as responsible for permitting decisions. NOAA prefers the second alternative because it assures an effective NOAA role in encouraging deep seabed mining and it does not require legislative change.

Appendix 2

Marine Research Efforts - Recent Findings

Although the exploration activities covered in this site-specific EIS have no potential for causing a significant adverse impact, NOAA has conducted research since the publication of the PEIS which was directed at the unresolved concerns in that document. A brief description of this research is included in this Appendix.

As a result of the DOMES mining tests, NOAA's PEIS was able to determine that most of the initial mining concerns had a very low probability of causing a significant or adverse environmental impact (Table 2). Some concerns related to mining activity appeared either to be certain to cause a negative impact or were unresolved; however, some of these uncertainties have been better resolved since the publication of the PEIS. The destruction of the benthos in and near the collector track will be adverse; however, the exact significance to the benthic ecosystem is uncertain at this time. The blanketing of the benthos and the dilution of their food supply away from the mine site have the potential for adverse impact but the exact significance is unresolved at this point. The potential for accumulation of fine particulates at the pycnocline, which was unresolved at the time of PEIS publication, appears now to have a very low probability of occurrence as a result of recent laboratory experiments. The potential for the surface plume to have a significant adverse effect on fish larvae also appears to have a low probability of occurrence.

Table 2. Deep seabed mining perturbations and environmental impact concerns

MINING PERTURBATIONS

		BENTHIC IMPACT		SURFACE DISCHARGE	
	STATUS OF CONCERNS *	COLLECTOR CONTACT	BENTHIC PLUME	PARTICULATES	DISSOLVED SUBSTANCES
CONCERNS WITHOUT POTENTIAL FOR SIGNIFICANT OR ADVERSE IMPACTS	Low Probability of Impacts	Light from collector	Nutrient or trace metal increase Oxygen demand	Bacteria growth deplete oxygen Alter phytoplankton species composition Affect fish Zooplankton mortality and species composition and abundance changes in plume Trace metals entry into food web Pycnocline accumulation Affect fish larvae	Trace metals effects on phytoplankton Nutrient increase cause phytoplankton blooms Airlift caused embolisms
	Potentially Beneficial Effects	Additional food supply for bottom scavengers	Not applicable	Bacteria increase food supply for zooplankton Filterfeeding zooplankton fecal pellets clean up plume	Not applicable
	Certain Impact Without Significant Adverse Effects	Not applicable	Not applicable	Increased turbidity reduce productivity	Not applicable
CONCERNS WITH POTENTIAL FOR SIGNIFICANT OR ADVERSE IMPACTS	Certain Impacts	Destroy benthos in and near track	Not applicable	Not applicable	Not applicable
	Unresolved Impacts	Not applicable	Blanket benthos; dilute food supply away from mine-site sub-areas	Not applicable	Not applicable

* NOTE: Status of concerns is to be verified during demonstration-scale mining system tests and during commercial mining

Because the at-sea tests monitored during DOMES were only pilot-scale (equipment was one-fifth commercial scale and production averaged one-fourteenth commercial scale) and of short duration (actual test mining totaled only five days, with the longest period of continuous mining being two days), NOAA has emphasized that it is essential for the PEIS findings to be validated through additional research and during monitoring of demonstration-scale mining system endurance tests. This need is also discussed in NOAA's Five-Year Environmental Research Plan and Deep Seabed Mining Technical Guidance Document. Although monitoring of tests will not occur until 1986-1988, at the earliest, NOAA is sponsoring research independent of these tests that is focused on issues to improve predictions of plume dispersion and benthic impact.

NOAA's first Five-Year Marine Environmental Research Plan addresses the scientific needs for fiscal years 1981-85 relating to the potential environmental effects from mining and at-sea disposal of processing wastes. Recently concluded and future research directed at the PEIS concerns include the following:

° The unresolved concern of fine mining particulates in the surface plume accumulating on the pycnocline has been investigated in a NOAA funded study (Ozturgut & Lavelle, in press). Laboratory experiments were conducted to determine settling velocities of the particles. Particles were introduced into a stratified settling column and observed with time-lapse photography using a laser beam light source. The average settling velocities of the particles differed (0.116 cm/s in the denser bottom layer of the settling column versus 0.16 cm/s in the less dense upper layer), with this difference almost all due to the difference in viscosity between the two layers. No accumulation at the interface was discernible. These experiments indicated that this contrast in settling velocities between the two layers determined the concentration of the particles in the layers. In the Pacific Ocean, although there likely would be a 30 percent decrease in settling velocity between the upper layers and the region of the pycnocline, due primarily to increased viscosity, this contrast is not expected to be sufficient to result in an accumulation of mining particles. Research indicates that the fraction of mining waste particles having densities equal to or less than the typical pycnocline densities is less than 0.1-0.2% of the total material discharged. In fact, based on test mining samples collected in 1978, less than 4% by volume of the mining discharge has a wet density less than 1.5 g/cm^3, validating field observations and modelling results that particles settle much more rapidly (i.e., 10^{-2}cm/s) than originally expected for disaggregated clay size particles. Although it was originally thought that such rapid settling was probably due to flocculation of the clay particles, laboratory studies suggest that re-flocculation was not a a dominant process, but rather that the collected particles are so strongly bonded as aggregates that not even the transit up the mining lift pipe breaks them apart.

° The extent of ingestion and assimilation by zooplankton of the trace metals in nodule fragments and the potential for food chain transfer to higher trophic levels were examined by NOAA's Beaufort Laboratory of the National Marine Fisheries Service (Hanson et al., in preparation). Two possible pathways of trace metal entry were examined using existing scientific literature and based upon ongoing research: direct uptake of dissolved forms of metals by plankton or other low level forms; and, uptake through ingestion of particles, living or non-living, containing trace metals. The potential for biomagnification was also evaluated. Entry of trace metals through direct uptake of the dissolved form does not appear to be a problem since present evidence suggests that concentration of free hydrated ions resulting from the surface plume, which is related to the toxicity of the metals, will not exceed ambient concentrations.

Analysis of the second pathway, uptake through ingestion of particulates, strongly suggests that zooplankton (mainly copepods) will ingest significant quantities of the fine particulates in the surface plume. However, it is unlikely that any adverse effects from the ingested trace metals will result. This conclusion, though not based on experiments with zooplankton and inorganic suspended sediments, is extrapolated from data showing that assimilation by zooplankton and juvenile fish of organic particulates containing metals does not appear to be an efficient process. In addition, organisms have been found to be able to regulate the essential elements and to be able to detoxify non-essential elements such as cadmium, mercury, and silver. Since the plume is rapidly diluted, the exposure time of plankton is brief, and trace metal concentrations low, the likelihood of any adverse effects is expected to be minimal. Also, since no evidence exists (except for methyl mercury, which is not found in the nodules) for the biomagnification of inorganic metals, the potential for food web contamination likewise appears to be low.

° The effect of the surface plume on the eggs and larvae of commercially important fishes (tuna and billfish) is presently being investigated at the National Marine Fisheries Service Laboratory in

Honolulu. Through an examination of the scientific literature, a report has been prepared on the distribution of these species, their larval feeding behavior and reproductive patterns, potential effects on larvae from the surface plume, the probability of adverse effects resulting from aggregation around mineships and consequent accelerated spawning activities, and the probability that these effects will significantly affect year-class strength. The report concludes that the rapid dissipation of the plume should preclude any significant adverse effects from increased suspended particulates or from sudden changes in the physico-chemical characteristics of the water due to the mixing of bottom water. Likewise, there is not expected to be a detectable effect from increased spawning activity in the vicinity of the mineships. Sample calculations showed that any adverse effects on year class strength would be indistinguishable from natural fluctuations. In addition, spawning of skipjack and yellowfin tuna also occurs to the north of the DOMES area. This area would thus provide a source for recruitment of juveniles into the Hawaiian fishery should any adverse effects occur in the DOMES area from mining.

° A research effort directed at obtaining a better understanding of the variability of the bottom currents and suspended particulate matter (SPM) concentrations in the DOMES area was begun in 1982. NOAA, in cooperation with Oregon State University (i.e., the National Science Foundation's Manganese Nodule Project-MANOP), moored several benthic current meters and nephelometers at MANOP Site S (near DOMES Site B) for the purpose of obtaining long-term (one-year) measurements of bottom currents and SPM concentrations. Long-term measurements of these parameters have never been collected in the DOMES area. Data on the velocity and variability of the currents will enable better predictions to be made of the dispersion of the benthic plume and hence on the potential for impact on the benthos away from the mine site. Data on the natural variability of the SPM will indicate the natural range of suspended material concentrations to which the benthic organisms are exposed.

° A research effort directed at examining benthic recolonization at a previously mined site was begun in 1983. NOAA, in cooperation with Deepsea Ventures Inc. (the service contractor for Ocean Mining Associates (OMA)) and Scripps Institution of Oceanography, revisited the area at DOMES Site C that was test mined by OMA in 1978. The collector track was located and surveyed with the Scripps' deep tow instrument package. Acoustically navigated box cores were taken in the area adjacent to the minetracks that would be expected to be affected by the mining. These box cores are presently being analyzed for both macrofauna and meiofauna and may provide a better insight into the question of benthic impact following commercial-scale mining.

° The Deep Seabed Hard Mineral Resources Act requires the United States to negotiate with other mining nations for the purpose of establishing "stable reference areas" (SRA). These areas are intended to serve as reference or control areas against which mining impacts can be assessed and as areas "to insure a representative and stable biota of the deep seabed." In order to address this issue, NOAA requested the Ocean Policy Committee of the National Research Council (NRC) to evaluate the issue in terms of its scientific validity and to design a cost-effective approach to implement this concept. The NRC concluded that the concept is scientifically valid <u>if</u> two types of SRAs are defined: Preservation

Reference Areas (PRAs) to be used as areas to insure a representative and stable biota of the deep seabed and Impact Reference Areas (IRAs) to be used for impact assessment. PRAs would be designated through international negotiations by the time of permit issuance and would be of sufficient size and appropriate location not to be affected by mining activities, nor to include substantial portions of the seafloor. The number, size and location would be based upon available information on the environmental variability of the DOMES region, additional research on plume dispersion, benthic current data, and locations of mining claims. Depending on availability of funding, studies will be conducted at these sites on long term variability in the benthic environment.

IRAs would be designated at locations affected by mining activities. Studies would then be conducted before and after mining to assess the impact resulting from commercial mining. The studies at the impact and preservation areas will provide a better understanding of the deep sea, thus assisting NOAA in differentiating mining impacts from natural variability, determining the significance of the impact and identifying measures that might facilitate more rapid recovery.

° NOAA is funding the development of two biological models to provide a theoretical basis for the design of baseline and monitoring programs. One model is examining existing sampling theory and how results are biased in an environment such as the deep sea where there is a high species diversity and low abundance. The model will be used to examine the importance of different parameters in reflecting the characteristics of the deep sea benthic environment.

The second model is evaluating existing data, mostly from shallow-water environments, on the recovery patterns of the benthic biota following a disturbance. By identifying similarities between shallow water species and deep water fauna, it is hoped that better predictions can be made of the types of recovery patterns that would follow deep seabed mining, and thus the measurements to be made to monitor this recovery.

° NOAA's National Environmental Satellite, Data, and Information Service is examining the feasibility of using satellites to collect environmental data for baseline and monitoring. Data from both the Coastal Zone Color Scanner and the Advanced Very High Resolution Radar have been examined. A major difficulty has been the frequent coverage of the DOMES area by clouds: less than 10% of the scenes examined are sufficiently cloud-free to allow further examination. Those scenes evaluated have provided some some interesting results. One scene showed the unexpected intrusion of a large eddy approximately 160 km in diameter extending into the eastern DOMES region from the north that exhibited chlorophyll concentrations nearly an order of magnitude higher than the surrounding waters! Results of this kind suggest that although the number of scenes that are cloud free is relatively small, the information provided from those scenes that can be analyzed can be extremely useful because so little is known about the natural changes in the area of future mining. Evidence on the natural variability of the DOMES environment is extremely important for the future interpretation of monitoring data in order to differentiate between such changes from mining-related effects.

° Ocean disposal of processing wastes is one of the disposal options being considered by industry. A one-year study of the environmental considerations associated with ocean disposal was recently completed for NOAA and EPA by Tetra-Tech, Inc. (Tetra-Tech Inc., 1982). The study examined the present regulatory regime; current disposal techniques and ocean disposal activity; present knowledge regarding the characterization of the wastes; environmental characteristics of representative disposal areas; environmental issues associated with the different disposal techniques in selected geographic areas; and the additional research requirements for assessing impacts. The report concluded that there appears to be no reason why ocean disposal should not be considered as an acceptable option. However, it was emphasized that additional analysis must be conducted when the exact site location, the detailed characteristics of the waste, and the regulatory regime governing ocean disposal at the time of application are known. The report nevertheless does provide guidance for industry and Federal and state agencies on the important questions that need to be answered when more specific information is available.

Three methods of offshore disposal were considered: surface dumping, surface dispersion, and subsurface dispersal. Nearshore methods included disposal through an outfall pipe or by nearshore dumping. The most appropriate method will have to be selected according to the particular environmental concerns of the disposal area. The report determined that the alteration of the substrate and the potential for bioaccumulation of trace metals could be the two most significant effects associated with ocean disposal. However, more information is required about the nature of the benthic communities and the depth of burial before accurate benthic impact predictions can be made. Also, predicting the likelihood of bioaccumulation requires more information on the metal species present, their physical/chemical form, their concentration in seawater, and the specific environmental variables that affect metal uptake.

