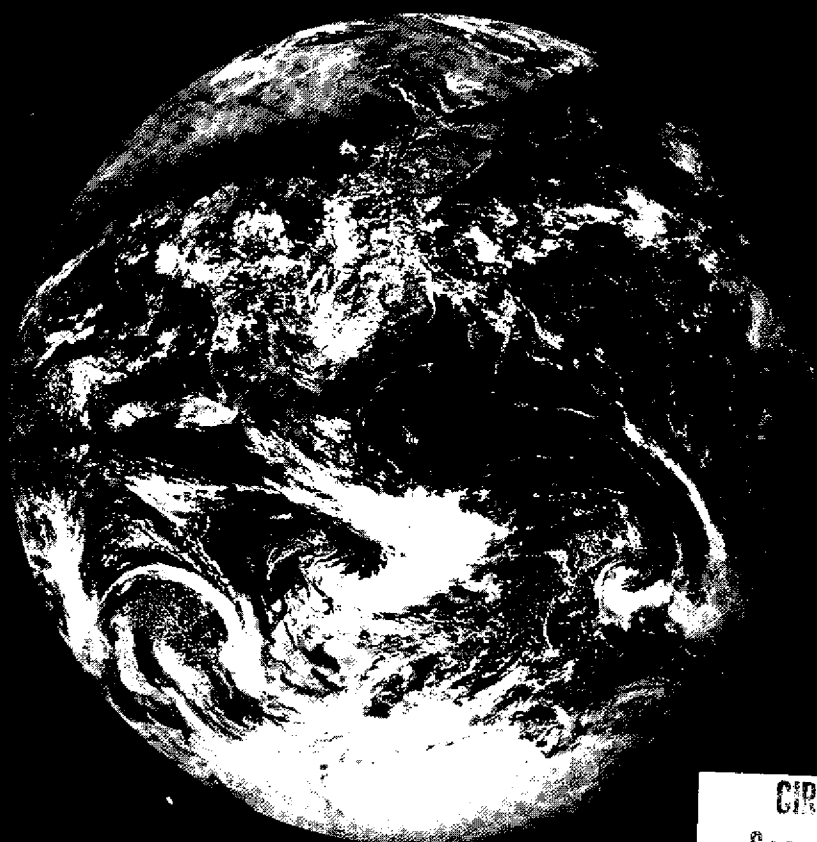
THE OCEAN ENTERPRISE CONCEPT



When we speak of space, let us not forget that in the space of our solar system only the earth has the atmosphere and ocean to support life. Therefore, the exploration, protection, and development of ocean space and its resources must be humankind's next priority.

REPORT ON THE

OCEAN ENTERPRISE WORKSHOP

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REPORT TO

THE NATIONAL SCIENCE FOUNDATION

ON THE

OCEAN ENTERPRISE WORKSHOP

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1. Executive Summary

In 1983 the area for potential economic development in the United States was almost tripled by Presidential Proclamation of a 200-nautical-mile Exclusive Economic Zone (EEZ) extending seaward. This zone added 3.9 billion acres of marine territory to U.S. economic jurisdiction, but the EEZ has not yet produced any new activities or economic benefits of significance. Unless the United States actively encourages the development of new or underdeveloped resources and uses in the ocean, the economic potential of the EEZ will not be realized. This inactivity contrasts sharply with offshore development in countries such as Japan and France which are rapidly exploring and exploiting new uses of their maritime territories.

The basic problem in ocean development is that new uses of the ocean are perceived as having overly high risks and diminished government support and interest. The Ocean Enterprise concept was formulated as a way of overcoming the constraints that have inhibited the development of EEZ resources and uses. By allying government, industry, and academia, the gap that exists between research and development in ocean projects could be bridged with private/public funding to support special development activities.

A workshop was proposed that would bring industry, government, and academia together in order to develop the blueprint for an economic engine which would focus and drive the technological advances for development of resources of the U.S. EEZ. The Ocean Enterprise Workshop, with lead sponsorship by the National Science Foundation, was held in February 1989 to bring the Ocean Enterprise concept into sharper focus, to agree on its necessary implementing infrastructure, and to decide, if possible, on the kind of initial projects that would best demonstrate the merit of the concept.

The lack of a U.S. national infrastructure has inhibited the development of ocean enterprises. To develop ocean enterprises, funding for large-scale ocean projects is needed outside of the nation's current operating budgets in order to keep from sacrificing other national political, social, and economic goals. These enterprises (e.g., large floating platforms, waste disposal mini-utilities, etc.) should be funded out of capital accounts and then reimbursed on a fiscally sound basis when the private or public users benefit.

This report details the presentations made at the workshop, the deliberations of its six working groups, and offers the following recommendations.

Near-term Recommendations

The Ocean Enterprise workshop focused the technical rationale of the Ocean Enterprise concept, and identified several projects offering near-term economic and environmental benefits. These are: marine mining, waste disposal, and OTEC with mariculture. The workshop participants agreed that, because of our perceptions of risk and uncertainty, a quasi-government organization (incubated within a lead federal agency and sponsored initially by federal funds) would be needed if any of these opportunities are to be realized in the near future. The Ocean Enterprise concept would offer national and international capital markets the choice to invest in private corporate ventures or in government sponsored long-term undertakings.

The National Science Foundation has shown interest in the Ocean Enterprise concept with its sponsorship of the Ocean Enterprise workshop. Participants at the workshop recommended that NSF continue to support the development of the Ocean Enterprise concept and initial feasibility engineering studies.

The immediate development of the Ocean Enterprise concept needs to be implemented by a Congressional charter, with a federal agency serving as an incubator (for embryonic development), i.e., within the Department of Commerce, an interagency commission, or a new federal agency.

As a first step, to initiate near-term goals, workshop participants recommended the formation of an Ocean Enterprise Coordinating Committee. Subsequent to the workshop, the committee has discussed and approved this report, and will continue to work towards implementing the recommendations of the workshop.

Long-term Recommendations

In the long term, an Ocean Enterprise Consortium may be necessary. This consortium would be composed of academic, industrial, and private sector institutions, venture capitalists and federal agency(s). To be effective the Consortium will require a declaration of policy and purpose from the Administration, and enabling legislation from Congress. Support for Ocean Enterprise activities will require that the proposed projects are worthy of support and development. Therefore, these projects must reflect the nature of the ocean as a public trust and as an unparalleled opportunity for national economic development and environmental management.

An Ocean Enterprise Consortium could have the following characteristics:

- It would derive its membership from public and private sectors but would operate as a corporation.
- It would derive its financial basis from government, participating industries, and private foundations.
- It would invest, own property, lease and sell, and earn a return from its investments.

- Upon reaching a level of success, it would be able to create its own endowment for future operation, independent of the need for continued public and private financial assistance.

- It would encourage participation from academic and professional organizations to review and validate its goals, objectives and projects.

- It would develop new technology itself for license and transfer to industry.

- It could be housed and incubated in a federal agency for a specified period of time while it begins its function of jump starting ocean enterprises and assisting industry in developing new ocean opportunities.

- As a quasi-governmental organization, it would:
  1) have the limitation of liability to that normally accepted by the federal government;
  2) have disallowance of intervener legal action (similar to the Trans-Alaska Pipeline).

Finally, such an ambitious plan can only be implemented with strong leadership. Therefore, a Presidential endorsement or commission is needed to expedite implementation of the Ocean Enterprise concept.

2. Introduction

In 1983, President Reagan proclaimed a 200-nautical-mile Exclusive Economic Zone (EEZ) for the United States. This new marine area, hugging the coastlines of the U.S. and its territories, added 3.9 billion acres to our economic jurisdiction, almost tripling the area for potential economic development in the United States. Following the Louisiana Purchase in 1803, the heartland of the nation was settled through the use of developmental policies such as the Homestead Act and the Morrill Act, and the building of the Union Pacific Railroad. Synergies achieved by government, business, and educational institutions working together at that time contributed to the growth and prosperity of the nation.

At best our new national asset, this vast area of ocean space delineated as the Exclusive Economic Zone, has received only limited attention from government, industry, and academia. Since the 1983 EEZ Proclamation, meetings and conferences have been held to focus on the resources of the Zone and technologies for its development. No new ocean resources or activities, however, have been developed thus far. A more positive example occurred in the late 1950s when it was decided as a national policy that R&D for the outer space program was critical and should be funded by the public sector. Within a decade man walked on the moon; and NASA's budget has now grown to over $20 billion annually.

Research and development funding for exploration and development of ocean space and its resources has fallen *de facto* to the private sector where emphasis is placed on those activities that will yield reasonably well defined, near-term economic returns. Such a policy neglects the many factors of long-term significance that are involved in the development of ocean resources, such as increased attractiveness of once uneconomic resources, discoveries of previously unknown resources, and increased accessibility to resources through engineering R&D and technological advances.

The Ocean Enterprise concept is an exciting and challenging mechanism for pulling together government, academia, and industry so that significant new areas of economic interest can be developed or current ones strongly bolstered. A partial list of ocean enterprises that presently exist in the U.S. EEZ includes commercial and sport fishing, oil and gas production, commercial shipping, national defense activities, and oceanographic research. The principal economic payoff remains in the areas of shipping, fisheries, and offshore oil and gas. An assessment of development in the ocean sector over the past 20 years reveals that not one new major economic area has been developed. Research and development investments have been made in such areas as mineral deposits (manganese nodules) and Ocean Thermal Energy Conversion, but no business of new economic value has yet come from these investments.

The Ocean Enterprise project is attempting to add dimension to this flat horizon of the ocean sector. The pages which follow outline the evolution of the Ocean Enterprise concept and offer a national plan of action for bringing this concept to fruition.

3. Background on the Ocean Enterprise Concept

The general concept of ocean enterprises and a proposal to conduct a workshop on the subject was formally broached to the National Science Foundation in May 1987. The idea seems to have originated from a series of meetings between the project's principal investigators, the National Ocean Industries Association (NOIA), Brown and Root, Inc., and the National Science Foundation. The idea was seen as one way to improve U.S. competitiveness in international markets. The concept was in reality a response to the observation that U.S. ocean industries, with the exception of offshore oil and gas, were virtually moribund. Despite the enthusiasm and optimism that characterized the earlier *Stratton Commission Report* and despite President Reagan's 1983 proclamation of a 200-mile Exclusive Economic Zone for the nation, little in the way of new ocean development had taken place in the United States. Yet, it is possible to see new and exciting ocean projects moving ahead in other nations, most notably Japan and France.

During discussions held in Washington, D.C. in the summer of 1987, the Ocean Enterprise concept began to take shape. In August of 1987, a draft proposal for an Ocean Enterprise workshop was circulated for review and comments. This was followed by submission of a formal proposal to NSF by Principal Investigators David A. Ross of the Woods Hole Oceanographic Institution (WHOI) and James E. Dailey of Brown and Root, Inc. (B&R). The centerpiece of the proposed project was to be a workshop which would bring together industry, government, and academia to develop the blueprint for an economic engine. This engine would focus and drive the technological advances for development of resources of the U.S. EEZ.

Subsequent discussions of the workshop took place at several meetings of an *ad hoc* Ocean Enterprise Project steering committee (in December 1987 and January 1988). Considerable attention centered on the difficulty of having the workshop deal both with a possible pilot-demonstration project on the one hand, and with the further development and refinement of the overall concept, on the other. It was the consensus of the steering committee that consideration of a specific project was needed to keep the workshop focused and realistic. Yet, caution was taken for the workshop not to become totally preoccupied with the project aspects and lose sight of the broader goal of formulating a workable concept and designing the necessary infrastructure to make it work.

On March 1, 1988, WHOI was notified by NSF that it was being awarded funding for an Ocean Enterprise workshop. A number of small working group meetings took place during the spring and summer of 1988 to advance the planning of the workshop. Brown and Root, Inc., WHOI,, and the National Oceanic and Atmospheric Administration's National Sea Grant College Program joined NSF as co-sponsors of the project.

The 'Oceans 88' Conference (held in Baltimore, MD in October 1988) offered an opportunity for a number of coastal states to learn of the Ocean Enterprise concept at a special session and panel discussion organized by the Coastal States Organization (CSO), the Marine Technology Society, and the steering committee of the Ocean Enterprise workshop project. The session resulted in positive expressions of interest by a number of representatives of the coastal states that were present.

Final plans for the Ocean Enterprise workshop were engineered during the fall of 1988. A number of authors were invited to prepare papers on topics central to the Ocean Enterprise concept (see Sections 4b and 4c). It was decided to hold the workshop on February 20-24, 1989 at Columbia Lakes, Texas, a site relatively close to both Hobby Airport (Houston) and Brown and Root, who had accepted responsibility for handling workshop logistics.

An important remaining task was to ensure that the right mix of individuals agreed to participate in the workshop. The steering committee devoted a substantial amount of time to this task in an effort to have all of the necessary interests represented at the meeting and to maintain balance in the process. It was clear that the success of the workshop depended very much on getting this proper mix of talent and expertise--from academia, from industry, from the financial community, from government (both federal, state, county, and Congress as well), and from representatives of the public. In the end, it appeared that this task was successfully carried out as a diverse and energetic group assembled in South Texas on the evening of February 20 for the opening session of the workshop (see Appendix A for listing of workshop participants).

4. The Ocean Enterprise Concept

Before summarizing the outcome of the workshop, a review of the Ocean Enterprise concept is in order, tracing its evolution through the period leading up to the workshop. This will aid in understanding some of the debate at the workshop and in interpreting the recommendations emanating from those discussions.

Fundamentally, the Ocean Enterprise concept is a way of overcoming the constraints that seem to be inhibiting the development of the resources and uses of the EEZ. Some ocean projects or developments fail to advance because of the perception that high risks are involved; some because the funding cannot be found to demonstrate the commercial viability of a new ocean technology; and some because of uncertainties and risks associated with the regulatory framework, public perception about ocean use, and the possible exposure to intervener judicial challenges. These are all examples where scales of time, risk, and/or magnitude are too great for one sector (of government, industry, or academia) to bridge the No Man's Land alone (see Figure 1). A mechanism to bridge this gap between research and development requires a larger, more integrated effort with private/public sharing of funding to support special development activities.

These constraints have overshadowed the many technical and economic factors that might normally drive the development of ocean resources such as:

a) increased attractiveness of previously uneconomic resources;

b) discoveries of previously unknown resources;

c) increased accessibility through engineering research and development and technological advances; and

d) new ocean uses (i.e., energy from waves or use of the ocean space for waste disposal).

The basic problem can be summed up as follows: new uses of the oceans are perceived as having overly high risks and diminished government support and interest.

As a part of the pre-workshop planning, a number of mechanisms were suggested to implement the Ocean Enterprise concept. These included an ocean-going Fannie Mae (to provide needed venture capital), a federal in-house incubator (to support successful ocean technologies from the R&D stage to a demonstration of commercial feasibility), and a federally chartered quasi-government corporation (to bestow the positive aspects of a federal connection without the downside problems of being located in the bureaucracy).

A wide range of projects was offered as appropriate for the Ocean Enterprise concept--from garbage-related projects, ocean thermal energy conversion (OTEC), ocean placer mining, to large floating platforms for air, space, commercial, and military applications.

It was clear, well before the workshop began, that the Ocean Enterprise concept was an attractive one to many people and interests. But the concept was not yet clearly

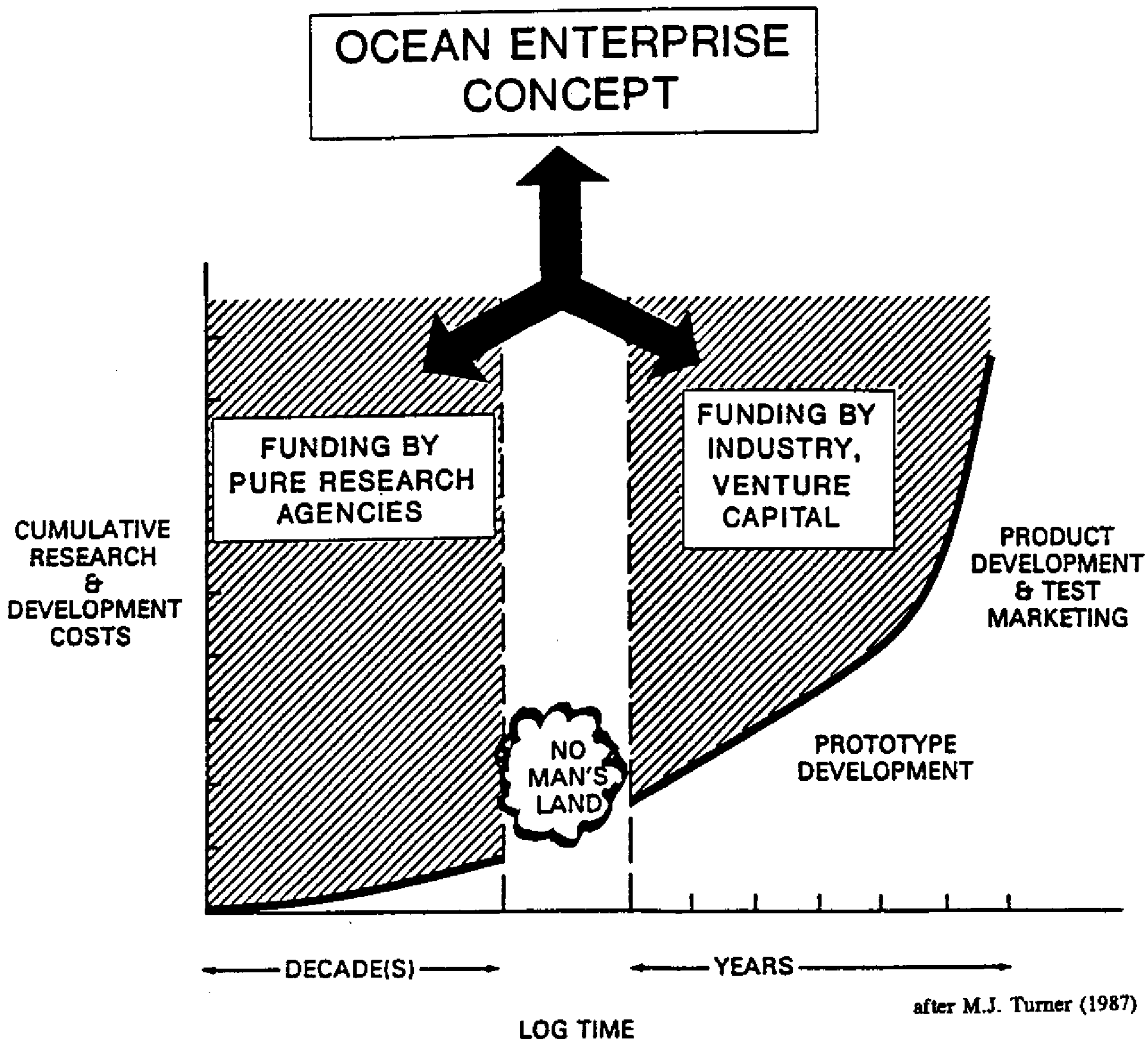

Figure 1. The Ocean Enterprise concept to bridge the NO MAN'S LAND GAP

defined or developed, and agreement was lacking on the kinds of projects with which it should be linked. The workshop's role was to bring the Ocean Enterprise concept into sharper focus, to agree on the necessary implementing infrastructure, and to decide, if possible, on the kind of initial projects that would best demonstrate the merit of the concept.

5. The Columbia Lakes Ocean Enterprise Workshop

a) Organization of the Workshop

After opening formalities (see Appendix B for the Meeting Agenda), a presentation on the Ocean Enterprise concept was made and six speakers presented a sense of the opportunities associated with potential EEZ development (see Section 4b). This was followed by a session on the constraints (environmental, economic, social, and political) that act to inhibit ocean development (see Section 4c). The workshop then moved to the working group phase, with the designation of six working groups: Marine Mining of Heavy Minerals, Waste Management Opportunities, Ocean Energy and Mariculture, Air and Space Ocean Platforms, Structure and Organization, and Implementation and Strategies.

The working groups met for the better part of a day and an evening, working both on their responses to a series of prescribed questions (see Section 4d) and additional issues based on their own areas of competence. At the conclusion of their deliberations, reports were presented to the full workshop outlining the suggestions of the various groups (see Section 4d).

During the final afternoon session, the group recommended formation of an Ocean Enterprise Coordinating Committee, nominated representatives to serve on the committee, and discussed particular actions that should be considered by the committee. The committee is composed of Earl Conrad (Sea Grant Review Panel), Ronald J. Hays (President and CEO, Pacific International Center for High Technology Research), Robert Knecht (Professor, College of Marine Studies, Univ. of Delaware), Dana Larson (Sr. Project Manager, ENSR Consulting and Engineering), and David Ross (Chairman, Geology and Geophysics Dept. and Sea Grant Coordinator, Woods Hole Oceanographic Institution).

b) Sense of the Opportunities

Economic activity in the U.S. Exclusive Economic Zone has been dominated, past and present, by the defense industry, commercial shipping, and the oil and gas industry. Fishing should also be recognized, but its investment magnitudes are much smaller. Future prospects for all these industries are murky, with little growth forecast and decline possible. Thus, the nation will likely have to look to new technologies and new industries to secure the benefits of the EEZ.

Papers presented in this section speak to a selected number of opportunities that could become future sectors of commercial importance in the EEZ. The papers do not represent a comprehensive or complete summary of all prospective enterprises, nor is there any attempt to rank them as to relative importance. The interest here is to provide some insight into the range and nature of the opportunities which can form the basis for discussion of constraints in the following section. Abstracts are offered herewith; full texts follow in Section 9.

- **THE OCEAN ENTERPRISE CONCEPT**
  by David A. Ross, Michael A. Champ, James E. Dailey and Clifford E. McLain

  The Ocean Enterprise concept has been proposed as an exciting and challenging mechanism for launching a new era of awareness, practical development, and utilization of ocean resources beginning in the early 1990s. It is only through a cooperative 'pulling together' of government, academia, and industry that significant new areas of operational economic interest can be developed or current ones strongly bolstered in the oceans' sector. Great strides in the scientific understanding of the oceans have been made in some areas, yet no new major economic area has been developed in the ocean sector in twenty years and a strong well recognized constituency has not yet developed for the oceans.

  This paper discusses the private sector environment and its necessary placement in bridging the No Man's Land gap between research and development. It defines an ocean enterprise using ocean platforms as an example and then discusses funding limitations and private sector incentives for oceans' development. An approach for the Ocean Enterprise concept is offered with the reminder that primary resources of basic ocean research lie within academia and the federal government, and that primary resources for development lie within the private sector. The model of a Research and Development Limited Partnership with government, academia and private industry in a 'triple alliance' is offered as a mechanism for launching Ocean Enterprises. In addition, an Ocean Economic Development Policy statement by the President is needed to follow up on the EEZ Proclamation of 1983, and a coalition of ocean resource states would be helpful in the development of a broader Congressional constituency as well.

  An implementation strategy for the Ocean Enterprise concept would entail a team effort, with coordination by key federal agencies backed by specific White House approval, supporting major activities in five areas: policy development; constituency establishment; awareness enhancement; new enterprise initiation; and research and development direction and augmentation. The technology, ideas, and interest for Ocean Enterprises are present. The initiative can, if vigorously encouraged and coordinated, yield a strong turning point for the history of ocean research and enterprise.

- **MARINE HARD MINERALS MINING: PLACERS AND PROFITS**
  by J. Robert Moore

  Marine placer mining has been underway since the turn of this century, chiefly on beaches and in shallow waters off Nome and other Alaskan sites. The introduction of a major dredge off Nome, and recovery of fourteen million dollars in gold, in 1987, signaled the start of profitable recovery at a high level. Some so-called problems in placer mining are only perceived as such, notably the lack of risk capital, the lack of suitable charts, and the lack of prospects. On the other hand, there are some real problems facing the marine placer industry, namely the lack of a realistic regulatory framework, the lack of technology for under-ice mining, rapid metal surveys, recovery of ultra-fine particles, and the lack of trained personnel. Based on the recent commercial success in the Bering Sea, the low cost for placer exploration and mining *vs* the high cost for deep water mining, the additional target metals in placer minerals, and the potential for new discoveries in US-EEZ, state and territorial waters, marine placer mining holds much potential for substantial economic return, particularly in the noble metals, for which the market is exceptionally bright.

- **OCEAN THERMAL ENERGY CONVERSION: A MULTI-PRODUCT ENTERPRISE**
  by Patrick Takahashi, Luis Vega, Elizabeth Udui and Leonard Rogers

  While the ocean thermal energy conversion (OTEC) concept is more than a century old, it is only during the past decade that major technological breakthroughs have occurred. Mini-OTEC, off the big Island of Hawaii, showed in 1979 that the Closed-Cycle option could produce net power. More recently, the concerns about biofouling and high cost of heat exchangers have been resolved through research, and Closed-Cycle OTEC only awaits a more favorable economic climate for commercial development.