Appendix 3

Onshore Research Efforts - Recent Findings

This Appendix summarizes NOAA's research efforts since the publication of the PEIS which were directed at onshore environmental concerns.

Since neither specific processing site locations nor processing technologies are presently known, the onshore environmental assessment in the PEIS was limited to a generic perspective. Some general effects of onshore activities are universal or inevitable and were described in general terms without reference to a specific site. NOAA has sponsored generic studies of the various processing technologies and the geographic areas of the United States where industry might locate onshore facilities.

The PEIS onshore assessment was based on four types of studies: a) identification of the most likely nodule processing techniques (Dames and Moore and E.I.C. Corporation, 1977); b) identification of potential areas of the United States where processing plants could be located and the attitudinal characteristics of these areas (e.g., Bragg, 1979); c) identification of the applicable state and Federal laws that may affect the siting of a processing plant (e.g., McGarry and Brown, 1981); and d) analysis of the environmental, social and economic aspects of onshore mining (Dames & Moore, 1980) for comparison to deep seabed mining.

Of all the activities associated with manganese nodule processing, disposal of the processing waste likely will be the greatest concern. The reasons for this concern are twofold: the sheer volume of wastes to be disposed of, and the chemical and physical nature of the wastes. Research addressing this waste disposal problem has been completed since the publication of the PEIS. Separate studies were initiated to: 1) characterize the wastes associated with manganese nodule processing; 2) assess the regional problems associated with onshore disposal; and, 3) study the impacts associated with nodule processing in two locations in Hawaii.

1. Characterization of Manganese Nodule Processing Rejects

A four-year interagency effort (NOAA, FWS, EPA, Bureau of Mines) entitled "Analysis and Characterization of Manganese Nodule Processing Rejects" began in 1980. Previous studies on possible processing methods and waste disposal options (Dames and Moore and EIC Corp., 1977; Dames and Moore et al., 1977) were described in the PEIS and formed the basis for these subsequent studies. The individual objectives of this recent effort are to: a) mineralogically and chemically describe the nodules from the Pacific Ocean; b) update the Dames and Moore processing report; c) predict the physical and chemical characteristics of nodule waste materials; and d) analyze the wastes generated under laboratory conditions. The overall objective of the entire cooperative research effort is to provide information needed by Federal and state agencies in preparation for receipt of industry's commercial waste management plans.

a. In order to be able to understand better the nature of the processing wastes and predict their potential environmental impact upon disposal, it is first necessary to understand the nature of the nodules themselves. The first report (Haynes et al., 1982a) describes the morphology, mineralogy, and elemental composition of the Pacific Ocean nodules. The description of the external characteristics and the internal structure of the nodules is important because both of these aspects of nodule morphology contribute to the total nodule properties.

The mineralogical composition was presented with some emphasis placed on major mineral differences with respect to the benthic environment (depth, sediment type). The elemental analysis section presented data on the 74 elements occurring in the nodules. The elements were broken into eight groups: major and minor elements of potential economic interest; other major and minor elements; elements of environmental interest; rare earth elements; precious metal elements; radioactive elements; other trace elements; and, anion-forming elements.

b. In 1977, NOAA published a report prepared by Dames and Moore entitled a "Description of Manganese Nodule Processing Activities for Environmental Studies" (Dames and Moore et al., 1977). That report identified the five most economically and technically feasible processing techniques and flowsheets for first generation processing plants. This second report (Haynes et al., 1983a) has taken the previous flowsheets and used the input from industry and other concerned parties to update the previous report and present, where necessary, changes and modifications in the flowsheets. These updated flowsheets were used to design, construct, and operate bench scale systems to generate reject materials. These materials were then analyzed to determine the exact physical and chemical characteristics for the wastes from each of the five processes.

c. A third report (Haynes and Law, 1982b), based on the information in the other two reports, predicts the physical and chemical characteristics of nodule reject waste material for each of the five processes. The physical characteristics are predicted based on land-based laterite processing or on process chemistry. Physical and chemical analyses as well as the Extraction Procedure (EP) toxicity test of industrially supplied pilot plant reject material are also presented.

In describing the chemical characteristics, 18 elements of potential economic and/or environmental concern were discussed. Thirteen of these elements (Ag, As, Be, Cd, Cr, Cu, Hg, Ni, Pb, Sb, Se, Tl, Zn) were chosen because they are listed as priority pollutants under the Toxic Substances Control Act. Four elements (Co, Fe, Mn, Mo) are included because they are major nodule constituents and/or are of economic importance. One element (Ba) was included because it is on the EPA list of leachable metals in the EP toxicity test.

Although the predictions and values given in the report are based on limited data and are estimates only - they may not necessarily represent the composition of the rejects from a full-scale commercial plant - it appears that the waste material may have only minor environmental concerns. Leachates from the EP toxicity of the two ammoniacal leach wastes, the sulfuric acid leach waste, and the smelting leach waste should be well below maximum limits for classification as hazardous waste. However, the presence of soluble chloride salts in the waste from the hydrochloric acid leach process may not enable this reject material to stay below the EP toxicity limits.

d. An additional report (Haynes *et al.*, 1983b) was prepared because of the need for accurate and precise analytical methods to be able to assess any potential environmental impact of nodule wastes disposal. This report outlined methods which the Bureau of Mines believes are applicable to the characterization of nodule feed materials and the reject waste materials from all five potential processes. Analytical procedures are described for the quantitative determination of 16 elements and 7 ionic species, the identification of major and minor mineral components, and measurement of physical properties associated with the nodules and processing wastes.

2. Onshore Disposal Options

A NOAA/Bureau of Mines sponsored report on onshore disposal options was recently completed (Rogers, Golden and Halpern, 1982). The objectives of this study were: 1) to identify all reasonable and emerging state-of-the art disposal techniques; 2) to provide a first-order assessment of applicable regulatory requirements and environmental considerations for the various disposal options and for those regions where processing may occur; and, 3) to guide research on the characteristics of the rejects and on refining disposal techniques by identifying those physical and chemical characteristics of the rejects that are most significant in predicting environmental effects.

In order to assess the environmental considerations and develop a scenario that is representative of first-generation processing operations, the study identified three classes of rejects from the five feasible processes, four classes of waste disposal techniques, and one site from each of five geographic regions. The reject and processes include: 1) leached tails from three-metal hydrometallurgical processes and lime boil solids if produced; 2) slags from smelting and from silico- or ferromanganese produced when manganese is recovered from tailings; 3) leached tails from four-metal hydrometallurgical processes and residues from electrolytic manganese reduction steps. Four classes of waste disposal techniques -- based on the similarity of potential effects -- include: above surface retention structures; specially excavated pits, backfill of mines, deep disposal; dewatered tailings disposal, including slag; and liquid waste disposal through evaporation or deep well injection.

The five geographic regions are: the Pacific Northwest, Southern California, the Gulf Coast, and two sites in Hawaii (one wet and one a dry climate).

Each site/process/disposal technique combination was compared against potential effects. Regulatory requirements were also considered at each site.

The report concluded that current disposal techniques used for terrestrial ores are generally applicable to nodule waste disposal. However, there is still an uncertainty as to the hazardous waste classification of the rejects under the Resource Conservation and Recovery Act and the classification of hydrometallurgical process tailings as toxic by EPA. Also, some states have hazardous waste disposal laws that are stricter than Federal regulations. The slags from the smelting process are expected to be inert and should pose little or no environmental problem in disposal. They may in fact have a beneficial use as land fill and construction aggregate. Three types of environmental concerns were identified: concerns common to all sites (e.g., aquifer contamination); concerns common to specific areas or regions (e.g., balance between precipitation and evaporation); and, site-specific concerns (e.g., wildlife attraction to tailings impoundments). Determining the toxicity of the hydrometallurgical process tailings was identified as the primary need for further study. The toxicity characteristics determine whether hazardous waste disposal regulations will apply.

3. Hawaii

A joint study, conducted by NOAA and the State of Hawaii (Hawaii Department of Planning and Economic Development, 1981), examined the feasibility and potential impact of locating a nodule processing plant at two different sites on the island of Hawaii. Part I of this report described the nature, location, and importance of the nodule resources; discussed the status of private industry and government programs; and, provided a general overview of the mining and processing operations. Part II provided an assessment of the feasibility and potential impacts of nodule processing. In order to assess these impacts it was necessary to identify illustrative sites and to postulate various mining and processing systems. Two illustrative sites were chosen on the island of Hawaii; one site (Puna District) has a wet climate while the other site (Kohala District) has a dry climate. The sites were assigned different fuels, bulk handling, and waste disposal systems in order to compare these variables. The report concluded with a review of applicable environmental laws and a discussion of attitudes expressed by the public during workshops and meetings.

The Puna District, near the major port of Hilo, has considerable unused land, a good highway, a geothermal well for an alternate energy source, and one of the state's best sources of fresh water. In the Puna scenario, nodules are transported to Hilo from the mine site and transferred by slurry pipeline nine miles to an oil-powered processing plant. Ocean disposal, through an outfall pipe or by ocean dumping, would be the preferred method of waste disposal because the high precipitation would make evaporative-type onshore containment structures only marginally efficient.

The Kohala District, which includes the commercial port of Kawaihae, is lightly populated and near one of the world's best potential wind energy resources. In the Kohala scenario however, coal is assumed to be the primary energy source. The port of Kawaihae is large enough to allow nodules to be transported in relatively large modified nodule transport ships. Nodules and coal would be transported to the plant by conveyor and other bulk handling methods. The topography and dry climate make land disposal of wastes feasible.

Potential environmental problems common to both sites include the possibility of groundwater contamination, marine environmental degradation, and possible construction problems due to seismic activity. The threat to a processing facility from natural hazards such as volcanism and tsunamis varies from place to place on the island. Due to the proximity of Mauna Loa and Kilauea, the Puna District includes areas of moderate to high risk. The risk of volcanic activity in the Kohala District is judged to be very low. Tsunami damage in the Hawaiian Islands has tended to be more intense on the eastern sides of the islands; thus, the port facilities at Hilo would be at a higher risk.

The tailings stream from a processing plant contains certain products that may have commercial uses. Gypsum sludges may be used as land plaster, nodule residues as land fill, fly ash as a polozonic material, and slag as aggregate or land fill. When vegetated or forested, fill areas may contribute to agriculture or forestry on otherwise near-barren land.

The report concluded that extensive environmental laws, the requirement for both state and federal environmental impact statements, and the number of permits that would have to be obtained, should preclude any negative environmental impact.

The most significant impacts at the two sites will likely be the social impacts. The main negative socio-economic effect would be the changes in the life-style of the people living near the processing plant and pipeline road system, particularly during the construction phase. The extent of in-migration could also affect the local population mix, possibly changing the local power structure in favor of the new arrivals. The potential beneficial effect is primarily the stimulation of the local economy though the creation of new jobs and sources of government revenues. For this reason, the Governor and his Department of Planning and Economic Development have encouraged the development of seabed mining in Hawaii.

Hawaii is the only specific location which industry has publicly stated is an attractive site for processing. Although no formal surveys or polls have been conducted to determine public attitudes, public input has been received during workshops, meetings, and in the local press. As is to be expected, some members of the public see nodule processing as a major economic opportunity; others see it as environmentally damaging; while others feel that socio-economic impacts will be most strongly felt. This last concern was addressed in comments received from a Puna community organization on NOAA's draft PEIS (National Oceanic and Atmospheric Administration, 1981c, pp. 35-44).

Appendix 4

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Appendix 5

Acronyms, Abbreviations, and Glossary

Acronyms

CEQ	-	Council on Environmental Quality
NEPA	-	National Environmental Policy Act
FWS	-	Fish and Wildlife Service
BOM	-	Bureau of Mines
EPA	-	Environmental Protection Agency
MANOP	-	Manganese Nodule Program
OMCO	-	Ocean Minerals Company
OMA	-	Ocean Mining Associates
OMI	-	Ocean Management, Inc.
KCON	-	Kennecott Corporation
DOMES	-	Deep Ocean Mining Environmental Study
NPDES	-	National Pollutant Discharge Elimination System
TCRs	-	Terms, conditions, and restrictions
SRA	-	Stable Reference Areas
IRA	-	Impact Reference Areas
PRA	-	Preservation Reference Areas
LOS	-	Law of the Sea
NMFS	-	National Marine Fisheries Service
PEIS	-	Programmatic Environmental Impact Statement
SPM	-	Suspended particulate matter
NAS	-	National Academy of Sciences
NPS	-	National Park Service

Appendix 5 (Cont'd)

Chemicals and Trace Metals

Al	- aluminum	Cr	- chromium	Mo	- molybdenum
Sb	- antimony	Co	- cobalt	Ni	- nickel
As	- arsenic	Cu	- copper	N	- nitrogen
Ba	- barium	Fe	- iron	Se	- selenium
Be	- beryllium	Pb	- lead	Ag	- silver
Cd	- cadmium	Mn	- manganese	Tl	- thallium
C	- carbon	Hg	- mercury	Zn	- zinc

Measurements

Distance

mm - millimeters

cm - centimeters

m - meters

km - kilometers

Weight

mg - milligrams

mt - metric tonnes

kg - kilograms

Ratios

ug-at/l - microgram atoms per liter

cm/s - centimeters per second

ug/l - micrograms per liter

ug/g - micrograms per gram

$^{o}/oo$ - parts per thousand

ppm - parts per million

g/m^2 - grams per square meter

umol/l - micromole per liter

g/cm^3 - grams per cubic centimeter

m/s - meters per second

C/m^3/day - carbon per cubic meter per day

ng/l - nannograms per liter

mg/m^3 - milligrams per cubic meter

mgC/m^2/day - milligrams carbon per square meter per day

Appendix 5 (Cont'd)

Others

°F - degrees Fahrenheit

°C - degrees Centigrade or Celsius

m^2 - square meters

m^3 - cubic meters

kHz - kilohertz

s - seconds

Brittle Star - A class of phylum Echinodermata of spiny-skinned, starfish-like, bottom-dwelling, mobile organisms with five or more elongated, brittle arms.

Bryozoan - A phylum of minute, colonial animals with body walls often hardened by calcium carbonate that usually grow attached to plants, rocks, or other firm surfaces.

Chaetognaths - One of a phylum of small, elongate, transparent, wormlike animals pelagic in all seas from the surface to great depths. Also called arrow worms.

Chain bag dredge - A sampling device consisting of a large metal frame attached to a heavy chain mesh bag which is dragged along the seafloor. Also called basket samplers and dredge baskets.

Chlorophyll a - One of a group of green pigments, identified as chlorophyll a, b, and c, occurring in plants that are active in the process of photosynthesis. The concentration of these pigments is used as an index of the standing crop of phytoplankton.

Clay - As a size term, refers to sediment particles ranging in size from 0.0039 to 0.00024 mm. Mineralogically, clay is a hydrous aluminum silicate material with plastic properties and a crystal structure.

Cnidarians (Coelenterates) - A phylum of mostly colonial marine animals that exist in both a free-swimming and an attached stage. Includes corals, sea anemones, and jellyfish.

Copepods - Minute shrimplike crustaceans that often occur in large concentrations ("insects of the sea") in the surface waters and are an important link in many marine food chains.

Crustaceans - A class of animals with a segmented external skeleton and jointed appendages. Includes barnacles, crabs, shrimp, lobster, copepods, and amphipods.

Deep-tow instrumentation - A towed, near bottom electronic system on which simultaneously operating sensors are mounted that telemeter data to the survey ship.

Echinoderms - One of a phylum of principally benthic marine animals having calcareous plates with projecting spines forming a rigid or articulated skeleton or plates and spicules embedded in the skin; includes starfish, sea urchins, and sea cucumbers.

Eddy - A circular movement of water usually formed where currents pass obstructions, between two adjacent currents flowing counter to each other, or along the edge of a permanent current.

Epifauna - Animals which live at the water-substrate interface, either attached to the bottom or moving freely over it, e.g., starfish.

Epipelagic - That portion of the oceanic province extending from the surface to a depth of about 200 m.

Euphausids - One of an order of shrimplike, planktonic crustaceans, widely distributed in oceanic and coastal waters.

First generation mining - Hydraulic mining of deep seabed manganese nodules in the DOMES area by four or five international consortia, coming into production between 1988 and 1995 at a rate determined by the world demand for nickel.

Fracture zone - An extensive linear zone of irregular topography of the seafloor; characterized by seamounts, steep-sided ridges, and escarpments.

Free-fall corer - An untethered sampling device that sinks to the seafloor, penetrates the bottom, and returns automatically to the surface.

Free-fall grab sampler - An untethered, bottom sampling device that sinks to the seafloor, recovers nodules, and returns automatically to the surface. May also have a sediment sampler and a camera attached.

Gastropods - A large class of mostly bottom-dwelling molluscs. Most forms have a spiral shell.

Gravity corer - Any type of corer that achieves bottom penetration solely as a result of gravitational force acting upon its mass.

Ichthyoplankton - Larval fish.

Infauna - Animals living in soft bottom sediments.

Isopods - An order of crustaceans with generally flattened bodies. Most are deposit feeders.

Larvacean - One of a class of small, transparent, planktonic tunicates in which the body is covered by a large tunic and is composed of a trunk and a long tail. Also called appendicularia.

Macrofauna - Marine animals retained on a sieve of 0.3 to 1.0 mm (0.02 to 0.04 in) meshes.

Macrozooplankton - Zooplankton ranging in size from about 1 mm to 1 cm in length.

Megafauna - Animals large enough to be seen with the naked eye.

Meiofauna - Usually refers to animals that will pass through a 0.3, 0.5 or 1.0 mm mesh sieve and be retained on a 0.05 mm mesh sieve.

Mesopelagic - That portion of the oceanic province extending from about 200 m down to a depth of about 1000 m.

Micronekton - Early planktonic stages of fish and other actively swimming organisms, such as squids.

Mollusk - A phylum of soft, unsegmented animals, most of which are protected by a calcareous shell. Includes clams, oysters, squids, and octopi.

Nepheloid layer - Suspension of fine sediment and organic matter found near the ocean floor.

Nephelometer - An instrument for measuring the concentration or particle size of suspensions by means of transmitted or reflected light.

Neuston - Surface dwelling organisms.

Neuston layer - The water surface film.

Ooze - A fine-grained pelagic sediment containing undissolved sand or silt-sized, calcareous or siliceous skeletal remains of small marine organisms in proportion of 30% or more, the remainder being amorphous clay-sized material or dead organisms, including fecal material.

Oxygen minimum zone - A subsurface water layer in which the dissolved oxygen is very low.

Pelagic - Relating to or living in the open sea.

Pelagic clays - Fine grained pelagic sediments, rich in silica, that are found predominately in the deepest portions of the ocean.

Phytoplankton - Plant forms of plankton.

Plankton - Passively drifting or weakly swimming organisms. May consist of plants, animals, and eggs or larval stages of fish.

Polychaete worms - Marine worms with segmented bodies.

Preparatory Commission - A commission of Law of the Sea Treaty signatories which will draft provisional mining regulations that will interpret, clarify, and apply the convention text with greater precision.

Primary productivity - The amount of organic matter synthesized by organisms from inorganic substances in unit time in a unit volume of water.

Pycnocline - Zone where density increases rapidly with depth. It separates the well-mixed surface waters from the dense waters of the deep ocean.

Rain of fines - See benthic plume.

Reciprocating state - A foreign nation designated by NOAA that agrees to recognize licenses and permits issued to U.S. citizens under the Deep Seabed Hard Mineral Resources Act and to regulate the conduct of its citizens in their exploration and commercial recovery of hard mineral resources in a manner comparable with this Act.

Red clay - A fine-grained, reddish-brown or chocolate colored sediment formed by slow accumulation of material a long distance from the continents in depths greater than 3500 m. It contains large proportions of windblown particles, meteoric and volcanic dust, pumice, sharks teeth, whale earbones, manganese nodules and debris rafted by ice. The calcium carbonate content ranges from 0-30%.

Salinity - A measure of the quantity of dissolved salts in sea water.

Sea anemone - Sedentary marine animal of the phylum Coelenterata, having a columnar body and one or more circles of tentacles surrounding the mouth.

Sea cucumbers - A class of the phylum Echinodermata; elongate, tube-like, bottom-dwelling organisms that feed by ingesting sediment or suspension feeding.

Seaknoll - A mound-like relief form of the seafloor, less than 1000 m in height.

Seamount - A submarine mountain, volcanic in origin, generally rising 1,000 m (3,300 ft) or more from the seafloor.

Sea star - True starfish with a flat, usually five-armed body.

Sea urchins - Bottom-dwelling marine animals with a skeleton composed of immovable hard plates; many species possess long sharp spines.

Side-scan sonar - Echo-sounding device that provides a picture of the variations of bottom roughness and small-scale topography to about 500 m to each side of the survey track.

Siliceous ooze - A fine-grained pelagic sediment containing more than 30% siliceous skeletal remains of pelagic plants and animals.

Siphonophore - One of an order of coelenterates. Many are luminescent and some possess an air-filled float.

Surface mixed layer - Layer of surface waters that overlay the thermocline. It is characterized by fairly uniform temperature, salinity, and density values. The waters are well-mixed through wind and wave action and are high in oxygen content. Nutrient content is low because of uptake by phytoplankton.

Surface plume - The suspended particles in the surface water composed of the sediment, nodule fragments, and bottom water discharged over the side of the mining vessel.

Suspended particulate matter - Concentrations of organic and inorganic particles found suspended in the water column.

Tailings - Waste materials from metal refining.

Tanaids - An order of very small crustaceans that live burrowed in the mud or in self-constructed tubes. Superfically, they resemble tiny (1 mm) lobsters.

Thermocline - Layer of water, at the base of the surface mixed layer, in which there is a sharp decrease in temperature with depth.

Tenor - The percent or average metallic content of an ore.

Tiering - Refers to the coverage of general matters in a broad PEIS with subsequent narrower statements or environmental analyses in a site-specific EIS.

Tonne - A metric ton (1000 kilograms).

Transponder - An automated receiver/transmitter for transmitting signals when triggered by an interrogating signal.

Trophic level - A successive stage of nourishment as represented by links of the food chain. In a representative food chain, phytoplankton constitute the first trophic level, herbivores the second and the carnivores the third level. In some ecosystems (e.g., detritus-based ones) exact trophic levels are very difficult to assign.

Tsunami - A long-period sea wave produced by a submarine earthquake or volcanic eruption.

Year-class strength - Relative term used to describe the number of fish surviving to a certain age from a single spawn.

Zooplankton - Animal forms of plankton.

Appendix 6

Federal Agency Review of License Applications

Section 103(e) of the Deep Seabed Hard Mineral Resources Act and Section 970.211 of the regulations implementing the Act require NOAA to consult with other Federal agencies which have programs or activities within their statutory responsibilities which would be affected by the activities proposed in the applications. NOAA has provided copies of the applications to and received comments and recommendations from the agencies listed below.

Agency

Environmental Protection Agency

Department of the Interior - Office of the Secretary and National Park Service

Department of Defense

Department of State

Federal Trade Commission

Department of Commerce - National Marine Fisheries Service and Office of Coastal Zone Management

Department of Labor - Mine Safety and Health Administration

Department of Transportation - U.S. Coast Guard

National Science Foundation

Department of the Treasury

Department of Justice

Small Business Administration

APPENDIX 7

Figures and Tables

from the Application of

Ocean Minerals Company

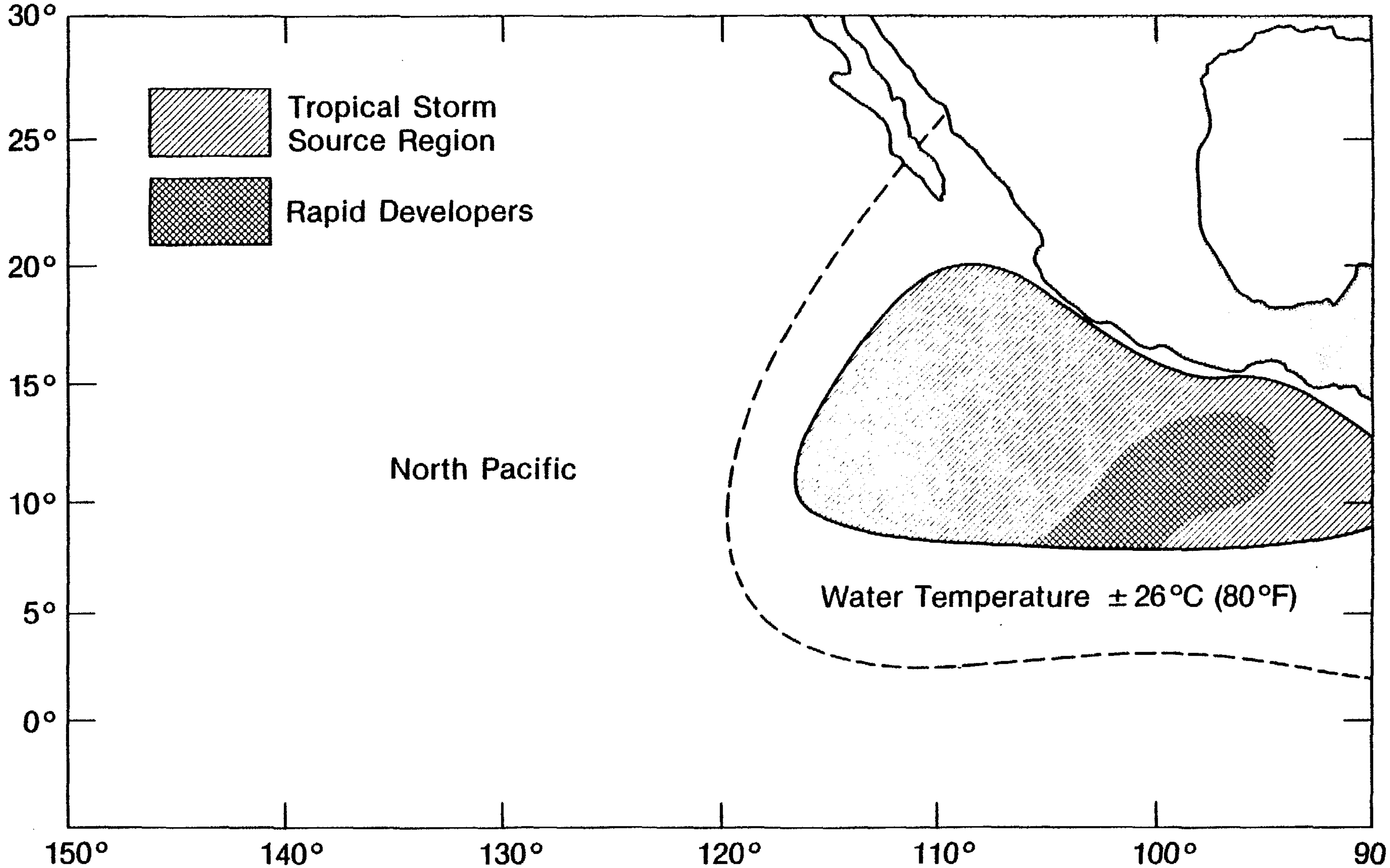

Figure 7-A. Tropical storm source region (Appendix E, OMCO license application, 1982).