  Open-Cycle and Hybrid-Cycle OTEC remain untested, with turbine uncertainties needing to be addressed for the former and the evaporator for the latter. Cold water pipe development also needs further research.

  During the early 1980s, large OTEC plantships of several hundred megawatts were the planning vogue. Current plans target 1 to 10 megawatt (MWe) land-based plants. At these smaller sizes, the co-products of food, air conditioning, mariculture, biopharmaceuticals, and fresh water become important revenue producers. These size modules show potential for upgrading the entire economy of island nations. The Pacific International Center for High Technology Research (PICHTR) has reported that virtually every Pacific Island nation has the natural conditions to utilize the technology.

  The transition to full commercialization will be accomplished through fabrication of a few 1 to 10 MWe Closed-Cycle plants and larger numbers of similar-sized Open-Cycle facilities, since the integrated multi-product OTEC systems are now cost effective in selected island communities. As the world moves into the 21st century, larger scale plants could gain wider acceptance, depending upon the price of conventional energy sources; the need for special applications, such as processing seabed ore, producing fertilizer, or transportation fuel; and the seriousness of the greenhouse effect.

- **KE-AHOLE POINT AS A PRECURSOR MODEL OF GOVERNMENT-INDUSTRY-ACADEMIC OCEAN ENTERPRISE**
  by John P. Craven

  The Ke-ahole Point Natural Energy Laboratory of Hawaii and the subsequently established Hawaii Ocean Science and Technology Park are facilities of the State of Hawaii which were built as a test of a government-industry cooperative concept to commercialize the natural energy resources of the County of Hawaii. The management model was designed to avoid the pitfalls of innovation development that have prevented the United States from commercializing the results of its own research and development. Fifteen years of operation have now demonstrated the success of this model.

  This paper describes the philosophy of management, the growth and development of the Laboratory and describes a few of the alternate development paths that have led to commercialization. The Laboratory and Science Park are to be merged this legislative year to permit a major increase in the scale and scope of resource development and commercialization. The prospects for these expanded developments are discussed in the context of competition from Japan and Taiwan and the technology transfer mechanisms that have heretofore favored these nations *vis-a-vis* the United States in the commercialization of new technologies.

- **OFFSHORE GARBAGE PROCESSING IN THE NORTH ATLANTIC**
  by Kenneth S. Kamlet

  Although the burning of municipal garbage at sea is not known to be practiced anywhere in the world, at least three different Municipal Solid Waste (MSW) ocean incineration concepts have been advanced in the U.S. since the mid-sixties. They involve: (1) nearshore burning on ships; (2) nearshore burning on platforms; and (3) offshore burning on ships.

Despite legal bans on at-sea incineration of noxious liquid wastes, industrial wastes, and sewage sludge, there is currently no regulatory prohibition against ocean incineration of nonhazardous MSW. However, because of staff cuts and competing priorities, the U.S. Environmental Protection Agency has not been willing to allocate the resources necessary to process and issue an MSW ocean incineration permit (but such a permit may not be necessary for burning on a nearshore or offshore platform).

Given the mounting MSW management crisis in many parts of the country and the upward spiral of MSW management costs, there appear to be no insurmountable economic, technical, or environmental barriers to implementing any of several ocean incineration options. The primary barriers are political and regulatory.

- **CONVERSION OF GULF OF MEXICO NONHAZARDOUS SHIP GENERATED WASTES INTO ARTIFICIAL REEFS ABOARD OFFSHORE PLATFORMS**

by **Dana Larson**

This paper will begin to explore the feasibility of the concept of upgrading nonhazardous shipboard wastes by converting them into artificial reefs and other valuable products aboard offshore petroleum structures located in the Gulf of Mexico. Very preliminary research of the concept indicates that the collection of ship-generated wastes at a few selected offshore locations is more economically practical than either retrofitting existing vessels for waste processing or separating ship wastes into three or four separate receiving containers onshore at upwards of an estimated 18,000 shorebased terminals in the Gulf of Mexico.

Initial research also indicates the need of creating long lasting plastic artificial reef fish habitat. Mariculture ventures associated with the reefs will help offset the problems of loss of natural reef habitat, overfishing, pollution, increased demand for fish products, and high levels of U.S. fish imports. Offshore waste conversion facilities will meet both the objectives of the recently adopted Annex V of MARPOL and the long standing objectives of the Department of Health in preventing importation of agricultural threats.

If the concept and a demonstration pilot project prove feasible for nonhazardous shipboard wastes, the offshore facilities may be used to process existing flotsam and jetsam, then beach litter and eventually, municipal solid and liquid wastes. It is hoped that the concept's push-pull economic engine, fueled by fees provided by producers of maritime waste and by profits from mariculture ventures, will both reduce future illegal dumping of solid wastes dumped into the Gulf and current levels of renegade trash. If the concept proves feasible in the Gulf, it may prove applicable to other U.S. locations and other countries.

- **CONSIDERATIONS FOR SUBSEABED STORAGE OF SEWAGE SLUDGE WASTE UTILIZING DEEP DRILLING TECHNOLOGIES**

by **Melvin N.A. Peterson**

Significant environmental hazards have been identified with disposal of sewage sludge, including potential contamination of the nation's surface and ground water supplies, degradation of our air quality, and marine pollution. These and additional adverse environmental consequences will become even more severe as treatment facilities double their output by the year 2000. Other factors such as increased industrial activity and regional population increases will produce extreme local problems.

This paper recommends investigation of an alternative sludge disposal method. It calls for drilling, or reaming, into soft nearshore sediments of the ocean floor, inserting waste into the bottom of the hole, and refilling the top portion with displaced sediments. The procedure could potentially isolate waste for geologic time. Calculations indicate this method could solve a significant portion of the nation's coastal sludge disposal problem while providing long-term safeguarding of our environment. At the very least, the proposed method represents a possible interim approach pending technological advancements in waste disposal, including proper segregation of toxic components from the massive waste stream.

c) Sense of the Constraints

Proclamation of the U.S. Exclusive Economic Zone has been likened by some to the Louisiana Purchase. Both acquisitions added significant territory and the Louisiana Purchase added to the nation's economic base. Our challenge is to make the EEZ equally profitable. The mechanisms, however, by which the nation secures economic benefits from the EEZ must surely be quite different. Economic growth in the territory acquired in the nineteenth century was stimulated through land grants to private organizations and individuals such as railroaders, miners, and farmers. Enterprises grew through private investment on private lands. By contrast, control of *wet* lands in the EEZ will likely remain in the public sector, with leases or permits granted to private entities for specific purposes such as oil and gas production, hard mineral mining, and mariculture.

The administrative machinery of government has grown to be very large and complex especially in the past few decades, with multiple interactions among executive, legislative, regulatory, and judicial systems. New enterprises in the EEZ will confront hurdles never contemplated in the last century.

Papers in this section characterize the constraints that new enterprises in the EEZ face, using opportunities discussed in the previous section as a frame of reference. Shared perception of the constraints serves as common ground for discussion of ways by which constraints can be confronted and remedied where needed. These discussions lead to recommendations and a plan of action for facilitating new enterprises in the EEZ.

- **CONCEPTS FOR STRUCTURING OCEAN VENTURES**
  by Clifford McLain

  The argument that there has been no significant new economic ocean development because there are no opportunities is refuted in this paper by the proposition that there are many ocean enterprise areas in which profitable enterprise might now be developed. There are many constraints to development, however, which are neither technical or economic and which are peculiar to the ocean. We recognize that the national ocean is a public asset with a wide variety of public constituencies and that these constituencies impose constraints on the ability and interest of the private sector in developing ocean enterprises. An ocean enterprise structure must, therefore, be designed to resolve and balance the constraints of technical risks and the marketplace along with the constraints imposed by the operating environment of policy, regulation, and other ocean users.

  A public-private partnership is proposed with a private sector team operating in partnership with responsible government agencies. The private sector team may be comprised of scientific and technical institutions, ocean users, and industrial and business organizations. Although initially funded directly by the government, the organization would be fed and increased through return on its investment derived from successful new ocean enterprise ventures which it has launched. Thus Ocean Enterprise is proposed as a self-supporting and self-endowing entity, eventually disposing of any requirement for Federal or outside capital support for its incubator operations.

  The assets of the ocean are not assigned to particular economic purposes whether of a commercial or public utility character. National and regional economic conditions will make it imperative that important resources in the national ocean be used wisely to augment dwindling, and in some cases, nonexistent natural resources, and to strengthen national and regional economies. The partnership approach can be an effective strategy for achieving Ocean Enterprise objectives.

- **LEGAL CONSIDERATIONS FOR THE ADVANCEMENT OF OCEAN ENTERPRISES IN THE U.S. EXCLUSIVE ECONOMIC ZONE: NEW WAVES AND OLD RIPPLES OF LEGAL UNCERTAINTY**
by David C. Slade

The U.S. Exclusive Economic Zone is nearly 6 years old. Nonetheless, beneficial use of EEZ resources remains limited to traditional activities such as fishing, oil and gas development, and navigation. New uses, such as marine hard mineral mining, offshore waste treatment, mariculture, and ocean platforms (coastal airports), and others, remain inhibited. The background materials for this workshop list the limitations of leadership, infrastructure, venture capital and technology as stifling development of new ocean enterprises. In addition, another major limitation must be included--an uncertain and volatile legal environment. Old ripples in the fabric of ocean law remain troubling, while new fundamental questions of legal interpretation have recently arisen. The 1988 Presidential Proclamation extending the U.S. Territorial Sea, for international purposes, from 3 to 12 miles is certain to reopen the policy debate over State/Federal jurisdiction and control of these resources, among other questions of law and policy. Congress should address these questions of ocean governance. Further, there are strong precedential arguments that Congress is constitutionally required to confirm the Proclamation.

Prior to congressional action on this score, even with leadership, shore- and sea-based infrastructure, capital and technology, these fundamental legal and policy questions will stifle investment in new ventures because of the risk inherent in such a shaky legal environment.

Any future Ocean Enterprise concept, no matter how it is structured and enacted, must be a part of a new, emerging national ocean policy and legal regime.

- **OCEAN ENTERPRISES IN THE 1990'S: ENVIRONMENTAL, ECONOMIC, SOCIAL, AND POLITICAL CONSTRAINTS TO DEVELOPMENT**
by Peter A. Johnson

This paper examines the current status of environmental, economic, social, and political constraints to development for emerging ocean enterprises. Since the focus of this workshop is how to structure a successful ocean enterprise in those areas that are not today commercial ventures, it is important to understand how such developments may be constrained. Some of the current constraints could possibly be modified under a new structure; others could be recognized and planned for; still others could be avoided. Constraints to development may establish the levels of acceptability of a project or put limits on its development. If limits and acceptability can be determined early in the development process, then both planning and implementation can be facilitated.

Since the workshop will explore new and innovative structures to foster development of fledgling enterprises, the types of activities that will be discussed are those that, today, are not commercially viable, but that have the promise of future viability. Excluded from the list are, therefore, the traditional and dominant ocean businesses such as oil and gas production, shipping, fishing, current military uses, and a range of current recreational uses. This leaves a myriad of both extractive and non-extractive uses of the ocean that are difficult to categorize and may have few common elements. The selections for workshop discussion include hard minerals developments, ocean thermal energy production, development of ocean platforms for missile and aircraft bases, and several proposals for offshore waste disposal operations. These selections should serve only as examples, because, with different participants or at a different time, the selections could expand in many directions. When discussing constraints, however, it is necessary to find the common elements among these selections as well as among the wide variety of other possible emerging ocean enterprises.

If new structures for developing ocean enterprises can allow for consideration of constraints at many stages in the development process, then there may be opportunities for facilitation. This paper first discusses some common aspects of the development process and then the notion of constraints. Finally, it concludes with comments about some specific constraints associated with the selected development topics.

- **OCEAN ENTERPRISES IN THE 1990'S: TECHNICAL AND ENGINEERING CONSTRAINTS TO DEVELOPMENT**
  by James E. Dailey

  This paper examines the issues of 1) project development and the designer; and 2) constraints as technical drivers, both discussed in light of ocean-oriented examples such as OTEC and offshore platforms. Given the project development process as a sequence of phases, the challenge to the designer is to produce solutions that satisfy all the key constraints at each phase.

  The technology base for various proposed ocean enterprise projects generally exists in discrete form within sectors of the technical community. Further innovations and enhancements will likely ensue as these sectors interact with one another. The greatest challenge to designers will be to function effectively in organizational settings and decision-making processes where they are drawn into the less certain world of social and political constraints.

d) Working Group Reports and Suggestions

The purpose of the working groups was to allow those with specific expertise in a given subject to answer the prescribed questions and to develop their concepts and proposals in greater detail. The working groups also were designed to obtain several different points of view on important issues connected with the Ocean Enterprise concept, such as the type of infrastructure best suited to the ocean context and the best candidate projects for early demonstration of the concept.

Six working groups were appointed:

1. **Marine Mining of Heavy Minerals**
2. **Waste Disposal Opportunities**
3. **Ocean Energy and Mariculture**
4. **Air and Space Ocean Platforms**
5. **Organization and Structure**
6. **Implementation and Strategies.**

In addition to the more detailed exploration of particular areas, all six working groups were asked to prepare responses to the same series of questions in five categories. This resulted in a unified form of response from each working group. These categories were:

Over-all strategic goals and objectives

- What important national purpose(s) would be served by the ocean enterprise concept?
- How can the purposes of the ocean enterprise concept be expressed in a way that compares favorably with the almost spiritual feeling many of us have with respect to the oceans and the ocean environment?
- How can we develop a set of strategic goals and objectives that avoid having the ocean enterprise concept seen as simply one more ocean exploitation project?
- How can the vision, the promise, the broad purposes be best expressed?

Suggested initial project

- What project (OTEC, waste-related, minerals, military platform) would represent the most attractive initial project for the ocean enterprise to use? Why selected?
- What characteristics, factors (tests) should be used to guide the selection of the first project?
- What kinds of side, piggy-back, or multiple uses would be most appropriate in the initial project?

Hurdles to be overcome

- What are the principal hurdles (challenges, barriers, constraints) to be overcome with the "selected" first ocean enterprise project? Could be technical, legislative, regulatory, economic, socio-economic, or environmental or any combination.
- What will be required to overcome these various hurdles?
- How much time and money are likely to be needed? What are major milestones and critical activities associated with the project development?

Institutional mechanism (infrastructure)

- Which of the various mechanisms (wet Fannie Mae, etc.) seems most appropriate? Why?
- What should be the key attributes of the chosen mechanism?
- Would one mechanism be superior to another, given your preference for the first project?
- What viable alternatives could be considered to form the ocean enterprise concept?

Steps needed for implementation

- Given the preference that your group expressed in the four previous categories, what will be the key steps in implementing your ocean enterprise approach?
- Is federal legislation likely to be needed? Specify type, committees, key contacts. Is there a companion state legislation requirement that should be developed?

- What preliminary steps might be needed to enact such legislation?
- What part does industry play in the process? What types of partnership arrangements are required?

The highlights of the working group reports and suggestions were contained in a series of viewgraphs prepared by each group. The summaries below have been prepared using the information contained on those viewgraphs and in the oral presentations. Where appropriate, important points which emerged during the discussion following the reports are also included in the summary.

WORKING GROUP #1 -- MARINE MINING OF HEAVY MINERALS

Chairman: JACK FLIPSE, Texas A&M University

General - The main thrust of the minerals working group was a multifaceted and forward-looking program aimed at developing U.S. capability to mine certain critical metals from the U.S. EEZ, focusing in particular on platinum group metals. This program was justified primarily on the basis of reducing U.S. reliance on foreign sources for strategic metals (now as high as 99% in some cases) but it would also provide other significant benefits such as demonstrating new multiple use technologies for seabed operations and reducing the negative balance of payments.

Institutional Mechanisms - The working group felt that the designation of broadly based task forces was the way to initiate the ocean minerals aspect of the ocean enterprise program. The group recommended the creation of three or four such task forces, one aimed at new mining legislation, one at the regulatory framework, and one or two dealing with technology and environmental issues. They also felt that a quasi-governmental corporation would be needed as a way of reducing perceived risks to the point where the necessary venture capital could be obtained. However, the working group clearly felt that this corporation should evolve into a private corporation as soon as possible (i.e., when the initial government funding had been repaid).

Hurdles - The minerals working group highlighted three hurdles that need to be overcome. The first of these involves the need for new legislation. The group felt strongly that the oil/gas-oriented Outer Continental Shelf Lands Act is not the right regulatory vehicle for the mining of hard minerals in the EEZ. A new mining law is needed which establishes more appropriate bidding/leasing schemes and, importantly, permits the firm conducting exploration and discovery of a hard minerals deposit to go on and develop it.

The second hurdle involves the need for new technology. Support must be obtained for the development and testing of new, multiple purpose, seafloor mining machines (*moles*), under-ice mining systems, and systems appropriate for mining mineral-laden crusts. Finally, the working group felt that selecting the right site for the initial ocean enterprise-sponsored ocean mining project could also represent a significant hurdle. For the initial demonstration project to succeed, a site would have to meet a multitude of critieria--economic, technological, environmental, and political. Hence, a great deal of care will have to be taken with this aspect of the program.

Recommended Actions - The working group set out a nine-step plan of action to initiate the suggested minerals component of the ocean enterprise program:

Month	Action to be taken
1	Establish task groups
2	Raise $100K
6	Initiate task group efforts
9	Prepare quasi-government corporation (QGC)
12	Interim task group reports
	Introduce legislation
18	Formal task group reports
20	Incorporate QGC
24	Initiate corporate program

In conclusion, the working group clearly believes that substantial minerals development opportunities exist in the U.S. EEZ and that the Ocean Enterprise mechanism (with its risk reduction and government assistance potential) is an appropriate and necessary way to accelerate beneficial minerals development.

WORKING GROUP #2 -- WASTE DISPOSAL OPPORTUNITIES

Chairmen: R. LAWRENCE SWANSON, State University of New York and IVER W. DUEDALL, Florida Institute of Technology

General - The centerpiece of the recommendations of working group #2 was an at-sea waste processing facility to perform a number of waste-related functions, including the processing of pre-sorted municipal solid waste (MSW), sea-generated trash and sewage sludge. Research and development on the use of waste and ash by-products in ocean related applications would also be involved. The facility would be planned and operated by a non-profit ocean enterprise public utility and would serve several important national goals: 1) it would decrease the adverse impacts of the present waste disposal practices in the ocean, perhaps on land as well; 2) it would help solve some significant waste problems facing the U.S. (for example, the serious decline in available land-fill space in parts of the nation); 3) it could produce electricity and fresh water from the waste heat for market ashore; and 4) the waste ash and other recycled products (plastic lumber, etc.) could be used to construct a variety of structures for shoreline protection and offshore including offshore islands, fishing reefs, or harbor facilities, creating much needed markets for recycled materials and having considerable environmental benefits as well.

Institutional Mechanisms - As mentioned above, the working group proposed the notion of an ocean enterprise public utility as a way of demonstrating the feasibility of employing new or existing ocean platforms as waste processing facilities. These utilities would be nonprofit, i.e., any surplus in revenues over costs would go back into new or improved facilities and/or research and development. The working group visualized that such ocean enterprise utilities would be directed by a board made up of citizens of coastal communities, as well as county, state, federal, and private sector representatives. It was proposed that the original funding for such an enterprise would come from the federal government, perhaps in the form of loan guarantees, but that eventually, the operations would become self-supporting through income from tipping fees, payments from municipalities and taxes, and mariculture ventures.

Hurdles - This working group distinguished itself by listing more hurdles than any other group--more than a dozen. They grouped these into four basic categories: economic, public-political, environmental-technogical, and legal / regulatory / legislative. Obviously, there are very significant problems to be overcome if this vision of an ocean enterprise opportunity is to be realized. The use of the oceans for waste processing runs counter to the strongly protective feelings that many Americans have for the sea. A solid and credible showing would have to be made that the processing of wastes at sea could benefit human health and the environment. If this could be done, the very substantial hurdle would be overcome on whether one coastal region of the country would be willing to accept (and process) the waste from another region.

Finally, it appeared that there was strong sentiment in the group that a subset of the Ocean Enterprise concept, the Ocean Enterprise Public Utility, offered a real opportunity to demonstrate the potential benefits of an offshore waste processing facility provided that ways can be found to overcome the sizeable cultural and political constraints that currently surround this type of activity.

WORKING GROUP #3 -- OCEAN ENERGY AND MARICULTURE

Chairman: PATRICK TAKAHASHI, University of Hawaii

General - In their report entitled *Harvest for Humanity* members of this working group laid out an ambitious proposal for a multi-product ocean thermal energy conversion enterprise. The working group felt that such an approach would have broad and compelling appeal because of its association with many important national priorities. Proposed is a series of projects beginning with a fundamental demonstration of the commercial readiness of the OTEC technology (both electricity and co-products) and leading to a major multinational ocean complex. The goal of this approach is to implement a realistic ocean enterprise that would be economically viable, environmentally benign, produce needed food, and provide an alternative to fossil/nuclear fuel. Additionally, such a project would serve to strengthen U.S. national security and international relations by providing a strategic presence in key regions of the world.

The initial project suggested was twin 5-10 MW OTEC facilities in the Caribbean and the Pacific with the two sites complementing each other in terms of geopolitics, technology (both open and closed systems), and applications with extensive mariculture and agricultural by-products.

Institutional Mechanisms - The working group suggested parallel and similar approaches in the Caribbean and the Pacific. Basically, the program would be carried forward by federal interagency task forces (made up of the Departments of Energy, Defense, State, and Commerce). In the case of the Caribbean, the World Bank and other international funding agencies would be brought in to aid in developing an attractive economic package for private sector participation. For the Pacific, the interagency task force would negotiate multilateral international agreements to share costs and benefits among interested nations. The federal government would be asked to provide financial incentives (loan guarantees) to U.S. companies to participate.

Hurdles - The working group listed six hurdles. These involved funding, gaining industrial involvement, obtaining local community acceptance, resolution of geopolitical perceptions, obtaining congressional support, and solving minor technological problems. The working group believes that strategies exist for overcoming all of these hurdles.

Recommended Actions - A five-step action plan consisting of increasingly larger scale OTEC projects was developed by the working group. Included were the following: completion of a 165 KW advanced OTEC experiment in Hawaii ($20 million, completion 1992); a 1 MW prototype facility in the Virgin Islands or Hawaii ($20 million, 1996); two 5-10 MW OTEC systems in the Caribbean and Western Pacific ($50-100 million each, by 2000); a 500 MW ocean mineral platform combining OTEC and seabed ore processing; and a 1000 MW Pan American complex featuring multinational cooperation and a full range of co-products (up to $10 billion, by 2010).

WORKING GROUP #4 -- AIR AND SPACE OCEAN PLATFORMS

Chairmen: ATHELSTAN SPILHAUS and
JOHN CRAVEN, Univ. of Hawaii

General - The working group was enthusiastic in its recommendation of multi-purpose floating complexes as the most appropriate focus for the Ocean Enterprise concept. The members of the working group saw the development of a modular, flexible system of floating platforms serving both commercial and military purposes and hence, as a way of re-establishing U.S. leadership in the international arena. The working group presented the vision of complexes of such platforms serving as overseas *freeports* for commerce and trade, and as overseas *freedom ports* (floating, forward-area military bases) replacing the need for exorbitant payments to maintain bases on foreign soil.

The initial ocean enterprise project suggested by the working group would consist of smaller demonstration modules that could be used in a variety of applications such as floating industrial parks, ocean farms and protein processing facilities, illegal immigration and drug interdiction, military stations, etc.

Institutional Mechanisms - This program would be launched by a directive from the White House establishing a new national initiative centered on the floating platform concept and its potential. The working group suggested a three-way partnership involving the executive branch of the federal government (including Dept. of Defense), the Congress, and industry, with policy guidance provided by a special Presidentially-appointed national commission. The initial seed money (estimated at $74 million) for the construction of the first demonstration modules would come from Congress and venture capitalists, with later full-scale applications funded by the users. The working group used a figure of $5 billion to characterize the level of effort expected in ten years.

Hurdles - The group saw four important hurdles to be surmounted if the floating platform concept is to be realized. First, is the acceptance of the concept itself. Do we really feel that activities long conducted on land can be successfully transferred to a floating platform? Can a floating platform be made stable enough, safe enough, defensible enough to be useful? The second hurdle listed involved the question of building a constituency for such an initiative. Can a sufficiently large constituency be developed for such an undertaking? The third hurdle has to do with the establishment of the concept as a new national initiative. To be successful, the floating platform idea will have to compete (and win) against many other meritorious ideas in a time of serious budget constraints. How best can this be done? On the technical side, the working group felt that the demonstration of the workability of full-scale mated modules was a significant hurdle to be overcome.

Implementation Plan - The working group suggested the following approach for implementation of their concept:

- issue a Presidential directive establishing the new initiative;
- secure executive branch, congressional, and industry support;
- appointment of a national commission to oversea the program;
- secure funding for the demonstration project.

WORKING GROUP #5 -- ORGANIZATION AND STRUCTURE

Chairmen: LANSING FELKER, Dept. of Commerce and
FRED BETZ, National Science Foundation

General - This working group concentrated on designing an organizational infrastructure capable of implementing the Ocean Enterprise concept. In this effort, the group relied heavily on the papers on this subject prepared for the workshop. Taking account of the wide range of possible candidate projects and the kinds of functions to be performed by the organization, the group recommended a new kind of institution, a national Ocean Enterprise authority (a kind of *wet* port authority), as the means for accomplishing the purposes of the Ocean Enterprise concept. The new entity would be a federally chartered *mixed enterprise* government corporation governed initially by a board of directors selected from government (federal and state), industry, academia, and the financial community. The Authority would be authorized to create regional Ocean Enterprise authorities to encourage and support ocean enterprises more suited to a regional scale.

The overall strategy of the Ocean Enterprise program, as seen by this working group, is to provide the stable regulatory and investment climate necessary for the commercialization of new ocean enterprises in the U.S. EEZ. Specific goals of the program would be to demonstrate new ocean technology; to identify commercial opportunities; to strengthen U.S. competitiveness; and meet important national and regional needs. These goals would be achieved by lowering political, financial, and economic risks to acceptable levels and by producing regulatory predictability.

The group suggested a set of criteria for selection of the initial project:

- it should meet important national needs or concerns;

- it should be a valid demonstration project, i.e., results should be transferable or have applicability elsewhere;

- it should have the cooperation and support of the region in which it is to be demonstrated; and

- it should be seen as compatible with good stewardship of the ocean and its renewable resources and environment.

Institutional Mechanism - As mentioned above, the group recommended creation by federal enabling legislation of a national ocean enterprise authority. The authority would have the following functions: it would act as landlord and manager of specially designated *enterprise zones*; it would broker development agreements promoting compatible use of the EEZ; it would act as lead agency in federal regulatory activities; it would act as a venture partner providing seed money for demonstrations of commercial feasibility. It might also operate commonly needed facilities such as OTEC-related cold water systems.

Hurdles - The working group saw these hurdles:

- establishing a positive image of the Ocean Enterprise program, i.e., as a market and technology-driven program and not a *wet* pork barrel or an industrial bail-out effort;

- getting space and attention on the crowded legislative agenda;

- getting a legislative sponsor;

- getting the support of the administration;

- obtaining the necessary initial funding (seed appropriations for administrative and initial operating expenses during the demonstration phase).

Implementation Plan - This working group put forward a five-step plan:

1. Create an effective EEZ education/awareness program.

2. Hold several background congressional hearings to publicize the problems and opportunities of developing this new territory.

3. Draft enabling legislation (for the *authority*) and continue to broaden the constituency.

4. House/Senate hearings on the legislation, with the goal of enactment before the end of the second session (1990).

5. Financial incentives to be available in 1992 (authority to issue tax-exempt revenue bonds).

WORKING GROUP #6 -- IMPLEMENTATION AND STRATEGIES

Chairman: LAWRENCE MALLON, Attorney

General - This working group, believing that there is no major action-generating issue present, felt that what was most needed to launch the ocean enterprise program was the creation of a comprehensive ocean/space use policy. In addition, they recommended that a two-track approach be followed having both high profile and low profile components. They saw a high profile as being needed to build the national consensus necessary to obtain the large amount of resources needed for an actual ocean enterprise project and saw the low profile as necessary to success in removing the regulatory and other barriers. This group also felt that no single ocean project was likely to generate the political support needed to advance the Ocean Enterprise concept. They recommended, therefore, the creation of high technology demonstrations and other high profile activities, mentioning specifically the notion of ocean space life-building environments through the creation of new habitats and subsequent development of populations and communities by the use of waste materials in the construction of artificial reefs.

Institutional Mechanisms - This group favored building on an existing mechanism, the President's Office of Science and Technology Policy (OSTP) and that office's science advisor, by adding two additional activities: a federal research committee on ocean space and a coalition for ocean space policy development. The first group would be charged with creating and demonstrating technical capability (re: advanced ocean technology); the second group would seek to remove barriers, formulate necessary legislation, and encourage private sector investment. While the research committee would be composed of federal agencies, the coalition would include industry, academia, environmental groups as well as federal and state government representatives. Also, the group felt that the Authority created to administer the ocean enterprise program should have the authority to operate the facilities necessary to support demonstration or incubation functions.

Hurdles - By implication, this working group saw the lack of an action-generating issue as a major problem. The group also cited as potential stumbling blocks the diffusion of commitment (support seems more energetic for particular projects than for the concept itself) and the fact that most of the suggested ocean enterprise projects still represent immature issues. Finally, the threat of single-issue group attack on the whole ocean enterprise vision was mentioned as a potential problem.

Implementation Plan - While a detailed implementation plan was not presented, it was clear that the group felt that an aggressive effort was needed early in the life of this program to publicize the large potential benefits that will flow from the application of innovative technologies to the resources/space of the EEZ. They urged a high profile effort to create a vision of what the future can hold.

6. Recommendations

Near-term

The workshop identified the technical rationale of the Ocean Enterprise concept and identified several projects offering near-term economic and environmental benefits. These are: marine mining, waste disposal, and OTEC with mariculture. The workshop participants supported the idea that, because of our perceptions of risk and uncertainty, a quasi-government organization (incubated within a lead federal agency and sponsored initially by federal funds) would be needed if any of these projects are to be realized in the near future. The Ocean Enterprise concept would offer the national and international capital markets the choice to invest in private corporate ventures or in government sponsored long-term undertakings.

The lack of a U.S. national infrastructure has inhibited the development of ocean enterprises. To develop ocean enterprises, funding is needed for large-scale ocean projects outside of the nation's current operating budgets in order to keep from sacrificing other national political, social, and economic goals. These enterprises (e.g., large floating platforms, waste mini-utilities, etc.) should be funded out of capital accounts and then reimbursed on a fiscally sound basis when the private or public users benefit.

The National Science Foundation has shown interest in the Ocean Enterprise concept with its sponsorship of the workshop. Participants recommended that NSF continue to support the development of the Ocean Enterprise concept and initial feasibility engineering studies. This recommendation stemmed from NSF's federal leadership role in technology and enterprise initiatives with its implementation of the Engineering Research Centers (ERC) program, and particularly in the ocean when it initiated the ERC for Offshore Technology Research at Texas A&M University. It was appreciated, however, that the immediate development of the Ocean Enterprise concept needed in the near term to be implemented by a Congressional charter, with a federal agency serving as an incubator (for embryonic development), i.e., the Department of Commerce, an interagency commission, or a new federal agency.

As a first step, to initiate near-term goals, workshop participants recommended the formation of an Ocean Enterprise Coordinating Committee. Subsequent to the workshop, the committee has discussed and approved this report, and will continue to work towards implementing the recommendations of the workshop.

Long-term

In the long term, an Ocean Enterprise Consortium may be necessary. This consortium would be composed of academic, industrial, and private sector institutions, venture capitalists, and federal agencies. To be effective the Consortium will require a declaration of policy and purpose from the Administration, and enabling legislation from Congress. Support for Ocean Enterprise activities will require that the proposed projects are suitable development. Therefore, these projects must reflect the nature of the ocean as a public trust and as an unparalleled opportunity for national economic development and environmental management.

An Ocean Enterprise Consortium could have the following characteristics:

- It would derive its membership from public and private sectors but would operate as a corporation.
- It would derive its financial basis from government, participating industries, and private foundations.
- It would invest, own property, lease and sell, and earn a return from its investments.
- Upon reaching a level of success, it would be able to create its own endowment for future operation, independent of the need for continued public and private financial assistance.
- It would encourage participation from academic and professional organizations to review and validate its goals, objectives and projects.
- It would develop new technology itself for license and transfer to industry.
- It could be housed and incubated in a federal agency for a specified period of time while it begins its function of jump starting ocean enterprises and assisting industry in developing new ocean opportunities.
- As a quasi-governmental organization, it would:
  1) have the limitation of liability to that normally accepted by the federal government;
  2) have disallowance of intervener legal action (similar to the Trans-Alaska Pipeline).

A key benefit of the Consortium would be the creation of a broadened and improved economic base for the nation, with the additional benefit of value-added environmental enhancement activities.

Workshop participants felt that Ocean Enterprises need both a civilian and commercial identity. Thus, alignment is preferred with a lead federal agency to manage and control the early technical risk across scientific and engineering disciplines in order for ocean enterprises to maximize the benefits to all sectors.

Finally, such an ambitious plan can only be implemented with strong leadership. Therefore, a Presidential endorsement or commission is needed to expedite implementation of the Ocean Enterprise concept.

7. Acknowledgments

The principal investigators of the Ocean Enterprise Workshop were David A. Ross, Woods Hole Oceanographic Institution (WHOI) and James E. Dailey, Brown and Root, Inc. Michael A. Champ, prior to joining NSF, assisted in preparation and formation of the Ocean Enterprise concept proposal. These three would like to acknowledge the support and diligence of a number of organizations for making the workshop possible. Primary sponsorship was provided by the National Science Foundation with Norman Caplan as the NSF Program Director. Additional support came from WHOI, Brown and Root, Inc., the Center for Ocean Resources Technology at the University of Hawaii, and the National Oceanic and Atmospheric Administration's National Sea Grant College Program. We also wish to thank ENSR, Inc. which hosted receptions at the Texas workshop, and the Marine Technology Society which sponsored, with the Coastal States Organization, an Ocean Enterprise Workshop for the Coastal States at the Oceans '88 Conference.

The workshop can be deemed successful by the sheer energy of its participants, whose efforts are gratefully acknowledged, and special thanks are due the working group chairmen for deftly handling their charges. Behind the scenes and prior to the workshop a number of individuals were supportive and helpful in bringing the concept and the workshop into being. Appendix C represents a directory of individuals (including workshop participants) and the parts they played throughout the evolution of the Ocean Enterprise concept. Editing and production of this final report were done by Judith Fenwick of the Woods Hole Oceanographic Institution.

For further reading: Interest in the workshop before and after it occurred is documented by several articles which appeared in *Sea Technology* and *Insight* magazines; these articles appear in Appendix D.

8. Appendices

A. Workshop Participants

B. Workshop Agenda

C. Ocean Enterprise Concept: Directory of Individuals

D. Ocean Enterprise in the Public Media

Ocean Enterprise Workshop

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OCEAN ENTERPRISE WORKSHOP

February 20-24, 1989

Columbia Lakes Conference Center
West Columbia, Texas

Monday, February 20

Afternoon Arrival

5:30 - 6:30 pm	REGISTRATION
6:30 - 7:30	DINNER
7:30 -10:00	EVENING PRESENTATIONS SPECIAL OVERVIEWS

WELCOME AND INTRODUCTIONS:

- JAMES E. DAILEY, Brown & Root USA, Inc.
  DAVID A. ROSS, Woods Hole Oceanographic Institution
- LEONARD J. ROGERS, U.S. Department of Energy -- The U.S. Ocean Energy Technology Research Program
- CAPTAIN DONALD B. WELLS, U.S. Navy, NCEL -- An Overview of Ocean Platforms for Ocean Bases, A Navy Perspective

Tuesday, February 21

7:00 - 8:00 am	BREAKFAST
8:00 -12:00	MORNING PRESENTATIONS

THE OCEAN ENTERPRISE CONCEPT:

- DAVID A. ROSS, WHOI AND MICHAEL A. CHAMP, NSF

SENSE OF OPPORTUNITIES:

- J. ROBERT MOORE, University of Texas -- Marine Mining of Heavy Minerals
- PATRICK TAKAHASHI, University of Hawaii -- Ocean Thermal Energy Conversion
- JOHN CRAVEN, University of Hawaii -- NELH/HOST: A Precusor Model of an Ocean Enterprise
- KENNETH S. KAMLET, A.T. Kearney -- Offshore Garbage Processing in the North Atlantic.
- DANA LARSON, ENSR -- Garbage Disposal Off Ships in the Gulf of Mexico
- MEL N.A. PETERSON, NOAA -- Considerations for Subseabed Storage of Sewage Sludge Wastes Utilizing Deep Drilling Technologies

12:00 - 1:00	LUNCH
Afternoon	FREE
5:30 - 6:30 pm	RECEPTION
6:30 - 7:30	DINNER *KEYNOTE SPEAKER*: ATHELSTAN SPILHAUS

Tuesday, February 21 (continued)

7:30 - 10:00 **EVENING PRESENTATIONS**

CONSTRAINTS:

- **CLIFFORD McLAIN, McLain Consulting Services -- Concepts for Structuring Public-Private Ventures in the Ocean. What are the Structures, Functions, and Mechanisms for Developing Partnerships for Ocean Enterprises?**
- **DAVID S. SLADE, Coastal States Organization -- Concepts for Implementation Strategies (Legal/Regulatory)**
- **PETER JOHNSON, Office of Technology Assessment -- Environmental, Economic, Social and Political Constraints**
- **JAMES E. DAILEY, Brown and Root, Inc. -- Technical and Engineering Constraints**

Wednesday, February 22

7:00 - 8:00 am **BREAKFAST**

8:00 - 8:30 **CHARGE TO WORKING GROUPS:**

- **ROBERT KNECHT, Knecht, Cicin-Sain and Associates**
  TERENCE McGUINNESS, Brown & Root, Inc.

8:30 - 12:00 **WORKING GROUPS:**

- **MARINE MINING OF HEAVY MINERALS**
  Chairman: JACK FLIPSE, Texas A&M University
- **WASTE DISPOSAL OPPORTUNITIES**
  Chairman: R. LAWRENCE SWANSON, State University of New York
- **OCEAN ENERGY AND MARICULTURE**
  Chairman: PAT TAKAHASHI, Univ. of Hawaii
- **AIR AND SPACE OCEAN PLATFORMS**
  Co-Chairmen: ATHELSTAN SPILHAUS and JOHN CRAVEN, Univ. of Hawaii
- **IMPLEMENTATION AND STRATEGIES**
  Chairman: LARRY MALLON, Proctor in Admiralty
- **ORGANIZATION AND STRUCTURE**
  Chairman: LANSING FELKER, Dept. of Commerce

12:00 - 1:00 **LUNCH: CHUCK BERNARD, Columbia Bay Co. -- The Ocean as a Multi-Resource Platform for Ocean Enterprises**

1:00 - 5:00 pm **CONTINUATION OF WORKING GROUPS**

5:30 - 6:30 **RECEPTION**

6:30 - 7:30 **DINNER** ***KEYNOTE SPEAKER*****: GARY MONTGOMERY, Sr. Vice President, Director of Engineering Worldwide, Brown & Root, USA, Inc.**

7:30 - 10:00 **PREPARATION OF WORKING GROUP REPORTS**

Thursday, February 23

7:00 - 8:00 am	**BREAKFAST:** ***KEYNOTE SPEAKER*: JOSEPH VADUS, NSF/NOAA -- Ocean Technology in the U.S.: Recent Advances, and Future Needs**
8:00 - 9:00	**PREPARATION OF WORKING GROUP PRESENTATIONS**
9:00 -10:30	**PRESENTATIONS OF ENCAPSULATED WORKING GROUP REPORTS**
10:30 -11:00	**INTEGRATION OF WORKING GROUP PERSPECTIVES**
11:00 -12:00	**SUMMARY DISCUSSIONS AND PLAN OF ACTION**
12:00 - 1:00 pm	**LUNCH**
1:00 - 5:00	**PREPARATION OF "DRAFT" WORKSHOP FINAL REPORT**

5:30 - 6:30	**RECEPTION**
6:30 - 7:30	**DINNER**
7:30 - 10:00	**NOSC* WORKING GROUP MEETING FOR OCEAN PLATFORMS**

* This NOSC (Naval Ocean Systems Center) follow-on meeting has been scheduled in conjunction with the Ocean Enterprises Workshop because of overlap of participants and potential cooperative initiatives.

7:30 - 8:15	***Opening Remarks:*** **THOMAS RONA, Deputy Presidential Science Advisor**
8:15 - 9:45	**PLATFORM TECHNOLOGY STATUS**

Friday, February 24

7:00 - 8:00 am	**BREAKFAST**
8:00 - 9:30	**PLATFORM CONCEPTUAL DESIGNS, PAYLOADS, ETC.** **GEORGE WILKINS, Univ. of Hawaii AND TEAM**
9:30 - 10:30	**MARKETING AND FINANCE PLAN** **CHUCK BERNARD, Columbia Bay Co. AND TEAM**
10:30 - 11:30	**DISCUSSION**
11:30	**DEPARTURE**

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Ocean Enterprise articles in the media:

Sea Technology Magazine

January 1989	*The Ocean Enterprise Concept: A National Strategy for Resource Development*
May 1989	*Giant Platforms Key to Economic Use of Oceans*
June 1989	*Ocean Enterprise: New Opportunities?* *(editorial)*

Insight Magazine

July 3, 1989	*Push on the Ocean Frontier Begins*

SEA TECHNOLOGY

INCLUDING UNDERSEA TECHNOLOGY

The Industry's Recognized Authority For Design, Engineering and Application Of Equipment And Services In The Marine Environment

JANUARY 1989, VOLUME 30, NO. 1

Review & Forecast:

The Ocean Enterprise Concept: A National Strategy for Resource Development

By Dr. David A. Ross
Chairman, Geology & Geophysics Department
Woods Hole Oceanographic Institution

Clifford E. McLain
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and

Dr. James E. Dailey
Engineering Manager
Brown & Root U.S.A. Inc.

Today less than 1% of the annual resources consumed in the United States comes from the sea. Yet the March 1983 Exclusive Economic Zone (EEZ) Proclamation by President Ronald Reagan gave the U.S. exclusive jurisdiction over the resources of the ocean out to 200 nautical miles. To date, the potentially great rewards from the development of marine resources by the private sector have been greatly inhibited by the peculiar nature of the risks involved in such candidate projects.

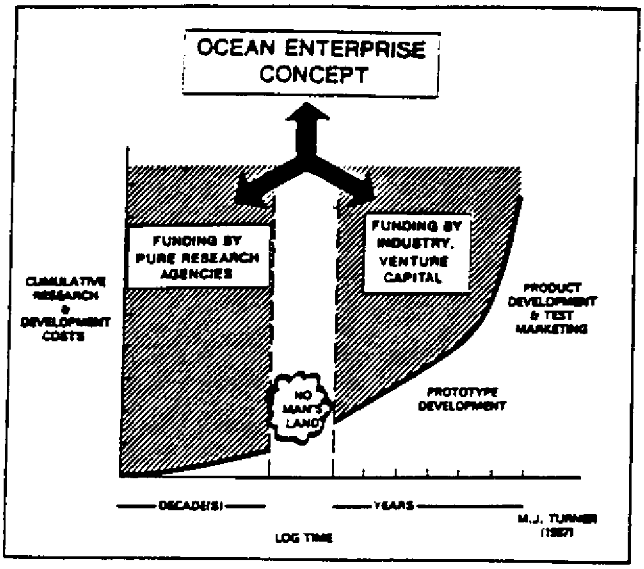
In the spirit of this annual "Review and Forecast," we will concentrate on looking ahead, rather than to the past, in presenting a new strategy for launching a new era of awareness, practical development, and utilization of those resources—the Ocean Enterprise Concept. It is a set of ideas whose time has surely come. Born in May 1987, the Ocean Enterprise Concept has since been examined and molded and sharpened, along with gaining co-sponsorship by the National Science Foundation and the National Oceanic & Atmospheric Administration's Sea Grant Program.

This rapidly maturing concept will be introduced at the Ocean Enterprise Workshop on February 20-24, 1989, at the Columbia Lakes Conference Center in West Columbia, Texas.

Several resource use areas and ideas show early promise: marine mining of coastal heavy minerals, ocean energy conversion, offshore waste treatment plants, mariculture (fish and shellfish), and installation of large, stable platforms at sea for aviation and space operations.

The construction of large (1-2 square kilometer) stable ocean platforms could not only offer this nation new commercial opportunities (coastal airports, etc.) but the technology for mobile overseas military bases to meet the future need of decreased reliance on overseas military bases. The U.S. has a worldwide military basing structure that will very likely dwindle significantly in the next ten years. Air bases in Panama, Spain, and the Philippines are becoming extremely expensive and less useful and available.

The Soviets have approached the problem differently by employing mostly movable or removable assets



(floating piers, tenders and repair ships, floating drydocks). Ocean bases could provide key aspects to hemispheric defense systems including border and internal defense. They can also serve as centers to suppress sabotage, terrorism, narcotics trafficking, and arms shipment; major weather stations for enhanced weather prediction and global climate studies; trans-ocean air traffic routing centers (with considerable fuel savings); alternative energy generating plants, both wave and thermal; and can serve as platforms to provide indirect U.S. military assistance to Third World countries (such as training, intelligence, communications, transportation, construction, medical supplies, physicians or disaster relief, and logistics).

It is only through a cooperative "pulling together" of government, academia, and industry that significant new areas of operational economic interest can be developed or current ones strongly bolstered. The original Stratton Report (*Our Nation and the Sea*, 1969) recognized the great basic potential of the oceans and provided a broad discussion of the many appropriate areas for economic development. An assessment at this time finds that: **Not one new major economic area has been developed in the ocean sector** in the past 20 years. The principal economic payoff areas remain those of shipping (merchant marine), fisheries, and offshore oil and gas. Heavy R&D investment has been made in such areas as mineral deposits (manganese nodules) and ocean thermal energy conversion (OTEC), but no practical business of net economic value has developed.

The Private Sector Environment

Broad technological and economic constraints have been suggested as the primary factors in preventing many of the Stratton Report goals from being achieved. Unfortunately, the development of these ocean resources has been constrained by the following factors: the lack of public/private venture infrastructure and legal/regulatory implementation strategies; environmental, economic, social, and political issues; and technical and engineering problems that arise from the "marinization" of land-based engineering concepts, technologies, structures, and facilities for use in ocean enterprises. However, the key limiting factors are really leadership, infrastructure, and venture capital (because the scales of risk are perceived to be large).

The infrastructure needs can be developed and supported by a federal inhouse incubator, an ocean-going "Fannie Mae," and a quasi-government non-profit corporation (chartered through federal enabling legislation). This quasi-government corporation is needed to provide the limitation of liability to that normally accepted by the federal government and minimize the risk of intervenor legal action (similar to the trans-Alaskan pipeline's Alyeska Corp. or Comsat Corp.). Several national and international workshops have stated that the key technologies exist but have not been utilized in such a manner on a commercial scale.

It is in the interest of this nation to create organizational infrastructures that bring together the resources of government, industry, and the academic sectors. These would undertake large scale resource and technology development projects, where scales of time, risk, and/or magnitudes are too great for one sector to go alone to bridge the "no man's land" gap between research and development described in the accompanying illustration.

What Is an Ocean Enterprise?

Ideally an ocean enterprise should generate economic benefits from the development of ocean resources and technologies, protect and conserve ocean environments, provide the benefits of a public service and reduce public risk, and support the nation's interests overseas.

It is also timely and desirable to foster new civilian and military partnerships to enhance this nation's competitiveness and economic growth. With current and future budget limitations (the trade deficit and the increasing national debt), it is also desirable to stimulate military/civilian synergy because projects of this scale (such as large ocean platforms) have costs that require multiple use benefits to society. Also these large projects must maximize the commercial spinoffs to distribute the construction and operation costs across a wider array of users.

Different kinds of ocean platforms (from ocean airports, mining-processing facilities, to recreational facilities such as floating hotels, resorts, etc.) will spin off entirely new commercial industries, providing significant public and private economic benefits.

Large scale ocean enterprises have to develop from a succession of smaller scale projects that perhaps develop for application in the shallower, near coastal waters, providing local public service benefits. These projects should have a dual use being initially developed with public-private sector funds for civilian use but engineered and evaluated with a military perspective and application in mind. Examples of these could be a moored floating ocean platform designed and engineered for a NIMBY (Not In My Back Yard) public service project such as a coastal airport or waste treatment facility (e.g., high temperature garbage processing and treatment plant). In the U.S., not a single major airport has been built since the early 1960s. By the year 2000, 80% of the U.S. population will live within 60 miles of the coast, and public air transportation, which has air space limitations today, will not be able to meet the demands for services in large U.S. coastal cities. The construction of stable ocean platforms for airports could be initially supported by public and private funding with repayment from user fees and capitalization of infrastructure.

Due to the increasing national debt and growing trade deficit, the policy of the new administration will be to reduce federal support for many programs for which such support would seem to be reasonable and appropriate from state and local governments and/or private sectors. The real question is: with the understanding that major increases in developmental funding from the federal government or from foundations are not to be expected, is there any basis for a major increase from the private sector?