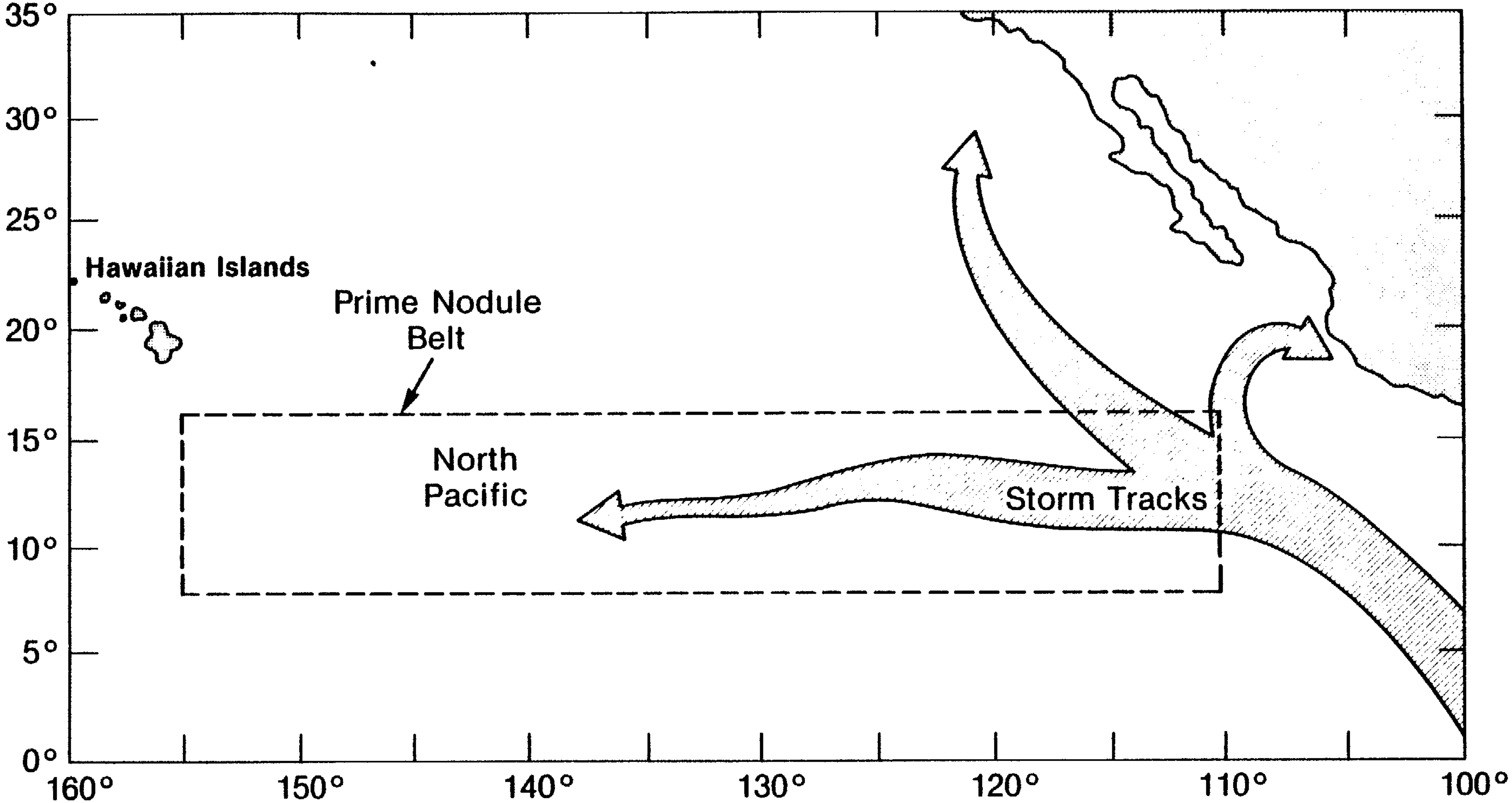

Figure 7-B. Normal storm tracks (Appendix E, OMCO license application, 1982).

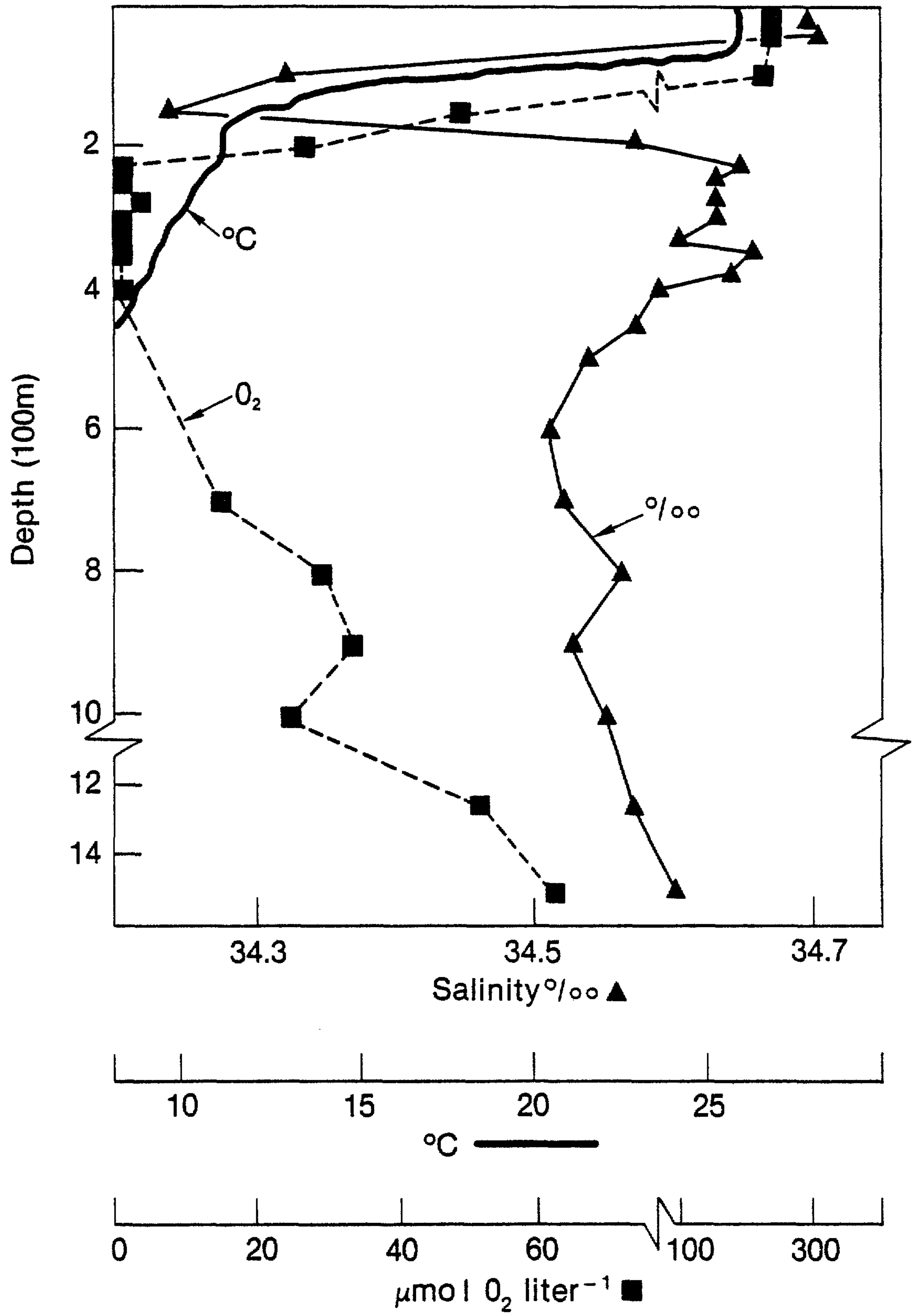

Figure 7-C. Vertical Profiles of salinity, temperature and dissolved oxygen in OMCO license area. (Appendix F, OMCO license application, 1982)

TABLE 7-A

PREDOMINANT ANNUAL ENVIRONMENTAL CONDITIONS AT THREE SITES ACROSS THE EXPLORATION AREA

(Appendix E, OMCO license application, 1982)

		SITE I		SITE II		SITE III	
WIND	DIRECTION	NNE-E	81%	E-NE	88%	E-NE	87%
	SPEED	0-10m/s	97%	0-10m/s	96%	0-10m/s	98%
SEA	DIRECTION	NNE-E	84%	E-NE	89%	E-NE	88%
	HEIGHT	0.5-1.5m	94%	0.5-1.5m	92%	0.5-1.5m	90%
SWELL	STATE	Calm	54%	Calm	53%	Calm	66%
	DIRECTION	NW	24%	NW	20%	NW-NNW	20%
	HEIGHT	0.5-1.5m	43%	0.5-1.5m	45%	0.5-1.5m	32%
	PERIOD	13-15s	21%	13-15s	19%	13-15s	15%

TABLE 7-B

FREQUENCY OF EASTERN NORTH PACIFIC TROPICAL STORMS/HURRICANES COMBINED BY MONTH AND YEAR SINCE 1966 (Appendix E, OMCO License application, 1982)

	MAY	JUN	JUL	AUG	SEP	OCT	NOV	TOTAL
1966	0/0	1/1	0/0	4/4	6/2	2/0	0/0	13/7
1967	0/0	3/1	4/0	4/2	3/1	3/2	0/0	17/6
1968	0/0	1/0	4/0	8/3	3/2	3/1	0/0	19/6
1969	0/0	0/0	3/1	2/1	4/1	1/1	0/0	10/4
1970	1/1	3/0	6/1	4/1	1/0	2/1	1/0	18/4
1971	1/1	1/1	7/5	4/2	2/2	2/1	1/0	18/12
1972	1/1	0/0	1/0	6/6	2/1	1/0	1/0	12/8
1973	0/0	3/1	4/3	1/0	3/2	1/1	0/0	12/7
1974	1/0	3/2	3/2	6/4	2/2	2/1	0/0	17/11
1975	0/0	2/1	4/2	5/3	3/1	1/1	1/0	16/8
1976	0/0	2/2	4/1	4/2	3/3	1/0	0/0	14/8
1977	1/0	1/0	1/1	1/1	3/1	1/1	0/0	8/4
1978	1/1	3/2	4/3	6/4	2/1	2/1	0/0	18/12
1979	1/1	1/1	2/1	2/2	1/1	2/1	1/0	10/7
TOTAL	7/5	24/12	47/20	57/35	39/20	24/12	5/0	202/104
ANNUAL AVG.	0.5/ 0.4	1.7/ 0.9	3.4/ 1.4	4.0/ 2.5	2.8/ 1.4	1.7/ 0.9	0.4/ 0	14.4/ 7.4

The number to the left of the slant mark represents the total number of cyclones while the number to the right represents those storms reaching hurricane force. For example, in September 1966, there were six storms including two hurricanes.