What constitutes an attractive R&D investment opportunity in the private sector? A few critical elements which must be present to validate a "first class" investment risk are suggested below:

- A well-prepared development strategy and business plan
- Definable markets and specific paths to those markets
- A basis for prediction of "comfortable" profit margins
- Technological uncertainties well-defined and directly addressed by a planned R&D program
- Business plan adequately structured within the international and national socio-political and economic environment
- A direct identified path for return on investment (ROI).

'Triple Alliance' R&D

One mechanism for R&D funding may be the use of private sector partnerships. A triple alliance is a partnership of government, academia, and private capital sectors to establish long term and vigorous support for applied R&D in the oceans area. Support from the private sector is provided through an R&D partnership, thereby providing a direct path for technology transfer and market application directed by the general partners through agreements with "user" industries. The latter pay royalties to the partnership in return for manufacturing and marketing rights received. The royalties are used to provide return on investment to the partnership investors.

Government and non-profit foundation support is separately solicited by each project but has the added attractiveness for projects and grants by providing "leverage" based on the concurrent programs supported by the contracts with ocean enterprise corporation(s). In this way, a formal tie is established between the successful market application of project developments and the future financial support of the initiative itself. Industrial (private sector) participants are protected by limited investments and benefit both through tax credits and by distributions or individual "user" contracts. The general partners, through the partnership, provide sufficient isolation that antitrust requirements are met. Finally, joint industry and government support of the center helps validate the products which are applied and sold through the private sector channels. This validation can be critical in reducing perceived risk and encouraging private sector investment. This mechanism can provide a helpful "umbrella" for encouraging a significant increase in private sector investment.

This mechanism also emphasizes the role of the private sector. Rather than relying on a single major industrial developer, a team of industrial and investor partners, perhaps through a joint venture corporation, would be established to develop a particular area of great potential economic benefit. Such an area would be characterized by some of the following traits:

- Development path featuring a graded investment startup
- Backup by favorable policy and

socio-political environment
- Meets environmental protection issues
- Takes short and long range economic and market conditions into account
- Does not require development of basic scientific understanding, i.e., is a technology development
- Scaling models exist for transition from laboratory to industrial practice
- Spinoff developments are inherent in the approach.

These fundamental traits allow the development of a business plan which permits the highest technological risk problems to be solved with a modest initial investment. Operations and market testing would be conducted under a prototype operation which again does not require a full scale manufacturing investment. It is also important to identify multiple potential paths for market development so that more than one option for investment payback exists.

In conjunction with those new incentives and special projects which could be directly encouraged by federal government actions, a movement to organize those states having direct or strong indirect interests in ocean development as well as currently established ocean business would be helpful in establishing a strong constituency for the oceans. The development of such a coalition in formal recognition of the increasing importance of the oceans as a major factor in state and local economic structure would provide a strong and effective boost to the Ocean Enterprise Concept.

Implementation Strategies

The overall program for the Ocean Enterprise Concept should, of course, embody much more than such major new thrusts as are discussed in the proceeding sections. Implementation of the concept ought to establish a total environment for the enhancement of ocean related activities and interests of all types. The principal measure of the long range effectiveness of the program will be the initiation of major new development areas that can sustain growth. Without the implementation of the total Ocean Enterprise Concept, the "new approach" initiatives as are discussed in the previous section would have little chance of successfully developing.

The foregoing arguments suggest that the basic operating approach for the program must be that of a team effort, with coordination by key federal agencies backed by specific White House approval, supporting major activities in five areas:
- Policy development
- Awareness enhancement
- Constituency establishment
- Research and development direction and augmentation
- Development of ocean enterprise projects.

Participation by the White House (particularly the Office of Science & Technology Policy) and other departments and agencies would be most important. Especially beneficial would be a presidential memorandum or statement ushering in the program and designating federal agency responsibilities. /mt/

Giant Platforms Key to Economic Use of Oceans

Rapidly Gaining Momentum, the Ocean Enterprise Concept Kicked Off a National Strategy for Ocean Resource Development at Recent Workshop

West Columbia, Texas—Co-chaired by Drs. David A. Ross (Woods Hole Oceanographic Institution) and James E. Dailey (Brown & Root U.S.A.), the Ocean Enterprise Workshop held in late February at the Columbia Lakes Conference Center here was a significant success. It brought together many of the interested parties—some 70 key individuals in all—involved in developing, protecting, and conserving ocean and coastal resources.

The workshop—which was supported by the National Science Foundation, Brown & Root, Woods Hole, NOAA's National Sea Grant College Program, U.S. Naval Oceans Systems Center, Coastal States Organization, and the Marine Technology Society—focused discussions on appropriate, specific areas for economic development and appropriate specific actions for encouraging those developments to take place.

However, it was clear by the conclusion of the workshop that significant near-term development of infrastructure mechanisms and actions in these areas will be needed before steps can be taken to put specific Ocean Enterprise developments in motion. Many of the workshop participants voiced an interest in taking part in these near-term activities, which will be more explicitly detailed in the workshop report to the National Science Foundation and which will lend structure to the projects and action areas discussed at the workshop.

Coordinating Group Named

In mid-April, Ross announced that a coordinating group had been formally chosen to develop plans for the next steps. Members are Earl Conrad, Rockland, Maine; Ronald J. Hays, Pacific International Center for High Technology Research, Honolulu; Robert W. Knecht, Knecht, Cicin-Sain & Associates, Santa Barbara, California; Dana W. Larson, ENSR Co.; and co-chairman Ross.

Several key background papers were presented at the workshop following opening remarks on objectives and history by Ross and by Michael A. Champ, NSF.

Under the heading of "opportunities," papers included "Marine Mining of Heavy Minerals" by J. Robert Moore, University of Texas; "The U.S. Ocean Energy Technology Research Program" by Leonard J. Rogers, Department of Energy; "Ocean Thermal Energy Conversion" by Patrick Takahashi, University of Hawaii; "NEHL/HOST—A Precursor Model of an Ocean Enterprise" by John Craven, University of Hawaii; "Offshore Garbage Processing in the North Atlantic" by Kenneth S. Kamlet, A. T. Kearney; "Garbage Disposal off Ships in the Gulf of Mexico" by Dana Larson, ENSR Co.; "An Overview of Ocean Platforms for Ocean Bases—A Navy Perspective" by Capt. Donald B. Wells, Naval Civil Engineering Laboratory; and "Considerations for Subseabed Storage of Sewage Sludge Utilizing Deep Drilling Technologies" by Melvin N. A. Peterson, NOAA chief scientist.

Tackling the subject of "constraints" were Clifford E. McLain, McLain Consulting Services, "Concepts for Structuring Public-Private Ventures in the Ocean"; David S. Slade, Coastal States Organization, "Concepts for Implementing (Legal/Regulatory) Strategies"; Peter Johnson, Congressional Office of Technology Assessment, "Environment, Economic, Social, and Political Constraints"; and co-chairman Dailey, "Technical and Engineering Constraints."

Following presentation of the background papers and accompanying discussions, key working groups were organized and chaired (see below) to review each of the subject areas and develop observations and recommendations. Those results were to be presented to the entire workshop attendance at a concluding plenary session. Working groups and co-chairmen included:

- *Marine Mining of Heavy Minerals*
  Jack Flipse, Texas A&M University
- *Waste Disposal Opportunities*
  R. Lawrence Swanson, State University of New York
  Iver W. Duedall, Florida Institute of Technology
  Dana Larson, ENSR Co.
- *Ocean Energy and Mariculture*
  Patrick Takahashi, University of Hawaii
  Greg McMurray, National Coastal Research Institute
- *Air and Space Ocean Platforms*
  Athelstan Spilhaus
  John Craven, University of Hawaii
- *Implementation and Strategy*
  Robert Knecht, Knecht, Cicin-Sain & Associates
  Lawrence G. Mallon, attorney
- *Organization and Structure*
  Lansing Felker, Department of Commerce
  Fred Betz, National Science Foundation.

Promise of Multiple Benefits

Workshop attendees suggested several specific areas in which ocean enterprise might develop. Each of these areas promised multiple benefits to the national and regional economy and to important national and regional issues. These included:

- Improved, highly efficient methods for waste treatment, including the stable combination of highly oxidized solid residues into long lasting concrete or ceramic products for use in ocean projects, such as coastal erosion protection and fisheries enhancement through "artificial reefs."
- Development of transportable "mini-utilities" to generate electrical power at the wellhead of offshore gas wells to take advantage of the clean power generation capabilities of natural gas and its low price.
- Development of highly stable floating platforms for commercial and military applications. Ultra stability was suggested, both to permit such acceleration-sensitive applications as land aircraft operations and to permit assembly of large platform units at sea under normal, rather than tightly restricted, sea state conditions. Ultra stable applications included recreational and resort facilities, commercial production or processing operations, extended port and harbor facilities, airports and extended base operations for civilian and military uses, and weather and surveillance stations.
- Application of closed-cycle OTEC to full scale power production and the inclusion of associated economic enterprises with the availability of high nutrient cold water from the ocean depths. These associated enterprises contribute a significant part of the overall economic benefit of an OTEC installation and include: mariculture (fish, crustaceans, shellfish), intensive agriculture (temperate plants in a tropical environment through available cooling effects of the residual cold water), air conditioning for associated living quarters, and fresh water for a variety of applications.
- Placer mining opportunities for heavy minerals, particularly the precious metals. The placers in U.S. territorial seas and EEZ areas constitute a particular near-term opportunity already being pursued in a profitable manner in Alaskan waters.

'Risk and Return'

Constraints and requirements for private sector participation were also vigorously discussed. It seems clear that if we are to expect any near-term new developments, the proposed projects will have to be put in terms of risk and return that are comparable with land-based economic endeavors.

Several ocean related enterprise areas appear to offer these investment characteristics within the near term.

Projects of three general development time characteristics were noted: Near term—2 to 5 years to profitability, medium term—5 to 7 years (characteristic of technology development applications), and long term—beyond 7 years (requiring the development of both new technology and significant new policy and regulatory mechanisms).

A report is currently in preparation in summarizing the workshop and its conclusions. The report should provide a very exciting new picture of what can be done and specific approaches for accomplishment. /st/

David M. Graham

Ocean Enterprise: New Opportunities?

Reconditioned offshore oil production rigs serving as incineration platforms to process tons of city-generated waste? Floating "islands" producing cheap power and drinking water? Platform-based ocean thermal energy systems producing abundant seafood and vegetables as byproducts?

These and other ideas are the now promising fruits of a recent ongoing entity called the Ocean Enterprise Concept. Within this ambitious but not-so-futuristic-as-you-think concept could be the first real seeds of expanded opportunity for the ocean business community.

Based in no small part on some of the visionary ideas promulgated by Dr. Athelstan Spilhaus in the 1960s, the concept of taking the first steps toward effective development of the nation's EEZ via large floating platforms is a viable one. The ideas being fleshed out today require no great leaps in technology, and their realization could solve some current problems that are overwhelming our crowded land areas.

The Ocean Enterprise Concept is simplistic on its surface. Initially it involves using existing oil platforms that are already in place or clustering three or more semisubmersible-type platforms tied together to form a much larger, very stable "super platform."

After that, the applications abound.

Waste management seems to be the easiest and quickest application idea to develop. Planning is afoot now to employ one or more of about a dozen available platforms in the Gulf of Mexico that have passed their prime. For example, one of these marginally economic platforms facing very expensive dismantling could act as a way station—equipped with a high temperature incinerator—for incoming ships discharging plastics and other wastes. In the past some of those wastes ended up on the beaches; under new federal and international regulations, those wastes now have to be off-loaded in port, costing shippers extra time and money and adding to the growing problem of waste disposal on land.

Along the same line, very conservative estimates put the cost of New York City's garbage disposal—in someone else's backyard—at better than $600 a ton. However, transportation and incineration/processing cost estimates for handling that same waste on an incinerator-equipped gas-producing platform at sea drop to just $90 a ton.

Several of these Ocean Enterprise platforms off our three coastlines could put a sizeable dent in today's waste disposal dilemma. . .and would ameliorate the accompanying problems of scarcer landfills and the widening threat of polluted groundwater.

Utility company managers have expressed keen interest in another scenario: development of garbage-fueled mini-power plants offshore that could be located closer to electric utility customers without creating environmental pollution problems inherent with larger onshore power stations. A valuable byproduct—especially for water-hungry areas like California—could be distilled fresh water.

Military applications of the giant platform concept seem to be capturing the imaginations of Pentagon planners as well. Political uncertainties have always plagued the security and the very futures of most overseas bases. But floating military bases, a mile square or more and composed of several large semisubmersibles, could house Air Force facilities complete with runways and flight lines, for example, as well as complete ship repair and drydock facilities and/or covert submarine repair and replenishment bases. Floating at roughly 6 knots on a large ocean gyre, the base would present a harder-to-hit moving target.

The possibilities appear to be endless, according to Ocean Enterprise planners. Prospects for coexisting commercial enterprises are equally numerous. The ideas now being generated on an expanding scale deserve the attention of the ocean business community. The seeds are being planted and nurtured now. The time for effective development of our ocean resources could be ripening. /st/

Push on the Ocean Frontier Begins

SUMMARY: Although the U.S. border was extended to 200 nautical miles offshore in 1983, the vast new territory has remained an unused resource. But some scientists have joined to promote exploitation of the seas. Impressive projects by Japan and Australia, including floating cities and artificial islands, are inspiring ventures elsewhere.

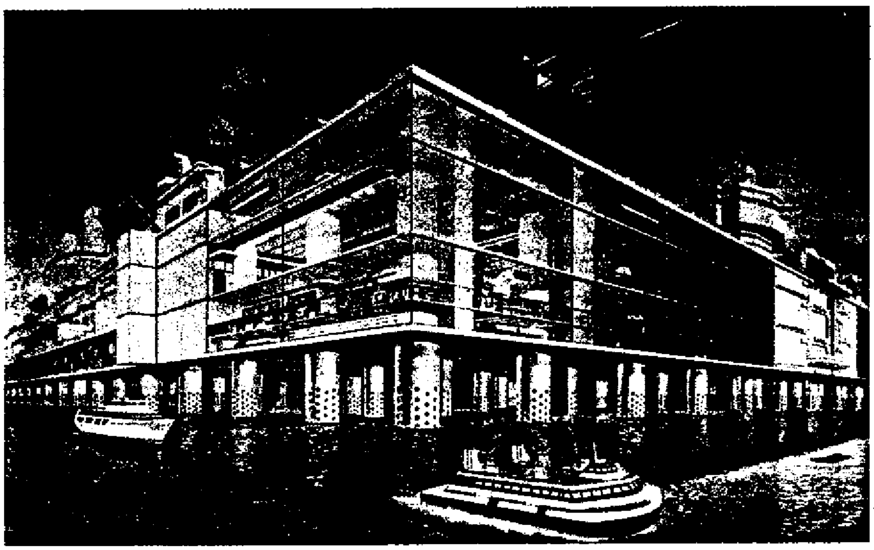
Six years after Ronald Reagan signed into law a bill known as the U.S. Exclusive Economic Zone Proclamation of 1983, which expanded the nation's territory to 200 nautical miles offshore along the entire U.S. coast, the nation has yet to take advantage of this incredible gain in resources.

Despite the addition of more than 2 billion acres of land to the country's domain, just about doubling its total size, there has been no significant exploitation of this frontier. Even today, only 1 percent of the natural resources that Americans consume annually come from the sea, according to the National Science Foundation. Consequently, a group of oceanographers from the public and private sectors have recently joined to promote an interdisciplinary consortium under the umbrella title of the Ocean Enterprise Concept.

The thrust of the project, as proposed at the first International Symposium on Coastal Ocean Space Utilization, held in New York in May, is to establish a "central, quasi-governmental organization, a sort of 'ocean-going Fannie Mae' that would receive its initial funding from Congress and would act to initiate, coordinate and form a partnership of interests with the objective of promoting new enterprise projects of significant value to the nation."

What the nation needs, the authors add, "is a single organization that can act to incubate these major new projects through their initial high-risk period and to bridge the gap between the basic technology and the acceptance of the risk of establishing a derivative business enterprise by the private sector."

The scientists propose to accomplish this by bringing together many disparate ocean interests, ranging from mining and energy production companies to the Defense Department. Additionally, their group "will serve to allay private sector financial reticence by making a financial commitment to the proposed projects. Most pioneering enterprises with a reasonable technical basis and a potentially rewarding economic prospect will attract private sector interest if it is clear that a single competent entity is willing to put in the first dollar."



NIPPON TELEPHONE & TELEGRAPH

Japan's planned Ocean Communications City would support 1 million residents.

So far, they say, the "potentially great rewards" from ocean development have been "greatly inhibited by the scale of the risks of such projects." In their opinion, the activities with the greatest promise include marine mining of heavy minerals, ocean energy conversion, offshore waste treatment plants and the construction of giant stable ocean platforms as large as 1 to 2 square miles. Such artificial islands could serve in many capacities: as bases for airports or rocket launch sites, military operations, weather stations, power generation plants, garbage incinerators and disposal sites, or even recreation centers or resorts.

Employing this model of government support of private sector sea projects, Japan has so far made the greatest strides and already has several major offshore projects well under way. Among them is the construction of an artificial island to accommodate the Kansai International Airport. Located three miles offshore in Osaka Bay, the structure, situated on a soft seabed, will stand in 60 feet of water and cover nearly 3,000 acres of sea. "This is the world's first artificial offshore island of its kind," says Susumu Maeda, managing director and vice president of Kansai International Airport Co. Construction of the island began in 1987 and is expected to be completed in March 1993.

Among the project's unique features, says Maeda, is that "both the island and the international airport are to be built and will be run by a private corporation created through a special government act." It is also "the forerunner of several other similar artificial islands being planned across the nation."

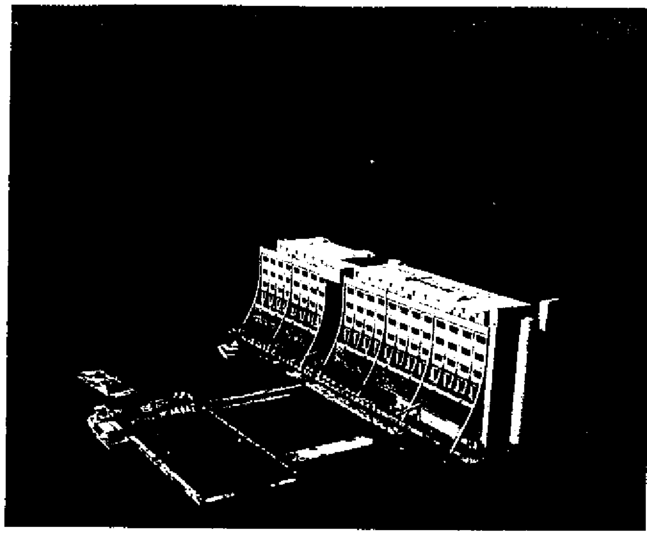
In various phases of planning and construction are more than 20 offshore Japanese projects, ranging from small manmade islands on which sit power stations and waste disposal sites to extensive floating islands to serve as bases for recreation and transportation, and even an entire floating city.

With four levels, each measuring 9 square miles, the so-called Ocean Communications City would be able to support 1 million permanent residents, who could enjoy such facilities as an international airport, a sports center and two baseball parks as well as hotels, restaurants, a banking and business district and a marine scientific research center. With an estimated price tag of $200 billion, this project, which is still in the planning stage, is being referred to as the greatest marine engineering and architectural feat since the construction of Venice.

"In order to understand why the Japanese have been so aggressive in developing the ocean as a resource, you have to remember that their land is very precious," says Michael A. Champ, program director at the National Science Foundation. "Only 30 percent of it is useful for agriculture. They've learned that good land must be used wisely.

"Another factor is cost. To build a build-

RICHARD KOZAK / INSIGHT



CAROLYN JOHNS / WILDLIGHT

HAWAII OCEAN SCIENCE AND TECHNOLOGY PARK

At Hawaii park (left, bottom) flowers are grown with seawater; an inspector at Maryland's Hart-Miller project; hotel floats over Great Barrier Reef.

ing in Tokyo costs roughly $55,000 per square meter, while building that same structure offshore might cost only $35 per square meter. They've also learned to see the ocean as a valuable resource, something to be worked with and utilized carefully and thoughtfully."

Although Japan today demonstrates the most elaborate visions and has pushed farthest out to sea, it is not alone on the ocean frontier. In Australia, floating above the Great Barrier Reef, the world's largest system of corals, is the John Brewer Reef Floating Hotel, a seven-story structure containing more than 200 rooms, a nightclub and shops. Completed last year, the resort is functioning successfully, attracting many of the thousands of tourists, naturalists and scientists who visit the world's largest marine park annually.

Since the northern Australian coast is subject to cyclones that can whip up gusts up to 120 mph, the hotel has been designed to withstand the wind and waves of such storms and already has proved itself seaworthy through several major storms. Measuring 300 feet long and 90 feet wide, the platform island is anchored to the reef in such a way as to rotate like a weather vane in the event of stiff storm winds.

"Many people were concerned about the ecological impacts of the platform," says John Kermond, director of the marine division of the National Association of State Universities and Land Grant Colleges. "The designers had to satisfy the park authorities that there would be no physical damage to or long-term ecological effects on the reef itself. All safety precautions were taken. Effluents from the sewage system have to be treated extensively so as not to affect the reef's waters. There are literally backup systems for backup systems for backup systems."

So impressed have been urban planners and ocean engineers with the success of the Japanese and Australian projects that many other nations, including the Netherlands, Israel, Brazil, South Korea and the Soviet Union, have begun to explore various offshore expansion projects, if only in theory, to evaluate their strategic advantages and potential economic returns. In several major port cities in the United States, including New York, Los Angeles and Seattle, city planners are considering the merits of offshore expansion.

In fact, at least two U.S. cities already have taken action. On the outskirts of Baltimore's harbor, on the edge of the Chesapeake Bay, is an extensive reclamation project known as the Hart-Miller Islands Program. As part of a harborwide dredging scheme aimed at deepening the port's main channels by 8 feet, which is necessary to give access to large cargo vessels, two small islands were joined together and developed into a 1,140-acre wildlife and recreational facility for public use. Although the project has cost the state of Maryland more than $60 million, estimates suggest that the economic benefits created by the deep-channel port will exceed $150 million annually in increased import and export business.

On a peninsula known as Keahole Point along the Kohala Coast on the island of Hawaii, scientists working at the Natural Energy Laboratory of Hawaii are making use of an abundant, though neglected, ocean resource: deep water. Rich in nutrients, free of pollution and very cold, water pumped from 2,200 feet below sea level is extraordinarily good for growing a wide range of flora and fauna, from strawberries to lobsters. This discovery was the by-product of other research into alternative methods of power production. In 1974, the state established the laboratory to conduct experiments in ocean thermal energy conversion, which takes advantage of the temperature difference between warm surface and deep cold water to generate electricity. The observation that the clean cold water had other uses was somewhat inadvertent.

Cold-water farming techniques have proved so successful, however, that the state has invested $15 million in a 547-acre facility, called the Hawaii Ocean Science and Technology Park, which it expects will attract much interest from business. Access to the 48-degree, nutrient-rich and pathogen-free water, state planners have found, is in itself a strong draw for many companies engaged in experimental harvesting techniques in such fields as aquaculture, agriculture, energy production and even pharmacology.

"Thinking of the ocean as a valuable pool of resources is something that Japan has been doing for a long time but something the U.S. has barely done at all," says Champ. "Americans tend to forget that the ocean is an incredible frontier, the equivalent of the West two centuries ago. And yet, as a nation, we rarely think about what lies just beyond our shores. The U.S. has spent billions of dollars exploring outer space but virtually forgotten about the space right along its own edges. And in a world of expanding population and limited land, we shouldn't ignore one of the sea's greatest assets, its vast and nearly untouched space."

— Richard Lipkin

9. Full texts of invited papers

- THE OCEAN ENTERPRISE CONCEPT
  by David A. Ross, Michael A. Champ, James E. Dailey, and Clifford E. McLain
- MARINE HARD MINERALS MINING: PLACERS AND PROFITS
  by J. Robert Moore
- OCEAN THERMAL ENERGY CONVERSION: A MULTI-PRODUCT ENTERPRISE
  by Patrick Takahashi, Luis Vega, Elizabeth Udui and Leonard Rogers
- KE-AHOLE POINT AS A PRECURSOR MODEL OF GOVERNMENT-INDUSTRY-ACADEMIC OCEAN ENTERPRISE
  by John P. Craven
- OFFSHORE GARBAGE PROCESSING IN THE NORTH ATLANTIC
  by Kenneth S. Kamlet
- CONVERSION OF GULF OF MEXICO NONHAZARDOUS SHIP GENERATED WASTES INTO ARTIFICIAL REEFS ABOARD OFFSHORE PLATFORMS
  by Dana Larson
- CONSIDERATIONS FOR SUBSEABED STORAGE OF SEWAGE SLUDGE WASTE UTILIZING DEEP DRILLING TECHNOLOGIES
  by Melvin N.A. Peterson
- CONCEPTS FOR STRUCTURING OCEAN VENTURES
  by Clifford McLain
- LEGAL CONSIDERATIONS FOR THE ADVANCEMENT OF OCEAN ENTERPRISES IN THE U.S. EXCLUSIVE ECONOMIC ZONE: NEW WAVES AND OLD RIPPLES OF LEGAL UNCERTAINTY
  by David C. Slade
- OCEAN ENTERPRISES IN THE 1990'S: ENVIRONMENTAL, ECONOMIC, SOCIAL, AND POLITICAL CONSTRAINTS TO DEVELOPMENT
  by Peter A. Johnson
- OCEAN ENTERPRISES IN THE 1990'S: TECHNICAL AND ENGINEERING CONSTRAINTS TO DEVELOPMENT
  by James E. Dailey

THE OCEAN ENTERPRISE CONCEPT

by
David A. Ross, Woods Hole Oceanographic Institution
Michael A. Champ, National Science Foundation
James E. Dailey, Brown & Root Inc.
Clifford E. McLain, Consulting Services

WHY OCEAN SPACE?