TABLE 7-C

FREQUENCY OF OCCURRENCE OF TROPICAL CYCLONES AT THE THREE STUDY LOCATIONS, 1966-1979 (Appendix E, OMCO license application, 1982)

Month	Days	Site I %	Site II %	Site III %
JUNE		36	<5	<5
JULY	1-10	37	15	<5
JULY	11-20	22	15	<5
JULY	21-31	15	15	<5
AUG	1-10	22	15	<5
AUG	11-20	15	15	<5
AUG	21-31	15	15	<5
SEPT	1-10	15	15	10
SEPT	11-20	30	15	<5
SEPT	21-30	10	<5	<5
OCT	1-15	10	<5	<5
OCT	16-31	30	10	<5

TABLE 7-D

Organic Carbon and Nitrogen Values of Material in Sediment Traps (Appendix F, OMCO license application, 1982)

Sample	Depth (m)	mg N	% N	mg C	% C	$C/m^3/day$
A-1		0.99	6.1	5.89	30.9	58.76
A-2	125	1.22	5.8	6.78	30.9	67.64
A-3		1.08	5.4	6.03	27.9	60.16
B-1		0.26	3.3	1.75	21.9	17.46
B-1	275	0.29	4.1	1.96	27.6	19.56
C-1		0.25	3.7	1.72	25.9	17.16
C-1	525	0.25	4.4	1.54	27.3	15.36
C-2		0.22	4.5	1.46	27.2	14.57
D-1		0.16	2.0	.66	15.1	6.58
D-2	900	0.13	3.4	1.06	24.4	10.58
D-3		0.23	2.2	1.73	17.1	9.57

Table 7-E - Trace Metal Concentrations of Material in Sediment Traps (Appendix F, OMCO License Application 1982)

Sample	Depth (m)	Mn (ppm) Leach	Bomb	Total	Sample	Depth (m)	Zn (ppm) Leach	Bomb	Total	Sample	Depth (m)	Cu (ppm) Leach	Bomb	Total
A-1	125	6.87	5.87	12.74	A-1	125	241	126	367	A-1	125	3.11	8.11	11.22
A-3		5.93	6.55	12.48	A-3		279	169	448	A-3		1.71	7.68	9.39
B-1	275	44.64	19.64	64.28	B-1	275	224	213	437	B-1	275	8.22	22.03	30.25
B-2		44.34	20.33	64.67	B-2		286	470	756	B-2		3.13	29.20	32.33
C-2	525	97.62	21.30	118.92	C-2	525	1010	1445	2455	C-2	525	6.90	25.95	32.85
C-3		116.94	20.90	137.84	C-3		1349	407	1756	C-3		10.50	45.63	56.13
D-2	900	113.04	17.18	130.22	D-2	900	1114	587	1701	D-2	900	9.21	48.64	57.85
D-3		55.18	8.90	64.08	D-3		601	371	972	D-3		5.36	21.76	27.12
DL-1		37.68	18.77	56.45	DL-1		185	311	496	DL-1		4.95	30.98	35.91
DL-2		88.07	13.22	101.29	DL-2		442	386	828	DL-2		5.68	41.66	47.34
DL-3		41.47	15.18	56.65	DL-3		230	1507	1737	DL-3		8.05	34.06	42.11
		Cd (ppm)					Ni (ppm)					Fe (ppm)		
A-1	125	3.13	0.18	3.32	A-1	125	30.28	11.50	41.78	A-1	125	55	555	610
A-3		2.84	0.18	3.02	A-3		15.57	11.55	27.12	A-2		32	762	794
B-1	275	0.52	0.22	0.74	B-1	275	27.48	41.16	68.64	B-1	275	71	1544	1615
B-2		0.70	0.13	0.83	B-2		100.29	40.41	140.70	B-2		170	1949	2120
C-2	525	0.47	0.44	0.91	C-2	525	121.68	54.67	176.35	C-2	525	368	2980	3348
C-3		0.71	0.23	0.94	C-3		215.10	67.29	282.39	C-3		297	2698	2995
D-2	900	0.57	0.33	0.90	D-2	900	183.14	66.60	249.74	D-2	900	399	2996	3394
D-3		0.42	0.07	0.49	D-3		150.09	36.77	186.86	D-3		456	2155	2612
DL-1		8.69	1.37	10.06	DL-1		410.41	71.61	482.02	DL-1		721	3305	4026
DL-2		1.81	0.31	2.12	DL-2		112.92	72.39	185.31	DL-2		179	2091	2270
DL-3		1.22	0.77	1.99	DL-3		243.21	58.46	301.67	DL-3		824	2448	3272
		Al (ppm)												
A-1	125	7.3	693	700	D-3		37.2	1665	1702					
A-3		10.8	1061	1072										
					DL-1		59.3	2959	3018					
B-1	275	32.5	2209	2242	DL-2		45.9	2119	2165					
B-2		37.8	1721	1759	DL-3		62.7	2372	2435					
C-2	525	55.4	3342	3397										
C-3		65.2	3606	3671										
D-2	900	65.4	3932	3997										

Table 7-F

Water Column Nutrient Concentrations in the Vicinity of the Application Area (Appendix F, OMCO License application 1982)

Depth (m)	PO_4^{-3}	SiO_2	NO_3^-	NO_2^-	$NO_3^- + NO_2^-$
	umol/liter				
25	.28	1.52	.422	.09	.512
50	.283	1.62	.598	.085	.683
100	.65	5.75	4.54	.24	4.78
150	1.650	13.9	18.68	.10	18.78
200	2.67	28.3	29.11	.09	29.20
225	2.80	31.4	32.18	.09	32.27
250-1	2.684	30.2	31.43	.10	31.53
250-2	2.997	32.9	31.54	.11	31.65
275	2.803	33.7	33.95	.09	34.04
300	2.84	32.4	32.57	.10	32.67
325	3.025	35.8	33.38	.28	33.66
350	2.89	43.5	35.35	.08	35.43
375	3.01	38.2	33.65	.34	33.99
400	2.917	40.6	40.08	.07	40.15
450	3.15	44.9	37.61	.10	37.71
500-1	3.309	50.1	38.20	.23	38.43
500-2	3.285	49.2	38.33	.10	38.43
600	2.83	54.8	35.86	.07	35.93
700	3.63	72.8	41.61	.11	41.72
800	3.575	75.5	42.44	.09	42.53
900	3.555	80.0	43.48	.08	43.56
1000	3.496	84.1	42.88	.17	43.05
1250	3.432	101	43.29	.10	43.39
1500	3.22	103	41.85	.05	41.90

Table 7-G

Water Column Dissolved Metal Concentrations (ng/l) (Chelex)

(Appendix F, OMCO license Application 1982)

Depth	Zn	Mn	Cd	Ni	Cu	Pb
25	169	46	1.9	145	26	21
50	166	45	1.5	147	29	9
100	168	90	4.1	158	26	19
150	50	44	34	191	23	17
200	98	51	81	282	27	11
225	111	47	88	306	25	8
250-1	95	41	99	316	24	13
2	117	69	89	277	25	8
275	49	38	97	332	22	5
300	226	44	95	330	29	39
325	87	33	100	369	22	8
350	76	36	87	303	23	21
375	87	47	100	351	28	7
400	136	30	107	351	23	6
450	211	41	97	356	27	3
500-1	132	40	114	383	28	2
2	111	38	110	383	26	1
600	204	35	109	397	31	8
700	276	56	133	495	31	5
800	290	32	127	462	31	4
900	389	146	130	524	26	6
1000	393	25	140	509	33	2
1250	433	22	131	548	36	3
1500	500	17	124	555	45	6

Table 7-H

Water Column Particulate Trace Metal Contents (ng/l)
(Appendix F, OMCO License Application 1982)

	Mn			Zn			Cu		
Depth (m)	Leach	Bomb	Total	Leach	Bomb	Total	Leach	Bomb	Total
25	0.48	0.27	0.75	3.8	2.1	5.9	2.7	2.2	4.9
50	0.76	0.29	1.1	2.3	0.98	3.3	0.94	2.7	3.6
100	1.3	0.39	1.6	15.7	139.4	155.1	31.0	14.7	45.6
150	6.2	0.61	6.8	18.7	2.3	21.0	7.6	6.6	14.2
200	11.9	0.67	12.6	1.3	1.2	2.6	0.84	2.2	3.1
225	21.4	1.6	23.0	1.7	1.2	2.9	0.65	0.99	1.6
250 #1	10.6	0.92	11.5	1.8	2.0	3.7	0.50	1.5	2.0
250 #2	21.4	0.77	22.2	6.5	1.8	8.3	12.5	3.6	16.1
275	9.0	0.43	9.4	3.6	1.8	5.3	0.62	2.8	3.4
300	10.9	1.1	12.0	3.3	1.8	5.1	1.2	2.2	3.4
325	7.6	1.1	8.8	6.5	1.3	7.8	1.9	2.9	4.8
350	3.1	0.31	3.4	1.7	0.87	2.6	1.2	1.6	2.8
375	3.9	0.24	4.1	3.0	0.38	3.4	2.4	1.5	3.9
400	6.6	0.73	7.3	1.6	1.4	3.0	1.5	2.6	4.1
450	4.5	0.51	5.0	1.5	1.5	3.0	0.35	1.7	2.0
500 #1	5.9	0.39	6.3	4.7	1.2	5.9	3.1	2.6	5.7
500 #2	7.4	0.38	7.8	1.4	1.1	2.5	0.8	1.5	2.3
600	5.9	0.55	6.5	2.3	3.1	5.4	2.0	3.8	5.7
700	9.5	0.38	9.9	1.7	0.91	2.6	0.76	2.0	2.8
800	10.5	0.27	10.8	2.7	0.79	3.5	1.4	2.1	3.5
900	5.9	0.55	6.4	2.7	0.62	3.4	0.83	1.6	2.4
1000	3.9	0.35	4.3	4.6	0.66	5.3	0.48	2.0	2.5
1250	5.4	1.4	6.9	2.6	1.4	4.0	0.53	1.4	1.9
1500	5.0	0.54	5.5	5.8	3.0	8.8	2.3	1.8	4.1

Table 7-H (cont'd)

Cd			Ni			Fe			Al		
Leach	Bomb	Total	Leach	Bomb	Total	Leach	Bomb	Total	Leach	Bomb	Total
0.31	0.03	0.34	1.7	0.48	2.2	0.87	40.2	41.1	0.82	35.2	36.0
0.49	0.03	0.52	1.9	0.81	2.7	1.3	51.1	52.4	1.6	20.0	21.6
0.47	0.05	0.52	0.28	0.92	1.2	0.74	22.2	22.9	1.7	45.2	46.9
0.49	0.01	0.50	2.6	1.2	3.8	2.3	53.8	56.1	3.0	25.0	28.0
0.19	0.02	0.21	2.2	0.59	2.7	3.3	19.5	22.8	4.0	43.0	47.0
0.24	0.03	0.27	0.39	0.73	1.1	2.3	33.9	36.2	1.5	26.9	28.4
0.24	0.02	0.26	0.34	1.4	1.7	1.0	33.6	34.6	1.5	22.1	23.5
0.30	0.02	0.32	1.1	0.86	2.0	8.9	37.2	46.1	4.2	30.6	34.8
0.21	0.02	0.23	0.57	1.8	2.3	2.5	08.4	110.9	3.3	32.5	35.8
0.20	0.02	0.22	1.0	1.2	2.2	2.1	38.3	40.4	3.8	33.9	37.7
0.27	0.05	0.32	1.5	0.86	2.3	3.3	41.6	44.8	3.3	22.8	26.1
0.13	0.01	0.14	1.1	0.67	1.8	3.0	67.6	70.6	3.7	28.8	32.5
0.13	0.02	0.15	0.61	0.58	1.2	6.9	21.1	28.0	4.6	46.8	51.4
0.14	0.03	0.17	0.68	0.74	1.4	1.4	22.7	24.1	3.4	93.2	96.6
0.12	0.01	0.13	0.81	1.0	1.9	2.1	76.7	78.9	3.8	27.9	31.7
0.10	0.02	0.12	0.78	0.78	1.6	2.6	30.0	32.5	3.0	28.6	31.6
0.11	0.01	0.12	0.58	0.54	1.1	4.9	33.4	38.2	3.1	21.4	24.4
0.11	0.02	0.13	1.7	0.87	2.5	1.9	32.1	34.0	4.6	34.7	39.4
0.10	0.01	0.11	1.1	0.78	1.9	6.9	37.1	43.9	2.8	33.6	36.3
0.07	0.01	0.08	4.8	0.63	5.4	14.6	23.0	37.6	6.2	25.0	31.2
0.37	0.01	0.38	1.6	0.48	2.1	6.6	34.5	41.1	5.4	22.9	28.3
0.08	0.04	0.12	1.9	0.65	2.5	5.8	28.9	34.7	4.9	17.8	22.8
0.12	0.01	0.13	1.0	0.62	1.7	4.8	40.8	45.6	3.5	33.0	36.5
0.16	0.02	0.18	1.3	0.67	1.9	4.8	38.0	42.8	9.3	36.3	45.6

Table 7-I

Day and night abundance estimates of invertebrate zooplankton taxa and radiolarians/forams within five depth intervals or as means and standard deviations in the Eastern Tropical Pacific. Abundance of numbers per 10 m^2 sea surface in (N). (Appendix G, OMCO license application, 1982).