Today less than one percent of the annual resources consumed in the U.S. comes from the sea. Yet the Exclusive Economic Zone (EEZ) Proclamation gave the U.S. exclusive jurisdiction to the resources of the ocean out to 200 nautical miles. This is an addition of over 3.9 billion acres of new territory--more than doubling the size of the U.S. To date, the potentially great rewards from the development of the resources of the ocean by the private sector have been greatly inhibited by the scale of risks of such candidate projects. The following areas show the most promise: marine mining of coastal heavy minerals; ocean energy conversion; offshore waste treatment plants; mariculture (fish and shellfish), and platforms for air and space operations (floating ocean military bases).

The Ocean Enterprise Concept has been proposed as an exciting and challenging mechanism for launching a new era of awareness, practical development, and utilization of ocean resources beginning in the early 1990's. It is only through a cooperative "pulling together" of government, academia, and industry, that significant new areas of operational economic interest can be developed or current ones strongly bolstered in the oceans sector. The original Stratton Report (*Our Nation and the Sea*, 1969) recognized the great basic potential of the oceans and provided a broad discussion of the many appropriate areas for scientific and economic development. An assessment at this time (some 20 years later) suggests some interesting observations.

- Great strides in the scientific understanding of the oceans have been made in some areas: the recent work on ocean rift zone geology, thermal vents, and their implications for ocean chemistry and biology, for example.
- No new major economic area has been developed in the ocean sector. The principal economic payoff areas remain those of shipping (merchant marine), fisheries, and offshore oil and gas. Heavy R&D investment has been made in such areas as mineral deposits (manganese nodules) and OTEC, but no practical business of net economic value has developed.
- A strong well recognized constituency has not yet developed for the oceans, although a lively basis for such a constituency appears to exist.

The construction of large (1-2 sq km) stable ocean platforms could also provide this Nation with mobile overseas military bases to meet the future need of decreased reliance on overseas military bases for the USAF-Army/Marines-Navy. The U.S. has a worldwide military basing structure that will very likely dwindle significantly in the next ten years. Air bases in Panama, Spain, and the Philippines are becoming extremely expensive, less useful, and less available. The Soviets have approached the problem differently by employing mostly movable or removable assets (floating piers, tenders and repair ships, floating dry docks). Ocean bases can provide key aspects to hemispheric defense systems including border and internal defense. Large stable ocean bases can also serve as centers to suppress sabotage, terrorism, narcotics trafficking, and arms shipment; major weather stations for enhanced weather prediction, global climate studies; air traffic routing centers (considerable fuel savings); alternative energy generating plants (OTEC); and serve as platforms to provide indirect U.S. military assistance to third world countries (such as training, intelligence, communications, transportation, construction, medical supplies, physicians or disaster relief, logistics, etc.).

Many actions have been initiated and ideas and technologies developed which, if supported under a strong long-term commitment by government, academic, and industrial sectors could provide a basis for very significant scientific and economic expression of our use of the oceans.

THE PRIVATE SECTOR ENVIRONMENT

Perhaps the major "disappointment" of the past 20 years has been the failure of any major new ocean economic area to develop. Broad technological and economic constraints have been suggested as the primary factors in preventing many of the Stratton Report goals from being achieved. The development of these ocean resources (from the use of ocean space to the development of individual resources) has been constrained by the lack of: public/private venture infrastructure; legal/regulatory implementation strategies; environmental, economic, social, and political guidelines; and technical and engineering problems that arise from the "marinization" of land-based engineering concepts, technologies, structures and facilities for use in ocean enterprises. The limiting factors are really leadership, infrastructure and venture capital (because the scales of risk are perceived to be large). The infrastructure needs can be developed and supported by a Federal in-house incubator, an ocean going Fannie Mae, and a quasi government non-profit corporation (chartered through Federal enabling legislation). This quasi government corporation is needed to provide the limitation of liability to that normally accepted by the Federal government, and minimize the risk of intervener legal action (similar to the Trans-Alaska Pipeline, or COMSAT Corp). Several national and international workshops have stated that the key technologies exist, but have not been utilized in such a manner on a commercial scale.

It is in the interest of this Nation to create organizational infrastructures which bring together the resources of government, industry, and the academic sectors to undertake large-scale resource and technology development projects, where scales of time, risk, and/or magnitudes are too great for one sector alone to bridge the NO MAN'S LAND gap between research and development as illustrated in Figure 1. The bridging mechanism requires a larger more integrated effort with private/public sharing of funding to support special development activities.

WHAT IS AN OCEAN ENTERPRISE?

Ideally an ocean enterprise should generate economic revenues, not only by cost savings, but also generate new revenues; create jobs and economic benefits from the development of ocean resources and technologies; protect and conserve the developed resources and ocean environments; provide the benefits of a public service and reduce public risk; and support the Nation's interests overseas.

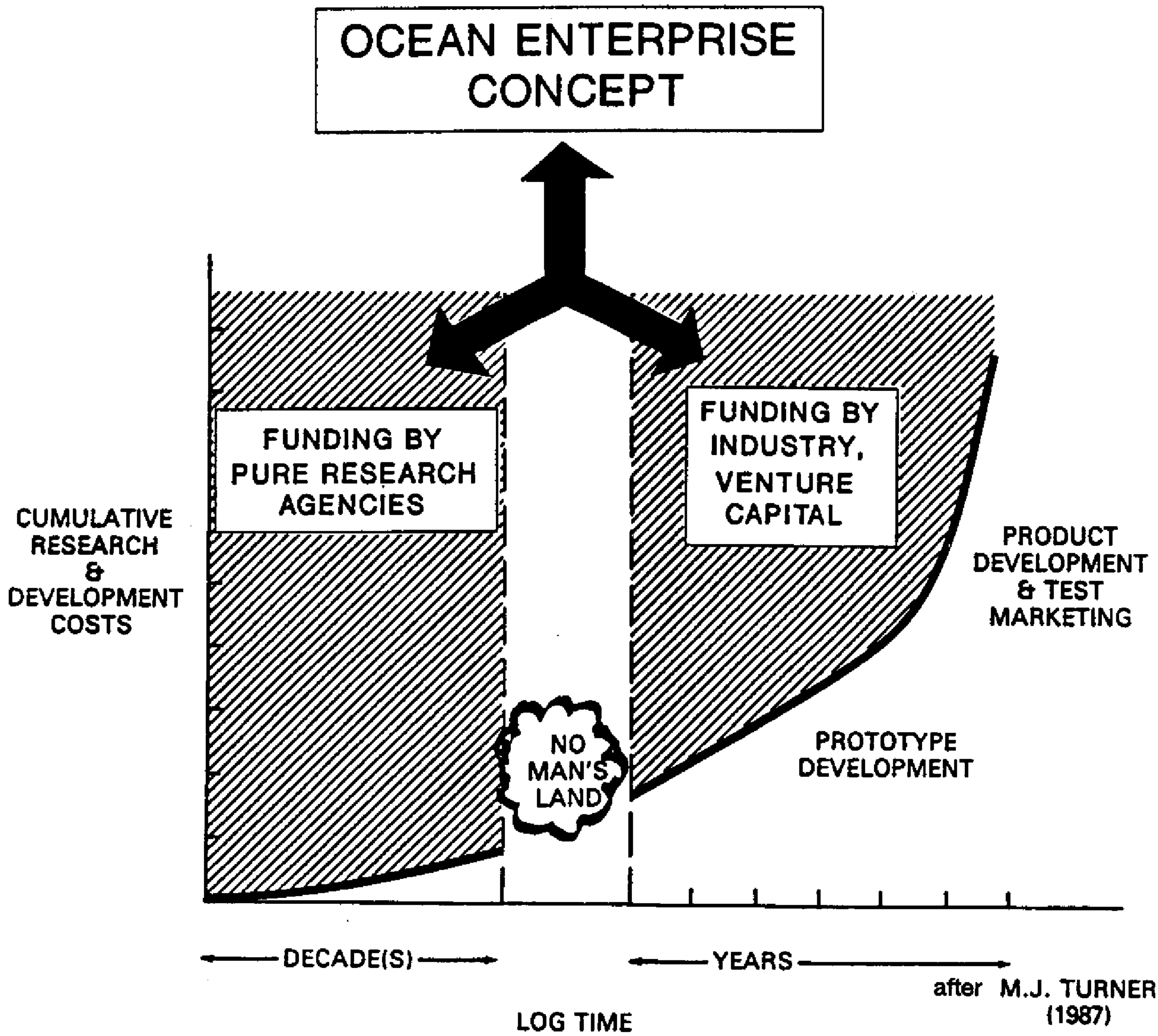


Figure 1. The Ocean Enterprise Concept to Bridge the NO MANS LAND Gap.

It is also timely and desirable to foster new civilian and military partnerships to enhance this nation's competitiveness and economic growth,with current and future budget limitations (the trade deficit and the increasing national debt). It is also desirable to stimulate military/civilian synergy, because projects of this scale (such as large ocean platforms) have costs that require multiple use benefits to society. Also these large projects must maximize the commercial spin-offs (e.g., as NASA with the space program) to increase the benefits to society and distribute the construction and operation costs across a wider array of users. Different kinds of ocean platforms (from ocean airports, mining facilities, to recreational facilities - hotels, resorts, etc.) will spin-off entirely new commercial industries, providing significant public and private economic benefits (see Figure 2).

Ocean enterprises have to develop from a succession of small scale projects that perhaps develop for application in the shallow, near coastal waters, providing local public service benefits. These projects should have a dual use being initially developed with public-private sector funds for civilian use, however, engineered and evaluated with a military perspective and application in mind. Examples of these could be a moored floating ocean platform designed and engineered for a NIMBY (not in my back yard) public service project such as a coastal airport or waste treatment facility (e.g., high temperature garbage processing and treatment plant).

In the U.S., not a single major airport has been built since the early 1960s. By the year 2000, 80 percent of the U.S. population will live within 60 miles of the coast, and public air transportation which has air space limitations today, will not be able to meet the demands for services in large U.S. coastal cities (New York, Los Angeles, San Francisco, etc.). The construction of stable ocean platforms for airports could be initially supported by public and private funding with repayment from user fees and capitalization of infrastructure.

Vigorous efforts have been supported by the U.S. government, to encourage private capital involvement through a cooperative partnership approach to the development of new technologies and to the transfer of technology from the R&D environment to practical economic application in the marketplace. These have, in some cases, shown a modest degree of success. Yet, significant investment from the private sector for potential new economic areas is usually lacking. "Why doesn't industry get more excited about the oceans?", Federal agencies and academia have asked. The direct answer is that there are no perceived returns on investment justifying the perceived risk.

FUNDING LIMITATIONS

Due to the increasing national debt and the trade deficit, it will be the policy of the administration to reduce Federal support for many programs for which such support would seem to be reasonable and appropriate from the state and local governments and/or private sectors. Thus, one cannot really expect major direct Federal financial support for the increased efforts needed to truly develop and exploit new ocean resources. It can also be argued that, even under a variety of administrations with differing philosophies, there has really never been a basis for a major increase in Federal funding for major new ocean projects. The constant dollar support for underlying programs in basic and applied ocean sciences, charting and mapping, and related activity has been maintained at a fairly steady rate (though slowly decreasing through inflation). This situation is not likely to change in the future, regardless of administration. The real question is: with the understanding that major increases in developmental funding from the Federal government or from foundations are not to be expected, is there any basis for a major increase from the private sector ?

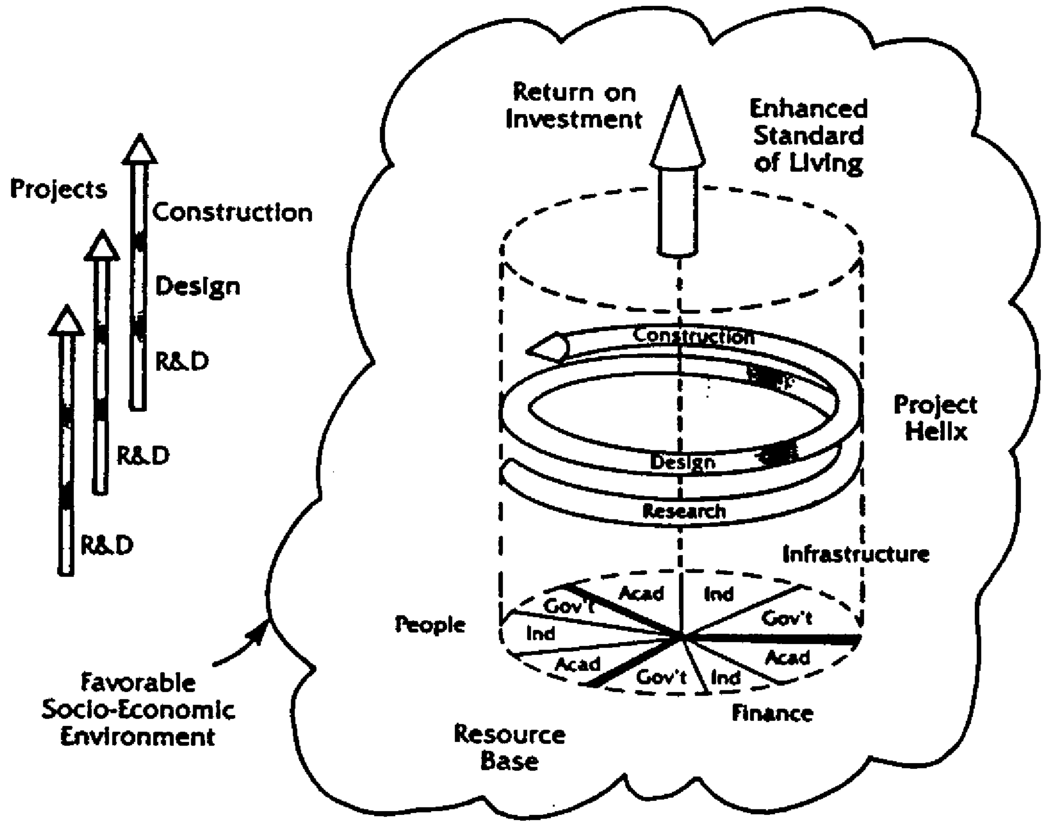


Figure 2. Partnership of Industry, Academia, and Government to Conduct Research, Design, and Construct Large Scale Ocean Projects.

PRIVATE SECTOR INCENTIVES FOR OCEANS DEVELOPMENT

The prime requisite for private capital financing of development is that an investment yield a profitable return. Moreover, most investors or companies looking at rewards for their own R&D efforts tend to evaluate the worth of investment opportunities in terms of near-term returns. The combination of potential immediate tax benefits and profitable return on investment realized in the 2-5 year time frame seems to be characteristic of the most attractive private sector investment opportunities. Investments in 5-20 year time payoff areas are only of interest in certain highly specialized industrial areas: oil and minerals exploration, timber production, and development of public and private power resources, to name a few. These long term areas are characterized by the long life-time of assets and the highly predictable long-term general requirements for their products (although short-term market conditions may fluctuate wildly). The basic reason that short-term payoff is so important is that futures can be "reasonably" predicted over a 2-3 year period at most, in the perceptions of a majority of investors.

What constitutes an attractive R&D investment opportunity in the private sector? A few critical elements which must be present to validate a first class investment risk are suggested below:

- A well defined end product.
- A well prepared development strategy and business plan.
- Definable markets and specific paths to those markets.
- A basis for prediction of comfortable profit margins.
- Technological uncertainties well defined and directly addressed by a planned R&D program.
- The business plan adequately structured within the international and national socio-political and economic environment.
- A direct identified path for Return On Investment (ROI).

This implies a clear economic model for the investment program showing how ROI will be generated.

There are doubtless additional important points. The bottom line argument is that the level of private investment will be strongly coupled to the degree to which the investment environment and market place is understood, and the potential for a reasonable ROI.

It seems self-evident that the reason for capital investment in the oil/gas, merchant marine, and fisheries areas, basically lies in the fact that these are perceived as well understood economic areas by the operators and investors. In the oil/gas area, certain developmental investments are regarded as essential, based on past experience (the need to explore, develop more efficient techniques, etc.). In shipping and in fisheries, requirements for investment in capital equipment are well understood, but the potential of R&D to improve profits through increased efficiency, understanding, etc. is less well recognized or accepted. New techniques in these traditional areas often must be spurred by Federal government R&D or by regulation.

In most other new technology areas of ocean exploration, development has been all but non-existent outside of those projects based on Federal government funding. A notable exception has been the once vigorous but now moribund investment in the manganese nodule mining potential. Here it looked as though all elements were in place to make industrial investment attractive, and large amounts of investment were actually undertaken by several large consortia of companies.

As it turned out, a declining metals market, the general long-term malaise of the world economy, and the recently concluded Law of the Sea Treaty, have all acted together to make the planned manganese nodule industrial development economically unfeasible. This has stung the investors severely, and has contributed to a doubly cautious approach on the part of private investors with regard to future opportunities requiring major investment levels.

AN APPROACH FOR THE OCEAN ENTERPRISE CONCEPT

An Improved Approach would seem to be a necessary part of any program designed to make the Ocean Enterprise Initiative a success in terms of the infrastructure that will lead to economic benefits. In addition to activities well within the operational potential of the current oceanic community, a new set of techniques and organizational methods must be developed. These methods must be expected to enhance the probabilities that major projects and new economic potentials will in fact be realized, as opposed to just being studied, evaluated, and then left to await some future development. This Improved Approach must in fact concentrate on bringing new elements of the private sector strongly into the ocean development arena. Government and academic resources are already there and do not have major new sources of support to draw from. Under this Improved Approach some things need to be recognized as rather fundamental:

- The basic incentive for private sector interest is that of perceived future return on investment.
- The basic reality for the legislative branch of the government is the perceived connection between congressional action and the reaction of individual congressional constituencies (i.e., programs must have real social/political/economic impact on real constituencies of Senators and Representatives). Strong private sector involvement enhances legislative interest.
- The primary resources for basic ocean research lie within academia (including the various oceanographic institutes) and the Federal government.
- The primary resources for development lie within the private sector.
- The private sector is becoming increasingly aware of the perils of investment posed by uncertainties in policy and the socio-political environment. A carefully planned and prepared basis of support in these areas, as well as a generally favorable economic projection, is becoming a requisite to investment.

Considering all of the above, a series of new mechanisms (as a means of attracting new private sector participation) is suggested to introduce new programs and initiatives.

TRIPLE ALLIANCE R&D PARTNERSHIPS

This mechanism is used to develop a model for R&D Limited Partnership investments. It proposes a partnership of government, academia, and private capital sectors to establish long term and vigorous support for applied R&D in the oceans area. The proposed structure is diagrammed in Figure 3a: an operating R&D center established under the auspices of one or more academic institutions. Support from the private sector is provided through an R&D Limited Partnership (RDLP), thereby providing a direct path for technology transfer and market application directed by the General Partners through agreements with user industries, who pay royalties to the RDLP in return for manufacturing and marketing rights received. The royalties are used to provide return on investment to the RDLP investors, and to self-endow the center after the RDLP limited partners are paid out. Ideally, the academic participants will be one of the General Partner. Figure 3b is a more complex example of a two phase model.

Government and nonprofit foundation support is separately solicited by each project, but has the added attractiveness for projects and grants by providing leverage based on the concurrent programs supported by the RDLP contracts with the Ocean Space Initiative. In this way, a formal tie is established between the successful market application of project developments and the future financial support of the initiative itself. Industrial (private sector) participants are protected by limited investments and benefit both through tax credits and by RDLP distributions or individual user contracts. The General Partners, through the RDLP, provide sufficient isolation that antitrust requirements are met. Finally, joint academic and government support of the center helps validate the products which are applied and sold through the private sector channels. This validation can be critical in reducing perceived risk and encouraging private sector investment. This mechanism can provide a helpful umbrella for encouraging a significant increase in private sector investment.

MAJOR ECONOMIC AREA JOINT VENTURE

This mechanism also emphasizes the role of the private sector. Rather than relying on a single major industrial developer, a team of industrial and investor partners, perhaps through a joint venture corporation, would be established to develop a particular area of great potential economic benefit. Such an area would be characterized by some of the following traits:

- Development path featuring a graded investment startup.
- Backup by favorable policy and socio-political environment.
- Meets environmental protection issues.
- Takes short and long range economic and market conditions into account.
- Does not require development of basic scientific understanding, i.e., is a technology development.
- Scaling models exist for transition from laboratory to industrial practice.
- Spin-off developments are inherent in the approach.

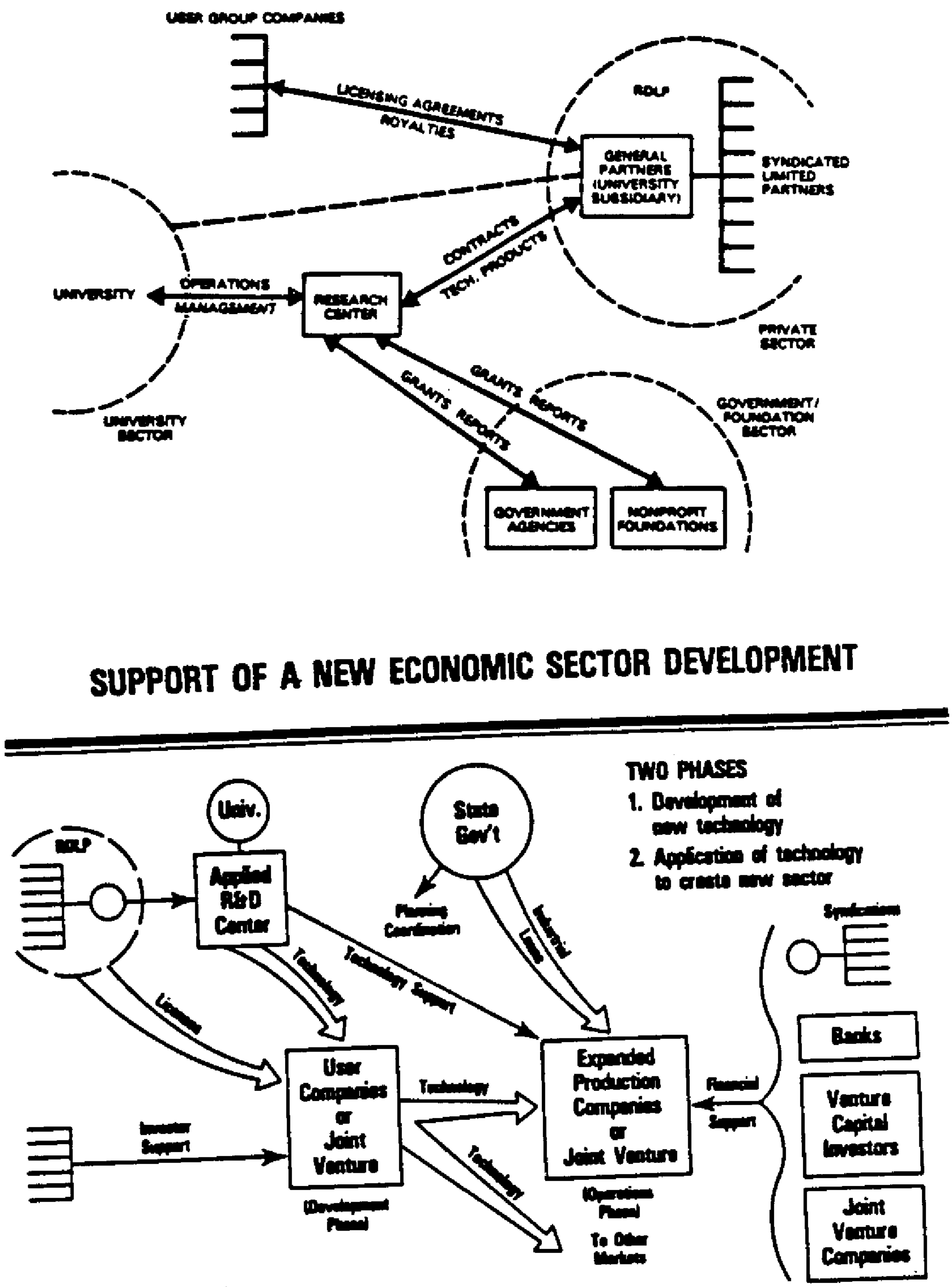


Figure 3. Simple (a) and Complex (b) Examples of Organizational Infrastructure Models for Ocean Enterprise Projects.

These fundamental traits allow the development of a business plan which permits the highest technological risk problems to be solved with a modest initial investment. Operations and market testing would be conducted under a prototype operation which again does not require a full scale manufacturing investment. It is also important to identify multiple potential paths for market development so that more than one option for investment pay back exists. A goal for the Ocean Enterprise Initiative might be to launch in early 1990 at least one major effort, with an initial 10 year development and business plan.

NATIONAL OCEAN POLICY STATEMENT

Simply stated, this would seek to provide an Ocean Economic Development Policy statement by the President which follows up on the EEZ proclamation of March 1983 and would include specific backup actions which strongly support ocean resource development by the private sector. Features of the policy should include:

- Operation within the EEZ.
- Cooperative guidelines for working with LOS signatories.
- Policies providing incentives for ocean development investment (tax credits, small business loans, SEC and Justice opinions on consortia, etc.).
- Emphasis on ties to economically depressed areas.
- Assurances on commitments to protect ocean environment while undertaking development; i.e., an intelligent balance between ecological concerns.

COALITION OF OCEAN RESOURCE STATES

In conjunction with those new incentives and special projects which could be directly encouraged by Federal actions, a movement to organize those states having direct or strong indirect interests in ocean development as well as currently established ocean business would be helpful in establishing a strong constituency for the oceans. Similarly, a parallel association of city governments might be developed for ports and other cities whose economic basis may depend or could depend heavily on ocean development and economies. Spearheading this effort should be the ocean related industries and professional societies, backed up by the general interest of the Departments of Commerce, Transportation, and Interior, and the National Science Foundation. Such an organization would, through the associated Congressional delegation of the member states, have a strong effect on the development of a broader Congressional constituency as well. The coalition would, among its goals, act to:

- Promote understanding of the interdependence of state and local economy and environment on ocean related development and industry, both present and future.
- Identify and support the development and adoption of appropriate policies, legislation, and planning at local, state, and national levels

which will best serve state and local requirements and interests, as well as meeting national concerns.

- Develop appropriate state-to-state operating relationships and agreements which will aid in the beneficial development of mutually shared ocean related opportunities.

One very appropriate path to the establishment of such a coalition may well be to obtain the support of the following organizations: Coastal States Organization (CSO) [the sponsor of the Ocean Enterprise special session with the Marine Technology Society at the Ocean '88 Meeting in Baltimore, Maryland, November 1, 1988], the National Association of Counties (NACO), the U.S. Conference of Mayors (USCM), and the League of Cities (LOC). These groups already have well knit operating committees and organizational objectives which broadly parallel the actions suggested above. For example, among the NGA standing committees, one or more of the committees on: National Resources and Environmental Management; Transportation, Commerce and Technology; and Community and Economic Growth, might be very receptive to developing a working group of interested states in the ocean area. Further, the NGA already sponsors various coalition (cf: Coalition of Northeastern Governors) and Regional Commissions (cf: Four Corners Regional Commission, Old West Regional Commission, etc.). Such organizational sub-elements are a natural part of the NGA operating structure. The USCM, LOC, and NACO have similar objectives, structure, and operating methods. USCM maintains continuing efforts in areas of Energy and Environment, Urban Economic Policy, and Transportation, for example. The development of such a coalition in formal recognition of the increasing importance of the oceans as a major factor in state and local economic structure would provide a strong and effective boost to the Ocean Enterprise Concept.

IMPLEMENTATION STRATEGIES FOR THE OCEAN ENTERPRISE CONCEPT

The overall program for the Ocean Enterprise Concept should, of course, embody much more than such major new thrusts as are discussed in the preceding sections. Implementation of the Ocean Enterprise Concept ought to establish a total environment for the enhancement of ocean related activities and interests of all types. The principal measure of the long range effectiveness of the program will be the initiation of major new development areas which can sustain growth. Without the total environment created by the program, such new approach initiatives, as are discussed in the previous section, would have little chance of successfully developing. Without the resulting realization of such new initiatives, the program would be judged, over the long term, as a failure. The program must then have two objectives which are interrelated:

- The creation of a heightened environment of ocean related awareness and actions.

- The initiation of some significant new development with both technological and economic impact which will last (i.e., become an integral part of the national dynamic economic structure).

If these two objectives are met, then the Ocean Enterprise Concept may well be judged to have ushered in a new area of ocean utilization.

The foregoing arguments suggest that the basic operating approach for the program must be that of a team effort, with coordination by key Federal agencies backed by specific White House approval, supporting major activities in five areas:

- Policy development.
- Constituency establishment.
- Awareness enhancement.
- New enterprise initiation.
- Research and development direction and augmentation.

Figure 4 suggests a general way in which the team effort might take place under Federal coordination. Each of the participating sectors would contribute to the appropriate activities through a program master plan. Participation by the White House (particularly the Office of Science & Technology Policy) and other departments and agencies would be most important. Especially beneficial would be a Presidential memorandum or statement ushering in the program, and designating Federal agency responsibilities.

The Ocean Enterprise Initiative can, if vigorously encouraged and coordinated, yield a strong turning point for the history of ocean research and enterprise.

Acknowledgment

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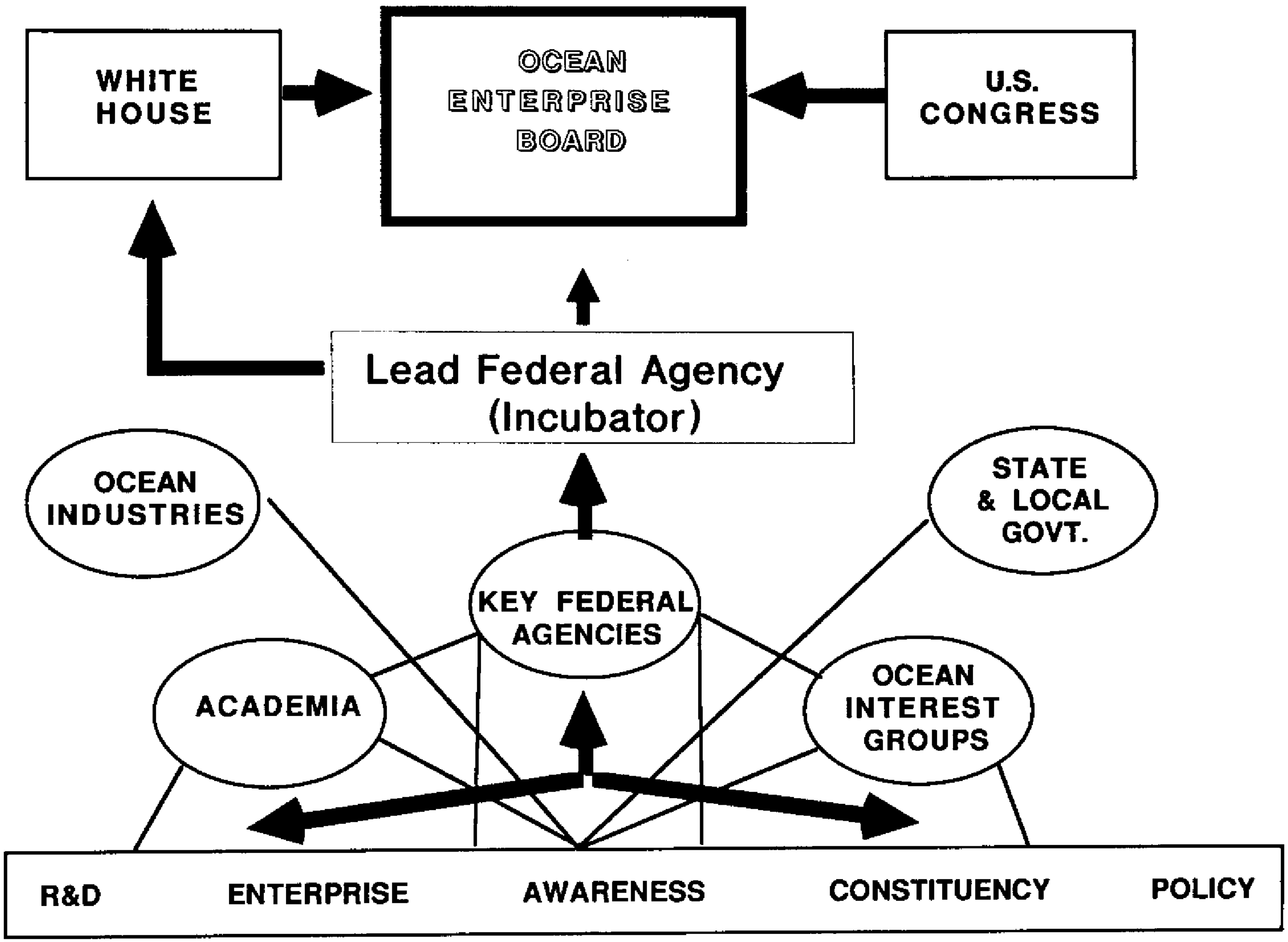

Figure 4 Proposed Ocean Enterprise Organization

MARINE HARD MINERALS MINING: PLACERS AND PROFITS

by
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ABSTRACT

Marine placer mining has been underway since the turn of this century, chiefly on beaches and in shallow waters off Nome and other Alaskan sites. The introduction of a major dredge off Nome, and recovery of fourteen million dollars in gold, in 1987, signaled the start of profitable recovery at a high level. Some so-called problems in placer mining are only perceived as such, notably the lack of risk capital, the lack of suitable charts, and the lack of prospects. On the other hand, there are some real problems facing the marine placer industry, namely the lack of a realistic regulatory framework, the lack of technology for under-ice mining, rapid metal surveys, recovery of ultra-fine particles, and the lack of trained personnel. Based on the recent commercial success in the Bering Sea, the low cost for placer exploration and mining *vs* the high cost for deep water mining, the additional target metals in placer minerals, and the potential for new discoveries in US-EEZ, state and territorial waters, marine placer mining holds much potential for substantial economic return, particularly in the noble metals for which the market is exceptionally bright.

INTRODUCTION

Basically, the mining of marine mineral deposits is neither new nor novel. In this country, beach and shallow-water marine gold placers were mined off Nome, Alaska, in the early 1900s. Indeed, the recovery of placer gold from beaches has long been pursued, usually by small operators, at or near Bluff, Hinchinbrook Island, Yakataga, Yakutat, Feather River and, of course, Nome, in Alaska, and near Crescent City, California. For some of these, intermittent mining operations continued into the early 1980s, and for some, new exploration is in progress, chiefly in attempts to expand the operations. By far the most profitable of these sites named, the recent large-scale gold mining operation in the Bering Sea, off Nome, has brought worldwide attention to the potential for developing additional, highly profitable marine placer mines in the Bering Sea and in other U.S. waters, as well. The successful mining off Nome has acted as a new-business catalyst, in that both domestic and foreign investors are focusing their attention on new marine mining ventures in high-latitude waters of the American EEZ, and to a lesser extent, in coastal waters bordering the contiguous states.

These several smaller mining operations have suffered, economically, in their uneven, intermittent histories as a result of undercapitalization, lack of specialized mining equipment, and inability to follow profitable mining into the adjacent deeper waters. Even the rich deposits off Nome and Bluff have not been immune from these problems. The headlands near Bluff are graveyards for mining vessels that were too small to survive in stormy waters, and until Inspiration Gold Inc. brought the large dredge, *Bima* to Nome, three years ago, the Nome offshore could not be mined for more than a few weeks in midsummer.

In the mid-nineteen eighties, with the price of gold holding firm and with market trend projections indicating that the price would continue firm, a bold new move was made by Inspiration Gold Inc. (now Western Gold Mining Inc.) to overcome the problems of periodic storms, undercapitalization, poor property assessment and remote logistical support. Inspiration, with an imaginative and aggressive management, as well as a first-class team of geologists and artificers, has now made sustained, profitable marine placer mining a reality, and they have done so in only three years. The latest report (*Wall Street Journal*, 18 Sept. 1987) confirms Inspiration's success off Nome: Over $14,000,000 worth of gold was mined from the seafloor off Nome during the summer operating season of 1987. Indeed, there are some Alaskan miners who believe the total was in excess of the published figure.

How did Inspiration achieve this success? Although much of their operation is proprietary, some steps in their success ladder are clearly identified. The earlier problem of using small mining vessels was overcome by bringing the giant placer dredge, *Bima*, 6500 miles across the Pacific and, after refitting, placing it in operation off the Nome coast. The problem of undercapitalization encountered by prior marine miners off Nome was overcome by an enlightened management who established a working budget sufficient to get the job done. Further, using modern geological and geophysical tools, the property was thoroughly cored, mapped and the gold reserves confirmed. Also, the permitting and leasing process was made easy by operating in the State of Alaska waters, for which sound, clearly defined legal requirements and operational regulations were already established, and which are fair to the miner. Other steps that helped ensure success included proper environmental monitoring, local employment, long-term planning and frequent review of all mining activities. Clearly, management's basic belief in, and firm commitment to, the project are fundamental assurances of continuity and, in turn, corporate profit making.

In addition to the pragmatics of using a truly seaworthy dredge and of ensuring appropriate financial commitment, Western Gold has also concentrated its efforts off Nome in State of Alaska waters, completed a thorough environmental assessment, and cooperated fully and openly with all concerned agencies, including the Native peoples of the area. Of all the parameters of success, the State-promulgated mining rules and regulations have been one of the most critically important factors to the venture. In short, industry is currently engaged in the profitable development of shallow-water marine mineral deposits, notably placer gold, and has done so, on a lesser scale, since 1900. Indeed, although production data for 1988 have not yet been released, it is estimated that the *Bima* produced *much* more gold in 1988 than it did in 1987.

In spite of the financial success at the Nome offshore mine, there are still problems and constraints to marine placer mining. For many of the prospective high-latitude mine sites, winter ice is a barrier that stops all mining for about six months of the year. At all latitudes, there are some problems that are common for all sites. There is a need for depositional models that can guide exploration programs. There are, as of now, no marine mining and processing vessels specifically designed to operate in rough seas, and, indeed, no designs are on the drafting boards of industry. While some headway has been made in developing reliable coring tools for testing placers, there is much research and development yet to be done before the ideal coring tool--light, with good penetration and recovery, and adaptable to any vessel--will be on the market. More importantly, considering the large size of the concessions envisioned for the next two decades, there is no rapid metal-sensing system available that will provide *in situ* data for all the elements critical to discovering new marine placer deposits. Likewise, there still remains the thorny problem of recovering the ultra-fine particles of gold, platinum and other placer minerals. We will expand on these problems later in this report, and suggest ways in which solutions might be obtained.

To this point, we have focused on marine placers. What about the other types of deposits? Do they appear to hold promise for profitable mining in this century? Very unlikely, and we offer a few reasons for this doubtful prognosis.

In the case of ferromanganese nodules, the cost of an entire deep sea mining operation--mining vessels plus processing facilities and infrastructure ashore--is, for the projected return on transition metals, simply too costly. My colleague, Jack Flipse, recently told me that, unlike the computed mining costs of 15 years ago, today it would require capital in the three-quarter billion dollar category to "start up" a nodule mine, even if the metal market was very favorable.

In the case of cobalt-rich manganese crusts, the target ore is so thinly coated on irregular sea mount slopes that, to be profitable, an extremely rapid mining system would be required. At this time, only two conceptual designs for crust mining machines have come from the engineering drafting boards--"artists' renditions" would be more correct--and neither has been tested, even in scale model. Not least, crust mining would be essentially a one-commodity operation, subject to a precarious market. Again, as with nodules, crust mining would be extremely capital intensive.

Regarding the much promoted sulfide deposits at spreading centers (the smokers), there has been no indication to date that the valuable sulfide deposits, i.e., those with high-value metals, are to be found in concentrations sufficient to form ore bodies. There is no realistic mining system design available for rift sulfides, conceptual or otherwise.

Lastly, for the marine phosphate deposits, we suggest that, while there does appear to be a potential for marine mining of bedded phosphates in U.S. EEZ waters, such mining is unlikely--indeed, doubtful--in this century. On the other hand, were we to predict the deposit type, after placers, most likely to be mined in the first ten years of the next century, we would unhesitatingly predict phosphates. With the gradual demise of upland phosphate mining in Florida, the potential for offshore mining of phosphate will become *very* promising, say by 2005. In short, based on poorly defined ore bodies, fewer high-value metal targets, high capitalization costs, and, in part, international political concerns, these other types of marine mineral deposits are not considered as potentially profitable in the decade ahead, at least not in a free enterprise system.

Is it possible, however, that some nation or nations may mine nodules, or crusts, within the next ten years? Yes, there is a possibility that a foreign government may initiate such mining; but, such mining would require large subsidies or other financial assistance in order to be successful. India, South Korea, PRC, and the USSR are trying. National prestige, i.e., being the first to mine in deep water, might serve as the reason to enter such an undertaking, perhaps the sole reason, and without concern for profit. Clearly, as of early 1989, economic realism must obtain in any marine mining ventures under the United States flag, and this means that our industrial efforts must be focused on *marine placers*.

THE CASE FOR MARINE PLACER MINING

Although treatises have been written on the formation of marine placers, for purposes of discussion at this workshop, we might summarize genesis by stating that placers are concentrations of heavy minerals formed as lag deposits. The familiar sight of patches of black sand along beaches is known to anyone who enjoys the seashore. High-energy waves and currents simply transport the lighter mineral grains faster than the heavy mineral grains, and the heavy grains lag behind and, hopefully, accumulate into economic deposits.

Within recent years, a second type of marine placer has been identified, the low-energy placer. This deposit occurs when ultra-fine (2-20 micron) particles are trapped with muds in bays and other depositional sinks. Basically, the high-energy placers are the principal targets at present. Further to our discussion of origin, the basic requirements for forming a marine placer are (1) a source rock containing valuable minerals, (2) an erosional or weathering process to release the ore minerals, (3) a processing conduit--stream, beach or coastal current pathway--to help concentrate the heavy minerals, and (4) a depositional site or sink that will accumulate the heavy minerals to form a placer. Although briefly stated, these are the basic factors involved, and as such, guide exploration. Inherent to placers alone are several attributes that combined make them more economically promising than the other marine mineral deposits in the near future.

1) Distribution. Clearly, the fact that marine placers are formed along the shore, in the shallow waters offshore and in some shallow bays is of operational, legal and financial importance. The several marine placers that have been, or are being, mined are located in shallow water. The present placer mining operations off Nome are conducted in waters less than 150 feet deep. Likewise, the placer-like titanium deposits--call them *known resources*, if you wish--reported off the coast between New Jersey and the Carolinas are largely in shallow water, as are the titanium, zirconium and rare earth deposits off Georgia and NE Florida. The titanium-zirconium-rare earth deposits off the Texas coast, as reported by the U.S. Geological Survey, while lower in grade, are in waters less than 200 feet deep. On the West Coast, beach placers near Crescent City, California, were once profitable to mine simply because they were on the shore. Other potential placer deposits off northern California, Oregon and Washington (gold, platinum, titanium, chromium, and rare earths) are, in part, in less than 500 feet of water, and, even so, are in striking contrast to the 5000- to 19000-foot water depths known for manganese crusts, nodules and sulfides. As well, beach placers of these metals are also known along the U.S. West Coast. The cassiterite (tin) and scheelite (tungsten) heavy mineral deposits off Teller, Brevig Mission, York, Tin City, and Cape Prince of Wales in Alaska, due to their local formation, are both close to shore and in shallow water. The same situation obtains at prospective sites in certain insular shoal waters of Micronesia. Thus, the characteristics of their origin, formation and distribution have made marine placers much less expensive to find and to develop than the deep-water deposits. Clearly, geological genesis favors the placer miner.

2) Larger Number of Metals. If we contrast the total number of potentially recoverable metals found in marine placers to the total metals found in other types of marine deposits, we find that marine placers, by far, contain more target metals. In regard to the deep-water nodules, crusts and sulfides, the following nine metals are of potential commercial interest and development:

manganese	gold (possibly)	copper
chromium	nickel	platinum (likely)
cobalt	vanadium	zinc

With further investigation, other metals may be found in amounts to be economically recoverable, e.g., osmium, antimony and, possibly, some rare earths. At this time, however, the total of recoverable metals in the deep-water deposits is nine in number. In striking contrast, there are some 22 metals that are known in marine placers and that are currently of economic interest, namely:

titanium	platinum	chromium
osmium	gold	iridium
tin	ruthenium	zirconium
rhodium	thorium	gallium
lanthanum	hafnium	niobium
mercury	beryllium	cerium
tungsten	germanium	scandium
holmium		

Of critical importance to the industrial firm considering marine placer mining, several of the target metals are high-value commodities. Based on recent market prices, as reported in the *Engineering and Mining Journal*, Oct., 1988, page 19, the following examples are instructive.

gold	$421.00	per troy ounce
platinum	$490.00	per troy ounce
rhodium	$1200.00	per troy ounce
palladium	$120.00	per troy ounce
ruthenium	$67.00	per troy ounce
iridium	$305.00	per troy ounce
gallium	$460.00	per kilogram
chromium	$3.40	per pound
tin	$3.57	per pound
titanium	$4.50	per pound
zirconium	$70.00	per pound

There are, as well, several "exotic" or "high tech" elements found in placer minerals, chiefly in heavy minerals, e.g., monazite and alanite, namely the elements lanthanum, holmium, thorium, hafnium, gallium, scandium, cerium, and several others. With the new technologies developing in electronics, rare earth catalysts and coatings, several of these lesser-known metals are now in much demand. The market for all placer metals, except perhaps tin, appears bright indeed.

It would appear then, that the entrepreneur who pursued exploration and exploitation of marine mineral deposits would have far more opportunities to seek profit from amongst 22 target commodity metals found in marine placers--including six high-value noble metals--then from fewer metals (some with very depressed prices) found in the non-placer deposits. For the operator doing business in a changing world market, with the favorable externalities of new technology and new uses, the 22 placer metals offer new business opportunities and timely adaptation to an unpredictable global market.

3) Less Cost to Develop Placers. Whether or not the exploration and exploitation is conducted by a one-person proprietorship, a small joint venture group or a large international corporation, the cost to develop marine placers is, by far, below the cost to pursue development of nodules, crusts and other deep water deposits. While the financial records of companies engaged in marine placer exploration are usually privileged information, there are several placer exploration programs, both in the U.S. and overseas, covering the period 1966-1987, to which I have had access. In a review of unpublished data made available to me by R.M. Thompson, it was determined that the average cost of a single-site exploration program--base study, geophysics, geology, geochemical and environmental surveys, *and* interpretations--was 1.6 million dollars U.S. (in equivalent 1980 dollars). When warranted, small pilot mining tests were made, at an average cost of $400,000. The range of costs for the several programs that I reviewed was from a low of $140,000 to a high of $4,000,000. Obviously, to actually *mine* the placer requires a capital outlay for machinery (dredge, clean-up equipment, etc.)--a very costly item--but, in the past three years, surplus dredges and other equipment, at much reduced costs, have begun to be available. Nonetheless, the cost of even a small dredging system can be $500,000 and a large dredge (but not a "giant" dredge) can easily cost $5,000,000 to $7,000,000. In regard to cost estimates, I have, since 1983, given my advance students a semester problem: Plan a placer exploration program for an assigned area (each starting with a different nautical chart) and cost-out the exploration program. For some 20 students each semester, for four years, their average cost estimate has been about $650,000 for an integrated exploration effort. This agrees favorably with the "real-world" costs, albeit, with limited data. In short, companies wishing to enter the marine minerals business would be advised on the basis of these arguments to consider marine placers first.

PROBLEMS AND CONSTRAINTS

In spite of the positive, upbeat arguments in favor of early development of marine placers, both on the beach and in the shallow waters of the Exclusive Economic Zone, there are some problems that must be overcome, particularly if industry is to develop marine placer mines in the vast Exclusive Economic Zone. Concerns expressed by my colleagues in the industrial sector include the lack of a "user friendly" regulatory framework, the lack of a viable technology for placer mining under high-latitude ice cover, the lack of a rapid, integrated exploration system for exploring large areas, the lack of depositional models to explain the genesis of certain (non-noble metals) marine placers, and, thus, clues for their discovery, e.g., guides to finding tungsten, rare earths and chromium, and, one of the thorniest of all technical problems: the lack of an on-line, continuous process for the recovery of ultra-fine (2 to 20 microns) particles of noble metals, chiefly platinum and gold.