75-100 m

Overall Rank	Taxon	Day (n=21) Rank	Day $\bar{x}$	Day S	Night (n=13) Rank	Night $\bar{x}$	Night S	Night/Day Ratio	Z	Significance Level
1	Copepods	1	33099.0	16609.8	1	27745.5	16394.5	0.84	0.92	
2	Chaetognaths	2	9733.8	5599.5	2	6019.2	3599.8	0.62	2.35	P<0.01
3	Siphonophores	3	4144.5	3271.0	4	3699.2	3476.5	0.89	0.37	
4	Euphausids	7	1796.8	1667.8	3	4543.2	4034.0	2.5	2.33	P<0.01
5	Amphipods	5	2241.8	4663.5	8	1824.8	2192.2	0.81	0.35	
6	Larvaceans	4	2664.8	2347.5	6	2312.2	1318.2	0.87	0.56	
7	Ostracods	6	2136.8	2761.2	7	2033.0	2938.2	0.95	0.10	
8	Thaliaceans	8	1508.8	1372.8	9	1158.5	980.2	0.77	0.87	
9	Medusae	12	256.8	287.5	5	2844.2	9802.0	11.1	0.95	
10	Pteropods	9	1205.2	1554.5	10	1102.0	1727.5	0.91	0.18	
11	Decapods	10	693.5	718.2	14	166.0	214.0	0.24	3.14	P<0.01
12	Crustacean larvae	15	125.2	439.2	12	523.0	843.5	4.1	1.57	
13	Cephalopods	14	162.5	319.8	11	538.5	1413.8	3.3	0.94	
14	Heteropods	11	296.5	1010.0	13	179.0	607.5	0.60	0.42	
15	Polychaetes	13	219.2	279.0	15	69.5	120.5	0.32	2.16	P<0.05
16	Echinoderms	16	28.8	96.2	16	27.0	68.8	0.94	0.06	
17	Cladocerans	17	9.2	42.0	18	-	-	-	1.00	
18	Salps	18	-	-	17	2.2	8.2	-	0.96	
	Radiolarians/forams		8561.2	7572.2		6838.5	8297.8	0.80	0.61	

Table 7-I (cont'd)

0-0.25 m (neuston)

Overall Rank	Taxon	(n=14) Rank	Day x̄	Day S	(n=9) Rank	Night x̄	Night S	Night/ Day Ratio	Z	Significance Level
1	Copepods	1	1169.4	1041.2	1	3040.1	1333.9	2.6	3.57	P<0.001
2	Mysids	16	0.4	1.4	2	792.2	772.7	1980.0	3.07	P<0.01
3	Larvaceans	2	160.8	146.6	4	333.4	141.0	2.1	2.82	P<0.01
4	Chaetognaths	4	51.2	34.1	3	412.7	310.2	8.1	3.48	P<0.001
5	Amphipods	12	2.6	4.0	5	297.9	309.5	115.0	2.86	P<0.01
6	Siphonophores	3	78.5	106.4	6	124.2	106.9	1.6	1.00	
7	Pteropods	5	71.2	66.0	9	55.1	49.3	0.77	0.66	
8	Medusae	9	9.3	15.9	7	90.6	63.9	9.7	3.74	P<0.001
9	Echinoderms	8	18.8	43.0	8	71.4	120.7	3.8	1.26	
10	Thaliaceans	7	31.2	109.3	11	42.7	28.4	1.4	0.37	
11	Decapods	10	4.2	7.1	10	53.9	40.0	12.8	3.69	P<0.001
12	Ostracods	6	36.7	137.4	18	1.0	2.9	0.03	0.97	
13	Euphausids	19.5	-	-	12	41.2	81.3	-	1.52	
14	Polychaetes	17	0.2	0.9	13	22.9	26.7	114.0	2.55	P<0.05
15	Crustacean larvae	11	3.2	4.9	14	7.2	13.2	2.2	0.86	
16	Turbelloria	14	0.9	2.7	15	3.7	11.2	4.1	0.74	
17	Cephalopods	19.5	-	-	16	3.3	6.7	-	1.47	
18	Nudibranchs	15	0.6	1.4	17	2.2	6.5	3.7	0.70	
19	Cladocera	13	1.6	2.9	19.5	-	-	-	2.06	P<0.05
20	Heteropods	18	0.1	0.5	19.5	-	-	-	0.75	
Radiolarians/forams			243.4	135.3		426.9	300.4		1.72	

Table 7-I (cont'd)

0-25 m

Overall Rank	Taxon	(n=29) Rank	Day $\bar{x}$	Day S	(n=15) Rank	Night $\bar{x}$	Night S	Night/Day Ratio	Z	Significance Level
1	Copepods	1	34101.8	32115.0	1	38884.2	25646.5	1.1	0.54	
2	Chaetognaths	2	11325.5	8730.5	3	19564.2	22415.8	1.7	1.37	
3	Euphausids	7	1697.5	3805.0	2	19567.0	18141.2	11.5	3.78	P<0.001
4	Larvaceans	4	3223.5	4180.8	5	3698.8	2406.5	1.1	0.48	
5	Amphipods	3	3238.2	7544.8	8	1311.2	1471.5	0.40	1.30	
6	Siphonophores	5	1882.8	2220.5	6	3163.0	3039.8	1.7	1.44	
7	Decapods	9	787.2	1796.2	4	3847.0	10388.2	4.9	1.13	
8	Pteropods	8	1146.0	2240.2	7	2682.5	3220.0	2.3	1.65	
9	Thaliaceans	6	1834.0	3119.0	10	904.2	1695.0	0.49	1.28	
10	Crustacean larvae	11	308.2	1188.0	9	1045.0	1782.2	3.4	1.44	
11	Heteropods	10	309.2	474.0	11	726.5	1345.2	2.3	1.16	
12	Cephalopods	13	168.2	561.2	12	328.8	638.2	1.9	0.82	
13	Polychaetes	12	222.2	570.5	15	186.8	376.5	0.84	0.24	
14	Medusae	14	141.5	23.5	14	195.2	514.8	1.4	0.38	
15	Ostracods	16	25.8	104.5	13	224.2	546.2	8.6	1.39	
16	Echinoderms	15	33.2	179.8	17.5	-	-	-	0.99	
17	Cladocera	18	-	-	16	11.5	44.5	-	1.00	
18	Ctenophores	17	2.4	9.0	17.5	-	-	-	0.10	
Radiolarians/forams			16686.2	22699.2		10716.8	11928.5	0.64	1.14	

Table 7-I (cont'd)

25-50 m

Overall Rank	Taxon	Day (n=29) Rank	Day $\bar{x}$	Day S	Night (n=13) Rank	Night $\bar{x}$	Night S	Night/Day Ratio	Z	Significance Level
1	Copepods	1	51758.2	21626.5	1	27643.2	13847.5	0.53	4.34	P<0.001
2	Chaetognaths	2	18074.0	11549.5	2	6937.8	2492.2	0.38	4.94	P<0.001
3	Siphonophores	4	4595.8	5145.8	4	3546.2	2218.5	0.77	0.92	
4	Amphipods	3	6333.2	8977.0	9	761.2	1031.5	0.12	3.29	P=0.001
5	Euphausids	6	2141.5	5085.5	3	5403.8	2434.8	2.5	2.81	P<0.01
6	Larvaceans	5	2739.5	2089.0	5	1728.8	1873.0	0.63	1.56	
7	Pteropods	7	1357.2	2605.5	8	868.5	692.0	0.64	0.94	
8	Ostracods	9	939.0	1761.0	6	1534.5	3345.5	1.6	0.60	
9	Thaliaceans	8	1256.5	1255.0	7	887.0	691.0	0.71	1.22	
10	Crustacean larvae	10	782.5	2135.8	10	300.5	543.5	0.38	1.14	
11	Decapods	11	747.2	979.5	11	204.2	202.0	0.27	2.85	P<0.01
12	Cephalopods	13	396.8	868.5	12	157.0	440.5	0.40	1.18	
13	Heteropods	12	421.2	1607.5	14	11.2	41.0	0.03	1.37	
14	Medusae	14	275.0	726.2	13	117.2	157.8	0.42	1.11	
15	Polychaetes	15	175.5	290.0	17.5	-	-	-	3.26	P<0.01
16	Echinoderms	16	63.0	190.8	15	11.0	39.5	0.17	1.40	
17	Gastropods	17	40.0	217.2	17.5	-	-	-	0.99	
18	Mysids	18	10.0	53.5	17.5	-	-	-	1.00	
19	Cladocera	19	2.4	13.0	17.5	-	-	-	0.99	
	Radiolarians/forams		17428.0	12864.0		6733.0	5184.8	0.39	3.84	P<0.01

Table 7-I (cont'd)

25-75 m

Overall Rank	Taxon	Day (n=26) Rank	Day $\bar{X}$	Day S	Night (n=14) Rank	Night $\bar{X}$	Night S	Night/Day Ratio	Z	Significance Level
1	Copepods	1	36490.5	20438.0	1	28932.5	18880.8	0.79	1.17	
2	Chaetognaths	2	11694.5	7724.8	3	4719.0	3390.5	0.40	3.95	P<0.001
3	Siphonophores	3	4928.0	5815.8	4	4635.8	3619.5	0.94	0.19	
4	Larvaceans	4	4583.8	6487.0	5	2931.8	2162.8	0.64	1.18	
5	Euphausids	5	1946.0	1516.8	2	7280.5	4884.5	3.7	3.98	P<0.001
6	Amphipods	6	1817.8	1949.5	6	1140.2	2207.5	0.62	0.97	
7	Thaliaceans	8	1198.2	1253.8	7	1065.2	955.0	0.89	0.38	
8	Pteropods	7	1209.2	1371.2	9	870.5	1072.8	0.72	0.86	
9	Ostracods	9	1054.5	1976.5	10	798.5	547.5	0.76	0.62	
10	Crustacean larvae	11	540.0	1319.0	11	436.0	1023.8	0.81	0.27	
11	Decapods	10	557.2	1488.8	13	278.0	236.0	0.50	0.93	
12	Cephalopods	15	176.8	278.2	8	1034.5	2555.0	5.8	1.25	
13	Heteropods	12	340.8	1242.0	12	428.2	1509.0	1.2	0.18	
14	Polychaetes	14	185.8	422.8	14	148.2	236.2	0.80	0.36	
15	Medusae	13	212.0	300.8	15	95.2	135.5	0.45	1.68	
	Radiolarians/forams		12234.8	9865.0		6674.0	7012.2	0.55	2.06	P<0.05

Table 7-J

Larval fishes collected in bongo net hauls within four depth intervals in the Eastern Tropical Pacific. Abundance for each taxon expressed as mean numbers per 100 m^3 (mean is day and night estimates) and as percent of total (0-100 m) summed abundance within each 15 m depth interval. The percent contribution by each taxon to the total ichthyoplankton is also provided. (Appendix G, OMCO License Application, 1982).

	Total Abundance	Percent	Depth Interval (m)							
			0-25		25-50		50-75		75-100	
	No./100m^3	of Total	No./100m^3	%	No./100m^3	%	No./100m^3	%	No./100m^3	%
BATHYLAGIDAE										
Bathylagus nigrigenys	20.8	0.90	---	---	0.2	1.0	1.0	4.8	19.6	94.2
GONOSTOMATIDAE										
Cyclothone spp.	19.7	0.85	11.5	58.4	4.0	20.3	2.3	11.7	1.9	9.6
Diplophos taenia	8.5	0.37	5.6	65.9	1.4	16.5	0.9	10.6	0.6	7.0
Vinciguerria sp.	1780.8	77.10	120.4	6.8	520.6	29.2	733.0	41.2	406.8	22.8
STERNOPTYCHIDAE										
Argyropetecus sp.	0.2	---	---	---	---	---	---	---	0.2	100.0
STOMIATOID FISHES										
Unid. Stomiatoids	1.5	0.06	0.1	6.7	0.7	46.7	0.3	20.0	0.4	26.7
ASTRONESTIDAE										
Unid. Astronestid	0.2	---	---	---	---	---	---	---	0.2	100.0
IDIACANTHIDAE										
Idiacanthus sp.	16.0	0.69	0.3	1.9	---	---	1.7	10.6	14.0	87.5
MELANOSTOMIATIDAE										
Bathophilus filifer	4.0	0.17	---	---	2.6	64.4	0.2	100.0	---	---
Eustomias sp.	0.05	---	---	---	0.05	100.0	---	---	---	---
Unid. Melanostomiatoid	0.2	---	---	---	---	---	---	---	---	---
PARALEPIDIDAE										
Type A (poss.)	2.8	0.12	---	---	1.4	50.0	0.6	21.4	0.8	28.6
Type B (poss.)	5.6	0.24	0.3	5.4	0.9	16.1	3.2	57.1	1.2	21.4
Stemnosudis macrura	12.5	0.54	0.2	1.6	4.6	36.8	5.7	45.6	2.0	16.0
Unid. Paralepidids	1.9	0.08	0.3	15.8	0.4	21.0	1.0	52.6	0.2	10.5

Table 7-J (cont'd)

	Total Abundance No./100m^3	Percent of Total	Depth Interval (m) 0-25 No./100m^3	0-25 %	25-50 No./100m^3	25-50 %	50-75 No./100m^3	50-75 %	75-100 No./100m^3	75-100 %
BREGMACEROTIDAE										
Bregmaceros spp.	7.9	0.34	---	---	0.3	3.8	3.2	40.5	4.4	55.7
EXOCOETIDAE										
Cypselurus sp.	0.1	---	0.1	100.0	---	---	---	---	---	---
Unid. exocoetid	0.1	---	0.1	100.0	---	---	---	---	---	---
BERYCIFORM FISHES										
Unid. beryciform fish	1.2	0.05	---	---	0.8	66.7	0.2	16.7	0.2	16.
MELAMPHAEIDAE										
Melamphaes sp.	2.0	0.09	---	---	---	---	---	---	2.0	100.0
Scopelogadus mizolepis bispinosus	1.6	0.07	---	---	0.1	6.2	0.3	18.8	1.2	75.0
TRACHIPTERIDAE										
Zu cristatus	0.6	0.03	0.3	54.5	0.1	18.2	0.1	18.2	0.05	9.1
Unid. trachipterid	0.3	0.01	0.04	12.1	0.05	15.2	0.04	12.1	0.2	60.6
CORYPHAENIDAE										
Coryphaena sp.	0.3	0.01	0.3	100.0	---	---	---	---	---	---
CHIASMODONTIDAE										
Unid. chiasmodontids	1.2	0.05	0.2	16.7	0.1	8.3	0.1	8.3	0.8	66.7
GEMPYLIDAE										
Gempylus serpens	3.3	0.14	2.6	78.8	0.3	9.1	0.4	12.1	---	---
TRICHIURIDAE										
Diplospinus multistriatus	1.4	0.06	---	---	---	---	0.8	57.1	0.6	42.9
Neolotus tripes	0.06	---	---	---	---	---	0.06	100.0	---	---