Surprisingly, the industrial sector is not concerned with problems, vis-a-vis placer mining, that are often proposed as problems by those outside the industrial community. Some examples are instructive. There is no real problem in obtaining risk capital for marine placer mining or any other mining, *if* the operator has legal access to the ground, the reserves are sufficient to justify mining, and there is a market for the commodity. As in any other venture, risk capital will go to the opportunity of highest profit potential. Once the basic requirements obtain--legal access, sufficient reserves, and a market--the smart operator, whether big or small, has welcome *entre* to the risk bankers in New York, Toronto, London, Singapore, Hong Kong, and Zurich. Indeed, the sources of venture capital, as sought by American firms, are mainly overseas.

Further, the once-upon-a-time problem of environmental protection--a critical constraint of the 1960s and early 1970s--has been essentially put to rest. Industry has learned how to conduct environmental assessments, how to do the monitoring and how to mine in an environmentally safe manner, at sea as well as ashore. This is not to negate the frontier environmental surveys made by government agencies. Data from such surveys were and are helpful to industry; but, the services of commercial contractors are readily available in 1988, and, as well, the spectre of pollution no longer shadows marine placer operations.

Another non-problem is that of the lack of adequate nautical and geologic charts for the potential exploration and development areas in North American EEZ waters. While this is not true for many foreign concession waters, and while better detailed charts of waters adjacent to the Northern Marianas and other insular U.S. Territories would be desirable, the placer mining sector is not held back for the lack of bathymetric and similar charts.

Lastly, this fledgling industry is not standing by, waiting, for another major economic assessment and projection survey. The placer mining executive, if he is worth his salt, knows the minerals market, understands its vagaries and volatilities, and comprehends the difference between profit and loss. In a true free enterprise system, business acumen does (and *should*) lead the way....not feasibility and economic theory, however well developed in computer modeling they may be.

Now, having commented briefly on what the non-problems are, let us return to our earlier list of those problems that *are* real, that do constrain development (at least, *full* development), and that are solvable; yet, they remain as thorny, tough problems. In the brief comments that follow, we identify these problems and, with a measure of prudence, suggest some pathways to their solution.

Regulatory and Legal Problems. The requirement that the miner have legal access to the ground and that the regulations for exploring and exploiting the property be clearly established are basic to the industry. No company will move ahead without these requirements being satisfied, and, indeed, no risk banker will finance a program without them. For those companies working within three-mile state waters, or in the territorial or economic zone waters of a foreign country, there is no real problem. In this country, all states with offshore mineral lands, save some Great Lakes states, have established firm legal frameworks covering exploration and exploitation--permits, leases and monitoring regulations. While all states do not have the same laws, the operator does know, precisely, what the requirements are for each. For some states, notably Alaska, the laws have been developed over a period of several decades, are realistic, and are such to encourage development. On the other hand, for the U.S. (Federal) Exclusive Economic Zone, there is little to recommend the laws and regulations for administering mining in OCS waters. The regulations have, to say the least, not been warmly accepted by either the industrial or the academic community. Keep in mind that, in light of the President's encouragement to develop this Nation's marine minerals resources--including both academic and agency research in aid of development--the regulations, as promulgated, are notoriously lacking.

Development of New Technologies. Marine placer miners have benefited from research supported by the NOAA-Sea Grant Program, by the Dept. of Interior, and, I hasten to add, by academic research supported by industry. Some breakthroughs have been made. We now know how to find noble metal placers, chiefly platinum and gold, and we have provisional exploration clues for finding tungsten, tin, titanium and rare earths. Nonetheless, technological problems remain. Two examples follow.

One of the most difficult exploration problems to be overcome is that of providing for a rapid, *in situ* survey of metal indications in seafloor surficial sediments. During the past 26 years, marine placer surveys have required physical recovery and subsequent laboratory analysis of the grab samples. This was not a severe constraint, when only three-mile waters were being explored. However, if industry is to explore and develop placers in the vastly larger Exclusive Economic Zone, then a rapid, metal-sensing system must be employed. Our cumulative lifetimes could not provide the effort to assess the EEZ by older methods. In this regard, it is promising, indeed, to see the pioneering research of Prof. John Noakes, at the University of Georgia, coupled with the pragmatic technology of Prof. Robert Woolsey, at the University of Mississippi. Let us hope that government and industry, alike, support and encourage this team, for in their joint efforts is the germ of ideas and new equipment that can overcome the snail's pace exploration of today.

A second example of needed technology is that of overcoming winter ice in order to mine marine placers twelve months a year in the high latitudes. Some of the greatest potential--and greatest profits--lies in finding a way to mine beneath the winter ice. Those areas of the Bering Sea where platinum, gold, tin, tungsten and rare earths hold the real promise for sustained placer mining are also areas where winter ice cover prohibits mining for seven months of the year. Perhaps the solution to this problem is twofold: (1) the transfer of ice engineering technology from earlier government and oil industry studies, and (2) turning loose the bright young scholars--scientists and engineers--in academe to tackle and solve this difficult problem. Clearly, this is a challenge for the new Marine Minerals Technology Center at the University of Mississippi and the University of Hawaii, as well as for other researchers in this country. In short, if mining is conducted during the winter, in high latitudes, thus doubling production, so are the profits doubled.

Recovery of Ultra-fine Particles. Long the woe of terrestrial placer miners, the recovery of "flour gold" (or "flour platinum", or any other ultra-fine target mineral), the marine placer miner is, likewise, not immune. Ultra-fine particles between two and twenty microns, nominal diameter, represent a significant portion of the total metal present in some marine placers; but, such particles are not recovered in mechanical (gravity) recovery systems. In low-energy, muddy placers, the ultra-fine particles predominate. These particles are largely the difference between the ore determinations made by geochemical analyses and the actual recovered metal; a fact well known to risk bankers. Perhaps, scientists at our new Marine Minerals Technology Center funded by the Bureau of Mines and university researchers funded by the National Sea Grant Program, and industry, can, together lick this problem. The solution must be cost effective and it must be a continuous (stream) process, not a batch process, and it must be suitable for dredge or attendant barge installation.

Placer Models. Clearly, if we know how a given placer is put together--platinum, gold, titanium or any other type--we will have the dual advantage of knowing how to find it and how to process the ore. Modeling is a flexible concept, e.g., geochemical model, geophysical model, sedimentological model; but, basically, the modeler is concerned with prediction. If we can predict, then we can design the system--concept and technology--to find, recover, and process the placer ore. Some reasonable understanding of depositional models for gold, platinum, tungsten, tin and titanium placers obtain; but, for the other metals, particularly the high-technology elements (gallium, niobium, rare earths, et al.), we know nothing. To provide these models, and the exploration guides to them, let us enlist the bright minds of academe, government and industry in genuine cooperative research. This, of all placer problems, is truly multidisciplinary and, as such, requires that we cross boundaries to solve it.

Trained Personnel. Of the constraints facing the marine placer mining industry, particularly in tackling the EEZ of this Nation, the most serious is that of finding trained personnel. The marine placer explorationist/exploitationist is a rare breed. Trained in marine placers, at home aboard ship, yet skilled in applying mineralogy, Pleistocene history, physical chemistry, geophysics, geochemistry, statistics and engineering, such types are not the products of conventional disciplinary degree programs. Much of their education is gained by hands-on training, in cooperation with real world projects in industry. If--a big if--the regulatory climate were ideal, and if industry soon moved full bore toward marine placer exploration and mining, there are not enough young scholars in training to supply the work force. Up to now, such special training has been almost a hand-tooled process, where the faculty member pursued applied placer research in a close cooperative mode with an industrial partner. This has been done effectively at Wisconsin, Mississippi, Oregon, Michigan, and Texas; but, the vastness of the new EEZ areas, North American and overseas, precludes this approach for the long term. It is suggested that a new partnership be formed for the training of youth in this specialized field, a partnership of industry and academe. Clearly, there must be no binding of intellectual pursuit, i.e., restricted freedom of research, placed on the faculty member who, by his or her own choice, chooses to pursue applied research on marine placers and to train others in the same field of professional endeavor. If academe is shackled in this pursuit, we shall most assuredly kill the goose who lays the golden eggs.

CONCLUSIONS

I conclude this brief essay with the following:

1) Marine placer mining, particularly of the noble metals, is already a profitable business.

2) Some problems are only perceived as such; e.g., there is no serious lack of risk capital, the environmental concerns of a decade ago have been overcome, and there is no evidence of a lack of promising mining sites in Federal and state waters.

3) There are some problems that, while not curtailing activity, do slow the growth of marine placer mining, notably the lack of realistic regulations for operations in the Exclusive Economic Zone, the lack of technology to cope with *in situ*, rapid metal surveys over large areas of seafloor, the lack of an on-line system to recover ultra-fine particles of economic minerals at sea, the lack of equipment to mine under ice, and the lack of sufficient trained personnel to undertake expanded exploration/exploitation of marine placers now. Suggested solutions for each of these have been given.

4) In summary, marine placer mining has proven to be a viable, profitable venture for industry, as confirmed by the current gold mining in the Bering Sea, off Alaska. It costs much less to find and mine placers than it does for deep-water deposits. Likewise, there are numerous placer prospect sites in shallow waters off other states, chiefly California, Oregon, Washington, off the Atlantic Coast, and I judge, off some coasts of the Commonwealth of Puerto Rico, and the former Trust Territory of the Pacific, now reorganized.

On Ship Off Alaska, All That Glitters Is Gold From Sea Floor

* * *

Former Tin-Mining Dredge Is Hauling Up a Treasure Of $14 Million for Summer

By KEN WELLS
Staff Reporter of THE WALL STREET JOURNAL

NOME, ALASKA—A rainbow arcs from a snowy mountain, casting a translucent leg onto the Bering Sea.

"Now you know why we're here," says Peter Bosse, an engineer for Inspiration Gold Inc. as he boards the Bima, the world's largest ocean-going mineral dredge.

He and the other crewmen of the Bima actually are here for the gold at the end of the rainbow. The pot of gold—in this case a rusting Hills Brothers coffee can used as a repository for the dredge's gleanings—is situated in a sealed room of the dredge, named for a Malaysian goddess of fortune.

The Bima, tugged 6,500 miles from Singapore into the waters offshore from this historic gold-mining town, is making the first large-scale effort to mine gold from the sea floor.

Tons of Anchors

Clamped to the bottom by 81 tons of anchors, the 14-story-tall Bima is essentially a battleship-sized gold-panning machine. The dredge uses 137 giant steel buckets on an escalator poking into the sea to scoop up gravel and silt, delivering about 11,000 tons a day into vast hoppers. Rocks and an occasional starfish are hosed down chutes for a noisy return to the sea.

What remains is sifted through fingernail-width wire mesh, eventually ending up on so-called shaking tables. On these tables, millions of tiny flecks of gold, and a few nuggets, are separated from the debris, forming a thin stream of gold flowing unceremoniously into the coffee container. By October, when the Bering Sea freezes and ends the Bima's first full summer of operation, the stream should accumulate 30,000 ounces of gold, worth roughly $14 million. Though the Bima has only 48 workers—an odd collection of geologists, adventurers, civil engineers and 15 Eskimo workers—its output rivals the annual production of a modest-sized U.S. gold mine.

Inspiration Resources Corp., the New York-based parent of Inspiration Gold, won't say whether the dredge is profitable yet, though Dennis Josephson, the project's manager, hints that, given the first-year production results, the Bima will probably be busy for the next five to seven years working its state-owned lease area off Nome.

Prototype Glitches

Yet company officials also concede that production fell 10,000 ounces short of its own expectations, in part because of technological snags. Though the Bima's success may spur others to get into the ocean gold-dredging business, the Bima currently is a "prototype" experiencing usual prototype glitches, says Jake Timmers, Inspiration Gold's president.

Then there is Alaska's climate. "Weather has been our big problem," Mr. Josephson says. The waters off Nome didn't thaw enough to permit work until mid-June, and the Bering Sea is a notorious storm cradle. The Bima was forced to close down for several full days this season

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On Ship Off Alaska, All That Glitters Is Gold From Sea Floor

Continued From First Page

when huge winds and waves made dredging impossible.

Walruses can cause problems, too. Three times this summer, they have taken rides up the Bima's bucket lines, causing work to stop. Because the huge mammals are an important source of food and ivory to the Eskimos who make up 60% of Nome's 3,700 population, dredge operators try to avoid mangling them. In one case, a worker found himself slowly herding a grumpy bull walrus a bucket at a time down the Bima's 270-foot-long bucket ladder.

The Bima began life in 1979 as a lowly tin dredge working Indonesia's tropical waters for a European concern. But when the tin market went bust in the early 1980s, the Bima was idled. About the same time, Inspirational Resources was concluding that the relatively shallow depths off Nome were worth mining. The location, says Mr. Timmers, had been seriously studied by a number of minerals concerns since 1964 and seemed a "logical" place for exploration, given Nome's golden past.

Nome's gold fields have yielded about four million ounces of gold since 1898, when three Swedish prospectors dug up the first nuggets, including an astonishing 11.4 pounder, on the outskirts of town. Because glaciers are thought to have pushed Nome's gold out of the mountains about a million years ago, and because 50,000 ounces were panned from the town's beaches in a single year, prospectors always thought that the gold might easily have migrated beyond the water's edge.

As miners eventually moved into the sea, however, they had less luck, says Mark Bronston, an Inspiration Gold geologist. [illegible] tried gold panning in the surf's 45-degree temperatures. Dredging efforts with "all manner of contraptions" habitually failed, he adds. Not long ago, a small dredging concern customized an oversized road-grader for dredging in shallow waters off the beach. But the grader's elephant-sized tires, designed to allow it to navigate the shallows, caused it to float away helplessly.

Mr. Timmers thought the massive 565-foot-long Bima might do the trick. In 1985, Inspiration Resources bought the out-of-work dredge for about a tenth of its original $40 million value and towed it from Singapore to Nome. After a successful test dredge in the summer of 1986, the Bima was towed to Seattle for a $15 million overhaul and returned here this June.

The Bima extracts gold in much the same way as Nome's turn-of-the-century miners, but on a far grander scale. Because gold is heavier than the elements around it, it eventually gravitates to the bottom of a container as other sediments are sifted out. The Bima lifts its ore in two-ton gulps, rids itself of coarse rock with high-pressure hoses and uses the big mechanized shaking tables to separate out the fine particles of gold.

Vernon Kugzruk, one of the Eskimos on the dredge, spends 12 hours a day directing the thin stream of gold into the coffee can and making sure the shaking tables don't stop shaking—a development that would grind all work to a halt.

Though the Bima's workers sometimes grouse about its seven-day work week, few complain about pay, which ranges from $25,000 to $35,000 for the short summer season. For gold-crazy Nome, where construction workers routinely pan the materials they have excavated at construction sites, the Bima has brought new jobs and a flush of excitement. After all, says Lois Wirtz, director of the town's visitors' bureau, "there are still old-timers in Nome who use gold as a medium of exchange."

METAL PRICES

American Metal Market
Monday, Sept. 26, 1988

Aluminum, cents/lb	
LME, 99.5%, spot close	105.29
Comex, 99.7%, closing, Dec.	108.00
Mar.	102.00
N.Y. merchant, 99.7%, 9/20/88	112-114
Antimony, $/lb	
Merchant, 9/20/88	1.05-1.10
Antimony oxide, 5/27/88	1.43-1.71
Beryllium copper, $/lb, 8/17/87	
Strip (No. 25)	8.00
Rod, bar, and wire (No. 25)	8.90
Bismuth, $/lb, ton lots	
Merchant, 8/8/88	5.90-6.25
Cadmium, $/lb, ton lots	
Producers, 5/23/88	10.60
Chromium, $/lb, 1/6/88	
Electrolytic metal, standard	3.35-3.40
Cobalt, 99%, $/lb	
Afrimet, f.o.b. New York	
Cathodes, etc., 1/21/88	7.25-7.50
Powder, 1/21/88	13.84
Extra fine, 1/21/88	16.75
Sherritt Gordon	
"S" powder, 1/20/88	7.75
Copper, cents/lb	
LME, Grade A, closing	
cash bid	112.87
three month	108.69
Comex, Grade 2, Sept. closing	119.60
U.S. producers, wirebar	119.5-125
cathode full plate	118-122
N.Y. merchant, cathodes, Oct.	120.1-121
Ferrochrome, cents/lb of chromium	
60-65%, 7/6/88	75-80
Ferromanganese, cents/lb of manganese	
Medium carbon, 1/6/88	36-37
Gallium, $/kg	
Eagle-Picher, f.o.b. destination, 8/1/83	
99.99999%, lots over 100 kg	525.00
99.99%, lots over 100 kg	435.00
Imported, f.o.b. warehouse	
99.9999%, 3/1/86	460-490
Gold, $/tr oz	
Zurich	400.00
Paris	400.83
London	400.35
Handy & Harman, N.Y.	400.35
Engelhard bullion	401.68
Engelhard fabricated	421.76
Iridium, $/tr oz	
Producer, 7/13/88	305.00
Lead, cents/lb	
U.S. and Canadian producers, 9/8/88	38-40
Secondary fabricated, 9/1/88	41-42
London Fix, $/mt	
Rudolf Wolff, spot	605.77
Rudolf Wolff, three month	608.35
Lithium, $/lb	
99.9%, 1,000-lb lots, 10/1/87	25.45
Carbonate tech.,10/1/87	1.55
Magnesium, cents/lb, 5-st lots	
Ingots, 99.8%, 9/1/88	156
Grinding slab, 9/1/88	158
Sticks, 1.3-in.-dia, 6/1/88	218
Manganese, cents/lb	
Electrolytic, 99.9%, 7/1/88	91
Mercury, 99.9%, $/flask	
New York prompt, 9/22/88	330-350
C.i.f. European port, 8/30/88	305-315
Molybdic oxide, $/lb	
Producer, 3/14/88	3.65
Nickel, $/lb	
Melting briquettes, 9/22/88	5.03-5.10
N.Y. merchant, spot, 9/22/88	5.10-5.20
Palladium, $/tr oz	
London p.m. fix, 9/23/88	119.25
New York Merc., Sept. close	120.60
Platinum, $/tr oz	
London p.m. fix, 9/23/88	496.25
New York Merc., Oct. close	490.60
Engelhard fabricated	596.25
U.S. merchant, 9/21/88	493.00-495.00
Rhodium, $/tr oz	
Producer, 9/21/88	1,210
Merchant, 9/21/88	1,200-1,210
Ruthenium, $/tr oz	
Producer, 3/21/88	67.00
Merchant, 8/17/88	62.00-67.00
Silver, cents/tr oz	
Engelhard bullion	628.00
Engelhard fabricated	672.00
Handy & Harman, N.Y.	626.50
London fix, spot	623.75
six months	650.25
twelve months	679.10
Zurich fix	623.25
Tin	
Kuala Lumpur spot, ringgit/kilo	19.80
Spot exchange, U.S.$/ringgit	0.375
AMM N.Y. ex-dock, $/lb	3.57
Titanium $/lb	
Sponge, 7/25/88	4.20-4.50
Sheet, Grade 2, 1/9/87,	8.50-8.75
Uranium, $/lb U_3O_8	
Nuexco, 8/31/88	14.15
Zinc,	
European producers, GOB, $/mt, 9/6/88	1,275-1,350
Other producers, cents/lb, 9/2/88	
High grade	66.0-69.0
Continuous galvanizing	66.5-69.5
Special high grade	66.5-69.5
Prime western	66.5-69.5
U.S. Producers, die casting alloys	
No. 3, 9/13/88	77.5
No. 5, 9/13/88	78.5
Zirconium, $/lb	
Powder, 1/1/88	70-150
Sponge, 1/1/88	12-18

LME, first session, Sept. 23, 1988

Settlement price (*) is the same as the first session cash asking price. All prices in pounds sterling per mt, except silver, in $/tr oz, and aluminum and nickel, in $/mt.

	Bid	Ask	Sales
Aluminum - Standard			
Cash	1,388	1,390*	2,350 mt
3 mos.	1,365	1,370	
Aluminum - High Grade			
Cash	2,390	2,400*	2,950 mt
3 mos.	2,365	2,387	
Copper - Grade A			
Cash	1,474.5	1,475.5*	16,300 mt
3 mos.	1,426	1,427	
Copper - Standard			
Cash	1,405	1,415*	Nil mt
3 mos.	1,375	1,385	
Lead			
Cash	363	364*	1,850 mt
3 mos.	368	368.5	
Zinc - High Grade			
Cash	1,325	1,330*	8,400 mt
3 mos.	1,285	1,286	
Nickel			
Cash	10,900	11,000*	348 mt
3 mos.	10,350	10,400	
Silver - 10,000			
Cash	6.19	6.20*	Nil oz.
3 mos.	6.31	6.32	
Silver - 2,000			
Cash	6.19	6.20*	Nil oz.
3 mos.	6.31	6.32	

OCEAN THERMAL ENERGY CONVERSION: A MULTI-PRODUCT ENTERPRISE

by

Patrick Takahashi, Luis Vega, Elizabeth Udui
Pacific International Center for High Technology Research
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U.S. Department of Energy

ABSTRACT

While the ocean thermal energy conversion (OTEC) concept is more than a century old, it is only during the past decade that major technological breakthroughs have occurred. Mini-OTEC, off the big island of Hawaii, showed in 1979 that the Closed-Cycle option could produce net power. More recently, the concerns about biofouling and high cost of heat exchangers have been resolved through research, and Closed-Cycle OTEC only awaits a more favorable economic climate for commercial development.

Open-Cycle and Hybrid-Cycle OTEC remain untested, with turbine uncertainties needing to be addressed for the former and the evaporator for the latter. Cold-water pipe development also needs further research.

During the early 1980's, large OTEC plantships of several hundred megawatts were the planning vogue. Current plans target 1 to 10 megawatt (MWe) land-based plants. At these smaller sizes, the co-products of food, air conditioning, mariculture, biopharmaceuticals, and fresh water become important revenue producers. These size modules show potential for upgrading the entire economy of island nations. The Pacific International Center for High Technology Research (PICHTR) has reported that virtually every Pacific Island nation has the natural conditions to utilize the technology.

The transition to full commercialization will be accomplished through fabrication of a few 1 to 10 MWe Closed-Cycle plants and larger numbers of similar-sized Open-Cycle facilities, since the integrated multi-product OTEC systems are now cost effective in selected island communities. As the world moves into the 21st century, larger scale plants could gain wider acceptance, depending upon the price of conventional energy sources; the need for special applications, such as processing seabed ore, producing fertilizer, or transportation fuel; and the seriousness of the greenhouse effect.

INTRODUCTION AND THEORY

All Ocean Thermal Energy Conversion (OTEC) systems make use of the temperature difference between the cold, deep seawater--transported to the surface from depths of 2,000 to 3,000 feet--and sun-warmed surface water to generate electricity. The advantage of the Open-Cycle option is that in addition to electricity, synergistic processes can also make use of the nutrient-rich, pathogen-free, cold water from the deep ocean. Processes include mariculture, production of fresh water for human consumption and agricultural uses, and chilled water for air conditioning.

Closed-Cycle OTEC, which was first proposed in 1881 by Jacques d'Arsonval, a French engineer, became a reality in 1979 when Mini-OTEC (mounted on a barge moored about two kilometers off Keahole Point in Hawaii) produced 50 kilowatts of gross power and up to 18 kilowatts of net power. Georges Claude, d'Arsonval's student, first proposed Open-Cycle OTEC in the 1920's and demonstrated its technical promise in 1930 in Cuba. However, Claude was not able to attain net positive results.

There are three common types of cycles employed to convert differential heat to electricity: Closed Cycle (CC), Open Cycle (OC), and Hybrid Cycle (HC). Because fresh water is an important co-product for Pacific-wide applications, PICHTR considered only the latter two. Three technologies are described below.

The basic concept of ocean thermal energy conversion is to extract energy from the temperature difference between surface and deep ocean waters. Solar energy has been absorbed and stored as heat in the upper layer of the ocean; cooler water from arctic regions lies below. The cost of energy recovery drops as the temperature differential increases. The temperature difference between the surface layer and water 1,000 meters deep is at least 20°C in equatorial areas year round. The map in Figure 1 shows the distribution of the world's OTEC thermal resource.

Further north or south of the equator, the maximum temperature difference is less and it varies over the year. Thus, OTEC is best suited to equatorial regions. Because of the relatively small temperature difference, enormous volumes of warm and cold sea water must pass through the facility to generate a given power as compared to cooling water requirements of a typical fossil fueled generating plant.

The availability of huge quantities of ocean thermal resources allows the possibility of very large OTEC baseload plants. OTEC plan concepts range from shore mounted plants with ocean intake pipes to fixed and moored offshore plants to drifting plantships.

Closed Cycle. In the closed cycle plant, warm surface water is used to evaporate an auxiliary working fluid such as ammonia or Freon. The vaporized working fluid drives a turbine which in turn drives an electrical generator. Cold water from the deep ocean is used to condense the vapor after it has passed through the turbine, much like in a steam power plant. The working fluid returns to the evaporator to be recycled. The Mini-OTEC demonstration plant, operated in 1979 in Hawaii by the State, Dillingham Corporation and Lockheed Corporation is an example of this system. Figure 2 shows the schematic for this system.