Table 7-J (cont'd)

Taxon	Total Abundance No./100m^3	Percent of Total	Depth Interval (m) 0-25 No./100m^3	0-25 %	25-50 No./100m^3	25-50 %	50-75 No./100m^3	50-75 %	75-100 No./100m^3	75-100 %
EVERMANNELLIDAE										
Unid. Evermannellid	0.05	---	---	---	0.05	100.0	---	---	---	---
SCOPELARCHIDAE										
Scopelarchoides nicholsi	27.3	1.18	0.1	0.4	0.2	0.7	8.2	30.0	18.8	68.9
NOTOSUDIDAE										
Unid. Notusudid	0.1	---	---	---	0.1	100.0	---	---	---	---
MYCTOPHIDAE										
S.F. MYCTOPHINAE										
Bolinichthys sp.	3.1	0.13	1.9	61.3	1.0	32.2	0.2	6.4	---	---
Ceratoscopelus sp.	1.9	0.08	0.2	10.5	0.9	47.4	---	---	0.8	42.1
Diaphus (prob. *pacificus*)	58.4	2.53	0.8	1.4	20.8	35.6	27.2	46.6	9.6	16.4
Lampanyctus idostigma	3.7	0.16	---	---	0.1	2.7	1.6	43.2	2.0	54.0
L. omostigma	2.4	0.10	---	---	1.4	58.3	0.6	25.0	0.4	16.7
L. parvicauda	7.2	0.31	1.0	13.9	2.8	38.9	2.2	30.6	1.2	16.7
Lampanyctus spp.	2.4	0.16	---	---	0.2	8.3	0.6	25.0	1.6	66.7
Benthosema sp.	0.2	---	---	---	---	---	0.2	100.0	---	---
Diogenichthys laternatus	184.3	7.98	1.0	0.5	0.7	0.4	50.4	27.3	132.2	71.7
Gonichthys tenuiculus	3.8	0.16	---	---	---	---	1.8	47.4	2.0	52.6
Hygophum atratum	6.5	0.28	0.05	0.8	0.02	6.3	2.0	30.9	4.4	68.0
H. proximum	23.0	1.00	---	---	3.1	13.5	12.8	55.6	7.1	30.9
Myctophum aurolaternatum	7.2	0.31	0.3	4.2	1.8	25.0	3.3	45.8	1.8	25.0
M. nitidulum	0.2	---	---	---	---	---	0.05	20.0	0.2	80.0
Myctophum spp.	0.3	0.01	---	---	---	---	0.1	33.3	0.2	66.7
Symbolophorus evermanni	78.8	3.41	0.2	0.2	2.0	2.5	30.4	38.6	46.2	58.6
CERATIOID FISHES										
Unid. Ceratioid	0.1	---	0.1	83.3	---	---	---	---	0.02	16.7
ONEIRODIDAE										
Unid. Oneirodid	0.4	0.02	---	---	0.05	14.3	0.2	57.1	0.1	28.6

Table 7-J (cont'd)

Taxon	Total Abundance No./100m^3	Percent of Total	Depth Interval (m) 0-25 No./100m^3	%	25-50 No./100m^3	%	50-75 No./100m^3	%	75-100 No./100m^3	%
SCOMBRIDAE										
Acanthocybium sp.	0.4	0.02	---	---	---	---	0.3	78.9	0.08	21.1
Auxis spp.	0.6	0.03	0.2	33.3	0.4	66.7	---	---	---	---
Katsuwonus pelamis	0.1	---	0.1	100.0	---	---	---	---	---	---
Thunnus spp.	0.8	0.03	0.6	75.0	0.2	25.0	---	---	---	---
Unid. Scombrids	0.3	0.01	0.1	25.0	0.2	50.0	0.1	25.0	---	---
CARANGIDAE*										
Unid. Carangid	0.2	---	0.2	100.0	---	---	---	---	---	---
ICOSTEIDAE*										
Unid. Icosteid	0.1	---	---	---	---	---	0.1	100.0	---	---
ECHENEIDAE*										
Unid. Echeneid	0.1	---	0.1	100.0	---	---	---	---	---	---
CHLOROPHTHALMIDAE*										
Unid. Chlorophthalmid	0.06	---	---	---	---	---	---	---	0.06	100.0
NOMEIDAE										
Cubiceps pauciradiatus	0.5	0.02	0.3	60.0	0.2	40.0	---	---	---	---

Table 7-K Midwater Fish The following list is a taxonomic account of all the fish retained in free fall grab samplers. (Appendix K, OMCO license application, 1982)

Order Anguilliformes
- Suborder Anguilloidei
  - Family - Nemichthyidae
    - *Avocettina* sp.
    - *Avocettina bowersi*
  - Family - Serrivomeridae
    - *Serrivomer sector*

Order Salmoniformes
- Suborder Stomaitoidei
  - Family - Gonostomatidae
    - *Cyclothone acclinidens*
  - Family - Sternoptychidae
    - *Argyropelecus lychnus*
    - *Sternoptyx obscura*
  - Family - Chauliodontidae
    - *Chauliodus sloani*
  - Family - Stomiatidae
    - *Stomias colubrinus*
  - Family - Idiacanthidae
    - *Idiacanthus fasciola*

Order Myctophiformes
- Family - Ipnopidae
  - *Ipnops meadi*
- Family - Myctophidae
  - *Lampanyctus idostigma*
  - *Lampanyctus omostigma*
  - *Lampanyctus macropterus*
  - *Symbolophorus evermanni*
  - *Diogenichthys laternatus*
- Family - Neoscopelidae
  - *Scopelengys tristis*
- Family - Scopelarchidae
  - *Scopelarchoides nicholsi*

Order Gadiformes
- Suborder Macrouridae
  - Macrouridae
  - *Coryphaenoids* sp.

Order Beryciformes
- Suborder Stephanoberycidae
  - Family - Melamphaidae
    - *Poromitra crassiceps*
    - *Scopeloberyx robustus*
    - *Melamphaes laeviceps*
    - *Scopelogadus m. bispinosus*

Order Perciformes
- Suborder Percoidei
  - Family - Chielodipteridae (Apogonidae)
    - Chielodipterid
  - Family - Bramidae
    - *Eumegistus illustris*
- Suborder Blennioidei
  - Family - Chiasmodontidae
    - *Kali normani*

Table 7-L Invertebrate Species Collected From Applications Areas (Appendix H, OMCO license application, 1982)

Protozoa

Xenophyophoria - at least two species, including Stanophyllum, which occurs on soft and hard substrates in Atlantic, Pacific and Indian Oceans in 700 - 7,000 metres (Tendel, 1972).

Porifera

Siliceous sponges - at least four species. These may live on hard substrates, or may be stalked forms, with the stalk embedded in soft substrates.

Cnidaria

Actinauge sp. - anemone. Lives on hard substrates. A widespread deep-sea genus.

"Anemone" - at least two species of white anemones living on hard substrates.

Umbellula sp. - a stalked coelenterate with the stalk buried in soft substrates.

Bathypathes sp. - a stalked coelenterate with stalk attached to hard substrates.

Pennatula sp. - a stalked coelenterate with stalk embedded in soft substrates.

Arthropoda

Scalpellum sp. - barnacles; attached to hard substrates.

Munidopsis sp. - galatheids, usually on hard substrates.

Acanthephyra cucullata Faxon - caridean shrimp; lives in midwater.

Acanthephyra curtirostris Wood-Mason - see above.

Shrimp ("red shrimp") - large red shrimp, common near seafloor.

Mollusca

Cirrate octopods - several specimens representing at least two species.

White gastropod

Limopsis sp. - a widespread deep-sea clam, to depths of at least 4000 metres.

Mastigoteuthis sp. - common deep-sea (midwater) squids.

Heliococranchia beebei Robson - common oceanic shallow to midwater squid.

Table 7-L (cont'd)

Spinula sp. - widepspread deep-sea clam to depths of at least 4500 metres.

Fissurellid limpet - most common in shallow water, but few species occur in deep sea. Single specimen damaged, and cannot be identified further.

Echinodermata

Class Crinoidea

Hyocrinus (?) *bethellianus* Wyville Thomson. Relatively common in some areas; sessile on manganese nodules and other hard substrates. This stalked crinoid was previously known only from the central Atlantic (1 record) and near the Crozet Islands, Antarctica (1 record) in depths of 2,880 ot 3,300 metres. The Lockheed specimens show some differences which might warrant their referral to a new species.

Class Asteroida

Eremicaster gracilis (Sladen). Not common; burrows in soft substrates. Eastern Pacific, from northern Chile to Southern Alaska, also near Kamchatka, 2690-5204 metres (Madsen, 1961).

Hyphalaster inermis Sladen. Not common; burrows in soft substrates. Northern and tropical Atlantic, Indian and Pacific Oceans. Previously unknown from eastern Pacific. 2278-5413 metres (Madsen, 1961).

Styracaster caroli Ludwig. Indian Ocean, east of Zanzibar and in the Bay of Bengal. 2600-4820 metres (Madsen, 1961). Not common; burrows in soft substrates.

Styracaster elongatus Koehler. Not common. Burrows in soft substrates. North Atlantic Ocean and Indian Ocean, 3310-4870 (Madsen, 1961).

Styracaster new species.

Plutonaster (?) new species.

Plutonaster is a widespread deep-sea genus, occuring in both Atlantic and Pacific Oceans. This species superficially resembles a small *Dytaster gilberti*, but differs in having less conspicuous spines around the margin.

Dytaster gilberti Fisher. Common. Burrows partially or completely into soft substrates. Off California, 3953-4010 metres (Fisher, 1911).

Hymenaster violaceus Ludwig. Common. Burrows partially into soft substrates. Off Acapulco, Mexico, 3382 metres (Fisher, 1911).

Freyella sp. Common. Either clings to hard substrates with arms upraised for feeding or lies on seafloor with arms horizontal. There are possibly two species represented, and it is possible that both are new. As the classification of this group of starfish is somewhat confused at the moment, it may be some time before this question can be resolved.

Table 7-L (cont'd)

Class Ophiuroidea

Amphiodia cf. verrilli Lyman. Rare. Probably burrows in soft substrates. This species is a new record for the Pacific; previously known only from the North Atlantic, 765 metres.

Amphioplus new species. Rare. Probably burrows in soft substrates. This is an unusual new species of a genus that has most of its representatives in shallow water. Only two or three species of Amphioplus extend into deep-sea habitats. The genus is widely distributed in world seas.

Amphiophiura convexa (Lyman). Common. On surface of substrate. Known from several localities in the Atlantic, Indian and Pacific Oceans, 2920-5270 metres (Madsen, 1951).

Ophiomusium armatum Koehler. Very common. On surface of substrate. Near Philippines, 2021 metres (Koehler, 1922).

Ophiura new species. Rare. On surface of substrate. This is a distinctive new species of the worldwide genus Ophiura.

Class Echinoidea

Plesiodiadema globulosum (Agassiz). Common. Eastern Pacific, Mexico to Chile, 2830-3990 metres (Mortensen, 1940).

(?) Brissopsis sp. Fragments of a spatangoid echinoid are unidentifiable. Spatangoids burrow in soft substrates.

Class Holothuroidea

Pseudostichopus mollis Theel. Common. On soft substrates. Eastern Pacific, South Pacific, Antarctic, 240-5320 metres (Ludwig, 1894).

Synallactes new species. This widespread genus is common on soft substrates.

Mesothuria new species. A widespread genus, common on soft substrates.

Deima validum Theel. Rare, on soft substrates. Cosmopolitan species, 1224-4320 metres (Hansen, 1975).

Oneirophanta mutabilis Theel. Common on soft substrates. Cosmopolitan species, 1800-5800 metres (Hansen, 1975).

Oneirophanta setigera (Ludwig). Not common, on soft substrates. Previously recorded from Gulf of Panama and vicinity in 2100-4064 metres, and from the southwest Pacific in 4540 metres (Hansen, 1975).

Psychropotes longicauda Theel. Common on soft substrates. Cosmopolitan species, 2210-5173 metres (Hansen, 1975).

Table 7-L (cont'd)

Psychropotes semperiana Theel. Rare on soft substrates. Atlantic and western Indian Oceans, 3465-5600 metres (Hansen, 1975).

Psychropotes verrucosa (Ludwig). Rare on soft substrates. Western Indian Ocean to eastern Pacific Ocean 2417-7250 metres (Hansen, 1975).

Psychropotes new species. A single badly damaged specimen which cannot be formally described.

Amperima species "A".

Amperima species "B".

Amperima rosea (Perrier). This is the Amperima species "C" of seafloor photographs. Not common on soft substrates. North Atlantic, between Azores and Portugal, 4060-5005 metres.

Amperima species "D".

Benthodytes incerta Ludwig. Not common on soft substrates. Eastern Pacific, 2417-3570 metres (Hansen, 1975).

Peniagone diaphana (Theel). Not common on soft substrates. Atlantic Ocean and Tasman Sea, 2550-5600 metres (Hansen, 1975).

Benthodytes new species. Not common on soft substrates. Cosmopolitan, 694-7250 metres.

New genus, new species. Common on soft substrates. This remarkable large new holothurian belongs in the Family Laetmogonidae.

Psycheotrephes new species. Rare on soft substrates. Genus known from Pacific Ocean and Antarctica in 4410-5029 metres.

Acaudina new species. Rare, burrowing in soft substrates. Genus known from Americas and Australia in relatively shallow water.

Molpadia new species. Rare, burrowing in soft substrates. Genus cosmopolitan, 5-5205 metres.

Table 7-M

Summary of Photographic Data (Appendix H, OMCO License Application)

CAMERA RUN	# PHOTOS ANALYZED	TOTAL AREA (m^2)	TOTAL # INDIVIDUALS	$\frac{X}{100\ m^2}$	H(s)	E/S	NUMERICALLY DOMINANT ORGANISMS
1	496	2538	533	21	2.1	0.3	Urchin
2	145	761	235	31	2.2	0.4	Urchin
3	317	2272	452	21	1.9	0.2	Urchin
4	182	1266	195	15	2.0	0.3	Urchin
5	160	837	76	9	2.3	0.5	Anemone
6	186	925	171	20	2.1	0.4	Ophiomusium
7	12	76	22	29	0.8	0.7	Urchin
8	61	390	75	19	1.8	0.4	Urchin
9	283	1944	301	16	2.2	0.3	Urchin
10	190	1228	139	11	2.1	0.4	Anemone
11	68	520	47	9	2.5	0.7	Anemone
12	205	1204	132	11	2.0	0.4	Anemone
13	495	2982	371	12	2.3	0.4	Anemone
14	423	3360	186	6	2.6	0.5	Anemone
15	208	1233	86	7	2.1	0.5	Anemone
16	270	1911	132	7	2.3	0.5	Urchin
17	323	1389	77	6	2.3	0.6	Anemone
18	159	1266	122	10	1.8	0.3	Urchin
19	64	299	28	9	1.3	0.5	Ophiomusium
20	506	2170	303	14	1.9	0.3	Ophiomusium
21	144	636	40	6	1.9	0.6	Anemone
22	55	196	11	7	1.6	0.9	Urchin

H (s) = Shannon-Wiener Community Diversity

E/S = Evenness

APPENDIX 8

Proposed Terms, Conditions, and Restrictions for Ocean Mining Associates (OMA)

NOAA proposes to issue a license, Delta-Gamma, authorizing OMA to engage in the deep seabed mining exploration activities described in OMA's exploration plan, consistent with the provisions of the Act and 15 CFR Part 970 and subject to the proposed terms, conditions and restrictions (TCRs) below. The issuance proposal is contingent upon a finding by NOAA that the exploration proposed in the OMA application will meet the requirements of § 105(a) of the Act. The proposed license would be exclusive with respect to OMA as against any other United States citizen or any citizen, national or governmental agency of, or any legal entity organized or existing under the laws of, any reciprocating state.

Proposed TCRs

(1) Diligence.

(a) OMA shall pursue diligently the activities described in its approved exploration plan (15 CFR 970.602). In order to show that it has diligently pursued the activities in its approved exploration plan (15 CFR 970.517), OMA shall submit to the Division of Ocean Minerals and Energy of NOAA, in accordance with 15 CFR 970.602 and 970.901(b) and within 90 days of each anniversary of the date of the license, an annual report demonstrating OMA's conformance to the schedule of activities, level of activity, and expenditures set out in its application and subsequent amendments. This report shall focus on exhibiting to NOAA the evolving ability of OMA to apply for a permit for commercial recovery by the end of the 10 year license period.

(b) As part of the requirements in (a) above, OMA's annual report shall contain a description of the types and number of survey activities conducted. Although corporate confidential data are not required by NOAA, the described activities, such as nodule sampling and seafloor mapping, shall be presented by OMA in such a manner as to provide satisfactory evidence of progress made toward the delineation of a permit area(s). OMA's annual report shall also contain (e.g., as an appendix) a list of the environmental data, samples, and photographic records collected each year (including related dates, locations, and type of equipment used) and a statement of the status of the disposition of any biological or geological samples taken (including where stored, how stored, analyses conducted, findings or conclusions of such analyses, and the name and affiliation of the person in charge of samples).

(2) Environmental Protection and Monitoring Requirements.

(a) OMA shall conduct activities under the license to assure protection of the environment (15 CFR 970.518) and so as not to create a significant adverse effect on the environment (15 CFR 970.506).

(b) OMA shall notify NOAA of any endangered species it observes, within 60 days of such observations, as discussed in NOAA's Technical Guidance Document (September 1981).

(c) OMA is not required to conduct any environmental monitoring under this license if no at-sea mining system tests are conducted.

(d) In order to ensure protection of the environment and in accordance with 15 CFR 970.700-.702, OMA is prohibited from engaging in at-sea mining system test activities until NOAA has both approved an OMA exploration plan revision (including NOAA preparation of a supplemental environmental impact statement (EIS)) relating to test activities, and amended the TCRs applicable to OMA's license to include an approved environmental monitoring plan and any necessary TCRs relating to conduct of mining system test activities.

(e) If OMA proposes to conduct at-sea mining system tests, OMA shall submit to NOAA, at least one year prior to the proposed test initiation date, an exploration plan revision and a plan by which OMA proposes to monitor the environmental impacts of test activities (hereafter, monitoring plan).

(f) If OMA proposes to conduct at-sea mining system tests, in order to prepare the supplement to the EIS, referenced in paragraph (2)(d) and as part of the site-specific monitoring activities required of OMA, the exploration plan revision shall include detailed test plans and test site-specific baseline data which NOAA determines are adequate to address the unresolved environmental concerns and to assess the adequacy of the environmental predictions contained in NOAA's Programmatic Environmental Impact Statement (1981) (see NOAA's Technical Guidance Document, September, 1981, for further guidance).

(i) The baseline data must include data from water column measurements acquired during at least two seasons, spaced approximately six months apart, and at least one statistically designed sampling of the benthic fauna.

(ii) OMA is strongly encouraged to consult with NOAA concerning the adequacy of OMA's proposed sampling strategy prior to initiation of baseline data collection. At the request of OMA, NOAA will provide written confirmation of the adequacy of a sampling strategy devised as a result of such a consultation.

(g) OMA's proposed environmental monitoring plan referenced in paragraph (2)(e) shall be responsive to the objectives in (2)(f) above, and shall incorporate the information developed from the baseline data. The monitoring plan shall involve areas expected to be impacted as well as nearby control areas and shall include provision for immediate pre-test data collection, test monitoring and post-test monitoring, and a schedule for submission of resulting data to NOAA. Post-test monitoring shall include at least three years of sampling, the most intensive sampling being conducted immediately following testing and emphasizing the recovery of the benthic fauna.

(h) Baseline and monitoring data shall be submitted to NOAA in accordance with current formats of NOAA's National Oceanographic Data Center.

(i) If onshore processing tests are to be conducted at either existing onshore facilities or newly constructed facilities, OMA shall consult with NOAA as soon as possible, so that a determination can be made as to the need for a supplementary EIS. If NOAA determines that a supplement to the EIS is required, OMA shall submit the necessary data to NOAA no later than one year prior to the proposed initiation of operations (see Technical Guidance Document, dated September, 1981). NOAA will work with other Federal, state and local agencies to incorporate their environmental information needs into a supplementary EIS, if deemed necessary, or other environmental assessment documentation and assist in facilitating the obtainment of the necessary permits from state, local and Federal agencies, as appropriate.

(3) Resource Conservation Requirements. OMA shall conduct activities with due regard for prevention of waste and future opportunity for commercial recovery of the unrecovered balance of the hard mineral resources in the license area (15 CFR 970.519). If at-sea mining system tests are conducted, NOAA requires timely information on the implications of OMA's pattern of mining. Therefore, OMA shall submit to NOAA all collector tracks, and relevant nodule production and other data indicative of mining efficiency, no later than 60 days after completion of each mining test (15 CFR 970.603).

(4) Freedom of the High Seas Requirements. OMA shall conduct its exploration activities in a manner which will not unreasonably interfere with the interests of other nations in their exercise of the freedoms of the high seas, as recognized under general principles of international law, such as fishing, navigation, submarine pipeline and cable laying, and scientific research (15 CFR 970.520).

(5) Safety at Sea Requirements. In order to promote the safety of life and property at sea (15 CFR 970.521), all U.S. flag vessels used in activities authorized by OMA's license shall meet existing regulatory requirements applicable to such vessels, including the possession of a current valid Coast Guard Certificate of Inspection. Foreign flag vessels used in activities authorized under the license shall comply with the certificate requirements of either the International Convention for the Safety of Life at Sea, 1974 (SOLAS 74), or the International Convention for the Safety of Life at Sea, 1960 (SOLAS 60), whichever is applicable to the flag state nation. If the nation where a vessel is documented is not a signatory of SOLAS 74 or SOLAS 60, alternatively, the International Association of Classification Societies (IACS) requirements shall be met (15 CFR Subpart H).

(6) Federal Observers' Monitoring Requirements.

(a) OMA shall permit NOAA to place Federal officers or employees designated as observers aboard vessels used by the licensee in exploration activities to (i) monitor, including data and sample collection by the observer, such activities at such time and to such extent as NOAA deems reasonable and necessary to assess the effectiveness of the TCRs of the license; and (ii) report to NOAA whenever such officers or employees have reason to believe there is a failure to comply with such TCRs.

(b) Whenever OMA is engaged in collection of baseline data or is otherwise monitoring pursuant to a monitoring plan, as described in (2) above, the at-sea observer, after consultation with OMA, is authorized to specify minor changes in OMA's sampling protocol or strategy if the observer determines that a change is necessary to address unanticipated results or to assure that the objectives of the monitoring strategy are met. The observer shall document such changes and rationale, in writing, and OMA shall comply with such changes.

(c) Arrangements for any observer shall be made between NOAA and OMA, and OMA shall cooperate with observers in the performance of their monitoring function, in accordance with 15 CFR 970.1105. OMA shall notify NOAA of each exploration cruise and the scope of cruise activities at least 60 days prior to each vessel departure.

(7) Records.

(a) OMA shall keep and maintain for not less than three years such records, consistent with standard accounting principles, as will facilitate an effective audit of OMA's expenditures for exploration for hard mineral resources in its license area (15 CFR 970.901).

(b) Records used as the basis for the annual report shall be maintained for not less than three years following submission of the report, except that environmental data, photographic records and samples shall be kept for the term of the license unless the licensee has requested, and received in writing from NOAA, either permission to dispose of these data, records and samples or instructions to deliver them to a location designated by NOAA. The licensee shall make its request to NOAA in writing six months in advance of its proposed disposition, and shall bear the expenses of delivery of such data, records and samples to the location designated by NOAA.

(8) Special TCRs. NOAA is authorized to issue special TCRs for the conservation of natural resources, protection of the environment and safety of life and property at sea, when required by differing physical and environmental conditions in the license area (15 CFR 970.523). At this time, NOAA does not intend to impose any special TCRs on the OMA license; however, should additional data (e.g., licensee-submitted environmental baseline data acquired in accordance with paragraph (2)(f)) suggest that such conditions are necessary, NOAA will amend the license TCRs to reflect appropriate conditions.

(9) Shipwrecks and Cultural Materials. Within 60 days of discovery, OMA shall notify NOAA of any shipwrecks or other cultural materials discovered in the course of exploration activities. (See National Historic Preservation Act.)

(10) Violations. It is unlawful for OMA to violate any provision of the Act, any regulation issued under the Act, or any term, condition or restriction of the license.

(11) Emergency orders. NOAA may order immediate suspension of the license, or immediate suspension or modification of particular activities under this license, if the President determines by Executive Order that such immediate suspension or modification is necessary to avoid any conflict with any international obligation of the United States established by any convention or treaty in force with respect to the United States or to avoid any situation which may be reasonably expected to lead to a breach of international peace and security involving armed conflict, or if the Administrator of NOAA determines such an action is necessary to prevent a significant adverse effect to the environment or to preserve the safety of life or property at sea. Upon receipt of an emergency order issued pursuant to 15 CFR 970.511, OMA shall immediately suspend or modify activities in accordance with the requirements of the order until such time as OMA receives written notification from NOAA that the emergency order is rescinded.

(12) Notice of Changes. OMA shall notify NOAA promptly of any changes in the membership or legal structure of its consortium, of any changes in its exploration plan, or of any other circumstances that might substantially affect any NOAA determination, or basis for license issuance or transfer, or the sufficiency of the TCRs to accomplish their intended purpose.

(13) Notice of Other Federal Requirements.

(a) The Department of Defense requested that the licensee be notified of requirements to file appropriate Notices to Mariners and, as required by law, to obtain export licenses.

(b) Pertinent statutory and regulatory authorities and requirements of other agencies and units of government are not satisfied by the issuance of this license and TCRs.

(c) NOAA commercial recovery regulations not yet promulgated may require submission, with the permit application, of environmental baseline data in addition to the data requirements of paragraph (2) of these TCRs.

(14) Modifications

These TCRs may be modified in accordance with 5 CFR 970.512 should OMA modify its exploration plan or otherwise change its program.

Date:________________

Paul M. Wolff
Assistant Administrator for
Ocean Services and Coastal
Zone Management