Open Cycle. This cycle evaporates surface seawater (25°C) in a vacuum chamber. The warm seawater vapor is used as a very low-pressure (0.35 psi) working fluid to drive a turbine generator set to produce electricity. After passing through the turbine, the vapor enters a condenser. The surface condenser permits cold seawater (5°C) to flow on one side of a heat exchanger and the condensate to form on the other side. The condensate becomes desalinated water. Figure 3 shows the schematic for this system.

Hybrid Cycle. The steam generated in the vacuum chamber, as in OC-OTEC, is used as a heat source to evaporate a working fluid such as ammonia or Freon. The advantage of this concept is that the turbine technology for these working fluids is much better understood. The limiting technologies specific to the HC-OTEC are the design parameters and performance characteristics of the seawater evaporator and the heat exchanger that serve as both the seawater vapor condenser and working fluid evaporator. Figure 4 shows the schematic design for this system.

UNITED STATES RESEARCH PROGRAM

The U.S. OTEC program began in 1972 at the National Science Foundation. In 1975, the OTEC program was transferred to the Energy Research and Development Administration (ERDA) and to the U.S. Department of Energy in 1977. Operational and ocean engineering aspects of the program were given to the Department of Commerce. Starting in 1977, the National Oceanic and Atmospheric Administration (NOAA) provided technical, engineering, and management assistance to DOE in developing ocean engineering technology for OTEC applications. The major elements of NOAA's work were the development of concepts for OTEC platforms or vessels; seawater transfer systems, including the large cold-water pipe; and mooring and foundation systems. The NOAA program was phased out in 1983.

Early efforts in OTEC were aimed primarily at feasibility and component studies. More recently, the effort has shifted to experimental hardware efforts to confirm seawater performance of fresh water based hypotheses. In 1979, technical viability of the closed cycle was demonstrated with an experimental 50 kWe "mini-OTEC" barge-mounted power plant off Keahole Point, Hawaii. Momentum from this technical success carried into 1980 when the U.S. Congress passed two important pieces of legislation that directly impacted OTEC development and utilization. The two laws--the OTEC R&D Act (P.L. 96-310) and the OTEC Act of 1980 (P.L. 96-320)--form the basis of the U.S. government's continuing role in developing the OTEC concept through R&D and in influencing the economic analysis through specification of the costing approach and financing assistance.

In 1980, a component engineering research vessel known as OTEC-1 began testing of closed-cycle heat exchangers and a bundle of three cold-water pipes, each 1.2 meters in diameter. The tests validated the heat-exchanger designs. A realistic, at-sea test of major OTEC sub-systems such as cold-water pipe designs, condensers, evaporators, and other major components was also completed.

In 1981, a Program Opportunity Notice (PON) dealing with the conceptual design of a 40 MWe OTEC system was announced by the U.S. Department of Energy, and design contracts were awarded to General Electric Corporation and Ocean Thermal Corporation. Following review of the conceptual designs, DOE asked Ocean Thermal Corporation to proceed with the preliminary design of a 40 MWe shelf-mounted unit in Hawaii at Kahe Point. The project did not proceed beyond a preliminary engineering design phase due to funding restrictions.

In the United States, research on closed-cycle systems concentrated on heat exchangers. Recently, Argonne National Laboratory found that modified brazed aluminum heat exchangers appear to be able to last more than 30 years in the warm seawater environment of an OTEC plant. In addition, Argonne discovered that biofouling will not be a problem in warm seawater if intermittent chlorination at levels far below U.S. Environmental Protection Agency standards is carried out for one hour a day.

Since 1978, the major thrust of research on Open-Cycle OTEC has been directed by the DOE-funded Solar Energy Research Institute (SERI) and Argonne National Laboratory (ANL). Emphasis has been directed toward evaporators, surface condensers, direct-contact condensers, mist elimination, deaeration process, and vertical spout evaporators. SERI, ANL, and the Pacific International Center for High Technology Research (PICHTR) have combined forces to build an experimental facility designed to allow testing of the OC-OTEC subsystems under actual operation conditions utilizing seawater.

Since 1986, PICHTR has selected as its highest priority project Open-Cycle OTEC. PICHTR is a non-profit corporation involved in technology topics which have potential for having a positive impact on the Pacific region. Emphasis is placed on international cooperative research and development projects, combined with education and technology transfer to promote economic development.

The laboratory for this work is the National Energy Laboratory of Hawaii (NELH), located at Keahole Point on the island of Hawaii. Five cold seawater pipelines up to 40 inches in diameter are available. Water is pumped for distribution to the various projects at the facility. Additional pipelines for the warm surface seawater are available.

The Heat and Mass Transfer Scoping Test Apparatus (HMTSTA) was built at Keahole Point by DOE to obtain data necessary for the design of a net power-producing systems experiment (NPPE). In August 1987, SERI, in collaboration with Argonne National Laboratory, produced 350 gallons per hour of fresh water from seawater under prototypical Open-Cycle OTEC conditions. No turbine is yet in place between the evaporator and condenser at the laboratory, but turbine development undertaken by the U.S. Department of Energy and PICHTR shows promise for the entire system to be operational by the early 1990's.

Thus during the past few years, the U.S. Department of Energy has marshalled significant progress in OTEC development. Figure 5 summarizes the advancements in one of the areas of technology obtained and to be expected in the 1982-1991 period.

A key breakthrough combination was the confirmation of aluminum as the base metal for heat exchangers with the use of small amounts of "natural" chlorine to prevent biofouling. Figure 6 depicts this improvement.

The U.S. Department of Energy has reported that a long-range goal for OTEC is attainment of $3,200/kWe as the projected capital cost in 1984 dollars. A 30-year levelized electricity cost of 6 cents/kWe is targeted. Table 1 provides various short, interim and long range goals.

The U.S. Congress has earmarked $3.5 million for two consecutive years to support the PICHTR/USDOE OTEC NPPE project. The funding is primarily for Open-Cycle OTEC with a budding interest in the hybrid system. The Ministry of Foreign Affairs of the Japanese Government has provided to PICHTR $1 million per year for two years now to survey co-products, socio-economic, and environmental aspects of the OC-OTEC system. PICHTR, furthermore, is discussing with Tonga, American Samoa, Northern Marianas, Guam, Western Samoa, Papua New Guinea and Taiwan the design and installation of pilot and pre-commercial plants up to 5 MWe. The Taiwan plan is furthest along, calling for a $61 million total system 5 MWe plant in five years, with a mariculture facility on line by 1991. Two packages, each worth $40 million, to build 2 to 5 MWe facilities, are being discussed with Tonga and American Samoa.

VALUE OF COLD WATER AND MULTI-PRODUCT OPTION

OTEC electricity, combined with one or more potential co-product industries, is an attractive, renewable energy and product source. Although OTEC has been experimentally demonstrated to be technologically sound, some design and economic uncertainties remain to be resolved before it can be pursued on a commercial basis.

To improve the overall economics of the total OTEC system, recent development plans include utilizing the nutrient-rich, pathogen-free, cold water from the deep ocean. Table 2 shows the water quality data from the seawater delivered to the facility at NELH. Products might include mariculture, fresh water for human consumption and agricultural irrigation, greenhouses with temperature controlled by cold water, and use of chilled water for air conditioning.

The entire system of co-products has been developing at a faster pace than OTEC electricity, primarily because the private sector has been able to attract funding to carry on the pre-commercial work. There is considerable need, however, to package the total system for specific locations, as many of the co-products will be site-specific due to market factors.

Table 3 shows potential OTEC co-products correlated with temperature.

Mariculture. The ability to provide flexible, accurate and consistent temperature control, high-volume flow rates, and seawater relatively free of biological and chemical contaminants leads to a natural synergism that can be translated into a saleable product. The cold water contains 200 times more nitrates and 20 times more phosphates than surface water. Organisms already grown in this environment at the Natural Energy Laboratory of Hawaii (NELH) site in Hawaii, include salmon, trout, nori (seaweed popular in Japanese diet), opihi, lobsters, abalone and both macro and micro algae. Some of these products require flows of cold water well within the volumes currently available for the OTEC operations at NELH. Other products' values are high enough so that costs of production can be recovered and profitability ensured even considering the high cost of the deep-ocean pipeline.

As an instance, to exploit this attribute of the OTEC water, it would be logical to culture an aquatic plant such as algae first. The aquatic plant could then be used either as a direct product or a feed for seafood life. Although a number of species have been identified as technically feasible, further work needs to be done to identify the culture method, scale size, and potential markets for mariculture products. The development of a viable mariculture system in conjunction with OTEC is species and site specific.

Fresh Water. The condensate of the OC and HC systems is desalinated water, suitable for human consumption and agricultural purposes. When flash-evaporated and condensed, the resulting water is less saline than water provided by the local water supply system in Honolulu. Market value of this water in the Pacific Islands ranges from $1 to $4.60 per kilogallon, and may even be higher where there are no ground water resources.

Refrigeration. The deep ocean cold water can be used as a chiller as well as the basis for an air conditioning system. The laboratory at the Natural Energy Laboratory of Hawaii (NELH) is air conditioned by passing the cold water through a heat exchanger.

Agriculture. Another possible use of cold seawater would be burying an array of cold-water pipes in the ground to exchange their temperature with that of the soil. This would be beneficial in many tropical islands where certain cool-weather plants cannot be grown. An equally important use of this system is drip irrigation from the atmospheric condensation on exposed cold-water pipes.

PICHTR has calculated the effect of co-products in conjunction with production of power. Table 4 indicates potential annual sales potential for a 1.5 MWe (net) OC-OTEC plant on a 6 hectare site. Note that while the sale of electricity appears to be the highest revenue earner, mariculture could quite readily be significantly greater should the product value and not the cold water sold be the sum considered. For example, a pearl culture operation alone could have annual revenues far in excess of $10 million. Also, too, for the developing tropical countries where OTEC is feasible, the social benefits from OTEC might far outweigh economic factors. Some of the benefits include:

1. An inexhaustible supply of clean energy
2. Energy self sufficiency
3. Avoided cost of fuel for power plants
4. Minimal environmental impact
5. Other beneficial uses of deep water not considered
6. Avoided cost for fresh water catchments and well-drilling
7. Improved sanitation and nutrition for inhabitants.

WORLDWIDE DEMONSTRATIONS

Japan, Jamaica, The Netherlands, France, and Taiwan have also engaged in OTEC activity. Japan is currently the most active with a recently formed OTEC Association of Japan involving 25 major corporations and the Ministry of International Trade and Industry (MITI).

In 1974, the "Sunshine Project" marked the beginning of OTEC R&D in Japan. In 1981, a 100 (35 net) kWe land-based OTEC plant was built and operated by the Tokyo Electric Power Co., Inc. and Toshiba Corporation in the Republic of Nauru. This was a Closed Cycle plant using Freon as the working fluid. In 1982, the Kyushu Electric Power Co., Inc. completed a 50 KWe OTEC plant in Tokunoshima, Japan. In 1985, a 75 kilowatt Thermal Fluid Simulation Plant was completed at the University of Saga, Japan.

In Jamaica, OTEC investigations were underway in the early 1980's sponsored by the Petroleum Corporation of Jamaica, in cooperation with the Swedish and Norwegian governments. A preliminary design for a 1 MWe, shore-based closed cycle-plant was prepared. Cost was estimated at $16 million, but no funding was identified and the project did not go forward.

The Netherlands and the Government of Indonesia completed a feasibility study and preliminary design for a 100 KWe system in Bali. Construction was scheduled to begin in 1984 but did not take place.

Following Claude's efforts, the French Government continued work on both Closed- and Open-Cycle systems. In the 1980's, a 3 MWe plant was designed for Abidjan, Africa, but it was never built. Floating Open-Cycle 7 MWe and Closed-Cycle 10 MWe plants were considered competitive with diesel powered plants in Tahiti. Feasibility of a 5 MWe plant for Tahiti was studied and temperature and topographic surveys were conducted. Problems with the cold-water pipe and overall costs have prohibited the French from building a plant. They are cooperating with the PICHTR effort by providing experimental information.

Taiwan has asked PICHTR to assist in developing a strategic plan for OTEC commercialization. At this time, installation of a 5 MWe CC-OTEC plant on its eastern coast is being considered.

POTENTIAL WORLD MARKETS

The United States now leads the world in the development of OTEC technology. When the remaining technical and economic uncertainties are resolved, penetration of the market in the near term is possible and in the long term likely. Of the three world-wide markets studied--U.S. Gulf coast region, Africa-Asia, and the Pacific islands--the Pacific islands are expected to be the initial market entry point for Open-Cycle OTEC based on the cost of oil-fired power to their governments, the demand for potable water, and the social benefits from this clean energy technology. Continued research and development spearheaded by the USDOE/PICHTR and the PICHTR/Japan efforts should lead to OTEC system designs in the Asian-Pacific region in the early 1990's.

Lyle E. Dunbar, in a 1981 survey, identified ninety-eight nations and territories with direct access to the OTEC thermal resource with their 200 nautical mile exclusive economic zones (EEZ). A market assessment study of 67 free market developing nations and U.S. territories followed to identify the potential for OTEC. The study assessed the OTEC resource, technology, market, and barriers and incentives to implementation of OTEC in developing nations. The results of the study indicated significant market potential for OTEC if the resource is within 2 nautical miles of shore (well within the EEZ) in most of the countries surveyed.

The United Nations Department of International Economic and Social Affairs also indicated the potential for OTEC in the developing countries. The World Bank indicated that developing countries' dependence upon imported oil affects the balance of payments of these nations negatively and takes away valuable resources which could be otherwise used for development purposes.

In 1987, PICHTR surveyed 26 Southeast-Asia and Pacific Island sites to determine their potential for this renewable energy resource. Total additional demand for power projected for these islands over the base year 1987 for the year 2000 was 2,953 MWe and in the year 2015, cumulative 24,898 MWe. In 2015, this represents a demand for about 250 plants of a ten megawatt size. Projections beyond 2015 to 2050 assume a tripling of the 2015 demand or at least 75,000 MWe. This would be 750 ten megawatt plants. If only 10 percent of these plants were constructed in the Pacific Islands, this would be 75 new OTEC plants. It would be possible to construct this many plants as they could be sited on individual islands within the 26 island groups. For example, in Western Samoa, at least 3 plants could be sited on the islands of Savai'i and Upolu.

Table 5 indicates the most attractive Pacific Island sites, based on the PICHTR 1987 survey. The rating process consisted of three stages or rounds. Throughout the rounds the rating was constant, i.e., no weighting was given to one category or another within a round. Each island was ranked relatively to the highest score, i.e., as a percentage of the maximum.

The market for OTEC in the Pacific Island countries depends on many factors. One thing is certain, it is the fresh water component and mariculture potential of OC-OTEC which has prompted six Pacific Island governments to request PICHTR to conduct studies of the feasibility of this technology for their islands. While the Pacific Islands are presently dependent on imported fuel for electricity generation, fluctuations in the price of oil do not seem a major determinant in their decision to request these studies. Even the availability of an inexhaustible, renewable, clean source of energy does not seem to be as attractive as the potential benefits of fresh water and mariculture for their economic development.

While the availability and cost of alternatives to OTEC may have some influence on the market, the costs of switching from diesel-fired power plants to another technology such as gas turbines, with all the accompanying difficulties in technology, have supported the Pacific Islands interest in OTEC as an alternative. The Asian and Pacific Island nations seem to be more influenced by the potential hazardous impact of current energy resources on their environment. OTEC promises a source of clean energy and little impact on the environment.

In summary, the Pacific Islands offer an immediate market for the 1 to 10 MWe OC-OTEC plants. Even though these OTEC plants have high initial capital costs, they can immediately compete with conventional diesel power on a cost basis, because of savings in fuel and additional revenues from co-products.

PICHTR-USDOE AND PICHTR-MOFA PROGRAMS

PICHTR's cooperative project with Japan involves technology transfer of the OC-OTEC system to selected Pacific island nations. PICHTR has been commissioned to develop a deployable OC-OTEC plant within a five-year period. The goal is a 1 to 10 MWe pilot plant on an appropriate Pacific island site. The data acquired will then serve as a base for the design, construction, deployment, and installation of similar plants to serve the Pacific island nations. PICHTR has determined acceptable levels of risk for technical, economic, social and financial factors, and has produced the following reports: *Socio-Economic Studies on the Commonwealth of the Northern Mariana Islands, Kingdom of Tonga and Western Samoa; Market Infrastructure of American Samoa; Rural Development Financing; Mariculture Applications;* and *Conceptual Design Methodology for Bottom-Mounted OTEC Pipes.*

Concurrently, in a separate effort, the U.S. Department of Energy through the Wind/Ocean Technologies Division with PICHTR assistance, will develop the Open Cycle concept to the point where the commercial sector can assess whether applications of the technology are viable in relation to present systems. This will be accomplished through resolving the technological problems that will permit the commercial development of land-based or near shore open-cycle OTEC systems ranging in size from 2 to 15 MWe. The DOE mission does not include the detailed design and construction of commercial OTEC plants, but PICHTR will work with the DOE on the development and acquisition of design data and will extend the federal government mission to bridge the gap to commercialization. DOE's primary objectives are to verify the predicted performance of critical technical aspects of the open cycle concept, reduce technical and cost uncertainties, and design cold-water pipes.

To accomplish these objectives, subscale model components will be built and separately tested by PICHTR at NELH. The components will then be assembled into a complete power plant and tested as a system, designated the net power producing experiment, NPPE. The model will be on the order of 165 KWe (gross), a system of sufficient size to permit extrapolation of performance and design data to power plants of larger size.

The current thrust of the project is to obtain experimental data using seawater as the working fluid to determine the performance of evaporators and condensers. The Heat and Mass Transfer Scoping Test (HMTSTA) apparatus uses 1,600 gallons per minute (gpm) of surface seawater and 1,000 gpm of cold seawater. Steam is produced at 0.44 to 1.02 pounds per second at 0.34 pounds per square inch vacuum and 77-81°F. This vapor is condensed to provide fresh water. A second system will supply up to 9600 gpm of warm seawater and 6,500 gpm of cold seawater to the NPPE, which will produce approximately 165 KWe of gross power.

The State of Hawaii, DOE, and PICHTR combined resources to install a 40-inch diameter cold-water pipe at NELH. The pipe system is 6,000 feet long and can pump fluid from a depth of 2,200 feet at a rate of 13,000 gpm. Deployment of the 40-inch pipe represents a significant accomplishment since it is the first time a pipe of this size has been located at so great a depth. The total cost of this pipe and related warm water and pumping components exceeded $7 million. There are now five cold-water pipes in place at NELH.

It should be noted that the cold-water pipe (CWP) represents a significant technical challenge to the goal of having an operating plant in a Pacific island in five years. The pipe must be sufficiently long for its intake to reach the cold depths of the ocean and must have a diameter large enough to accommodate the flow of massive quantities of water. A typical shore-based OTEC installation might require a CWP some 7,000 feet long, traversing the distance across the sloping sea bottom to a depth of 2,000-3,000 feet. If the OTEC plant were sized to produce say, 5 MWe, the pipe diameter would be on the order of 10 feet. The combination of length, depth and diameter, along with the need for a 30-year life--plus the need to minimize cost--presents a formidable challenge.

FUTURE SCENARIOS AND PROBLEMS

The combination of stable oil prices, growing environmental concern, need for freshwater, and drive for economic self-sufficiency will interest various equatorial islands in considering OTEC as a development option in the 1990's. In the 21st century, higher energy prices and expanded applications for OTEC could result in very large (1000 MWe) systems for processing seabed ores, producing fertilizer and transportation fuel, developing fisheries and generating baseload electricity.

The United States currently holds the technological edge over the rest of the world. It is imperative, though, for the private sector to participate in this developmental phase for American-led commercialization to occur. Blue chip corporations, however, are reluctant to commit financial and human resources unless a clear picture of profit can be envisioned.

SOLUTIONS AND CONCLUSIONS

During this perceived high risk period, it thus remains necessary for the Federal Government to offer the technical basis for meaningful industrial participation.

The strategy for making a case for the OTEC enterprise over the next few years might well be defense-related. The Pacific Exclusive Economic Zones (EEZ), for example, occupy immense territory. Perhaps a few OTEC facilities scattered throughout the region can gain friendships and thus strategic advantage.

Similarly, there is now a $6 billion strategic metals shortfall in minerals which are found in the EEZ, with a $2 billion surplus in other metals of our strategic stockpile. Perhaps, this could be explored as a source of funding to develop ocean resource options. It can be added that much of the critical mineral needs in the wanting areas are presently supplied by the Soviet Union, South Africa, and Zaire.

In conclusion, it is important that American leadership be maintained in the development of OTEC. We cannot afford to again lose control of a technology where we are the undisputed world leader, especially when there are compelling defense, energy, environmental, and economic development reasons for advancing the field.

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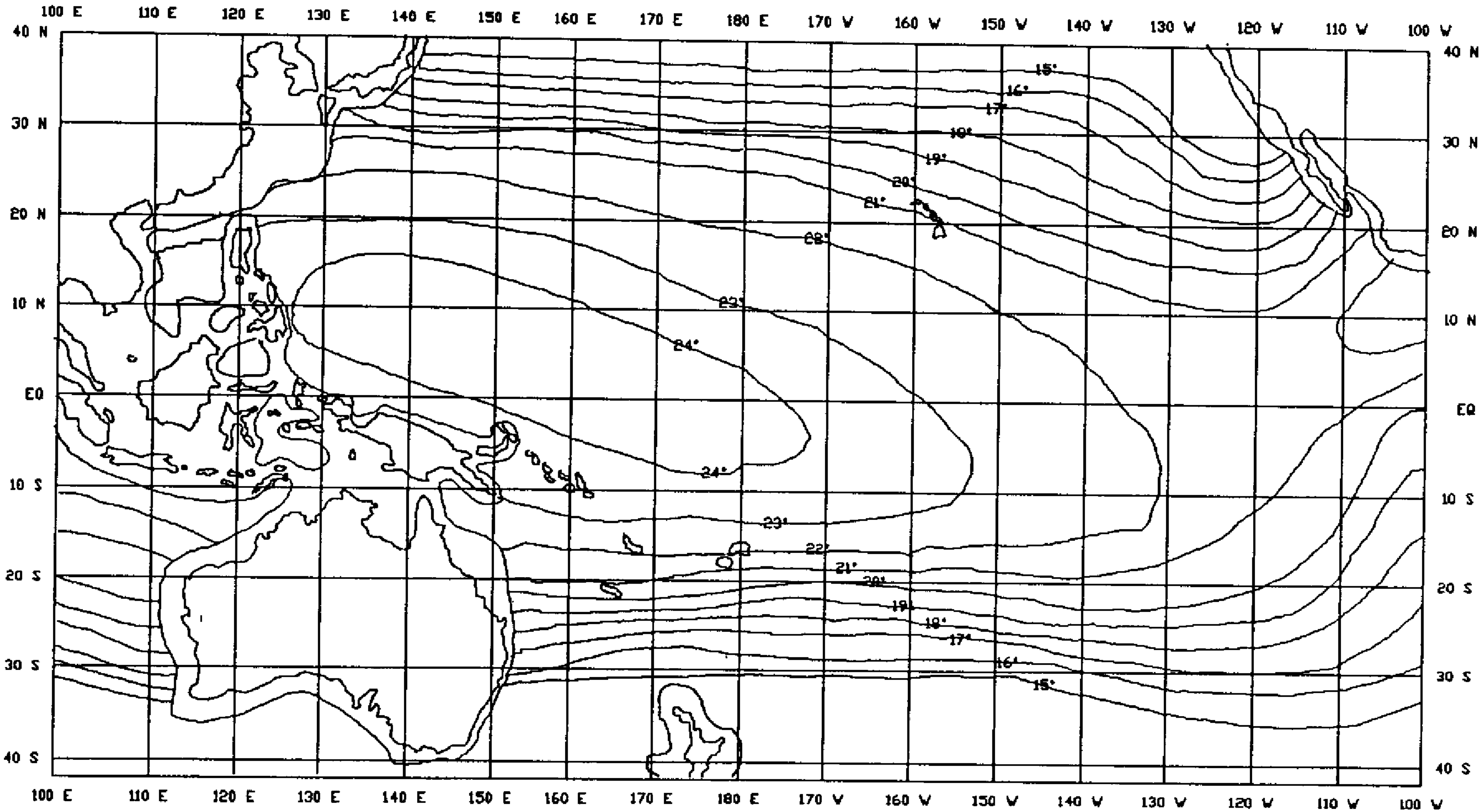
FIGURE 1

LARGE SCALE DISTRIBUTION OF OTEC THERMAL RESOURCE

ΔT(°C) BETWEEN SURFACE AND 1000 METER DEPTH



The OTEC Resource is available 24 hrs/day - 365 days/yr

FIGURE 2

SCHEMATIC OF A CLOSED-CYCLE OTEC SYSTEM

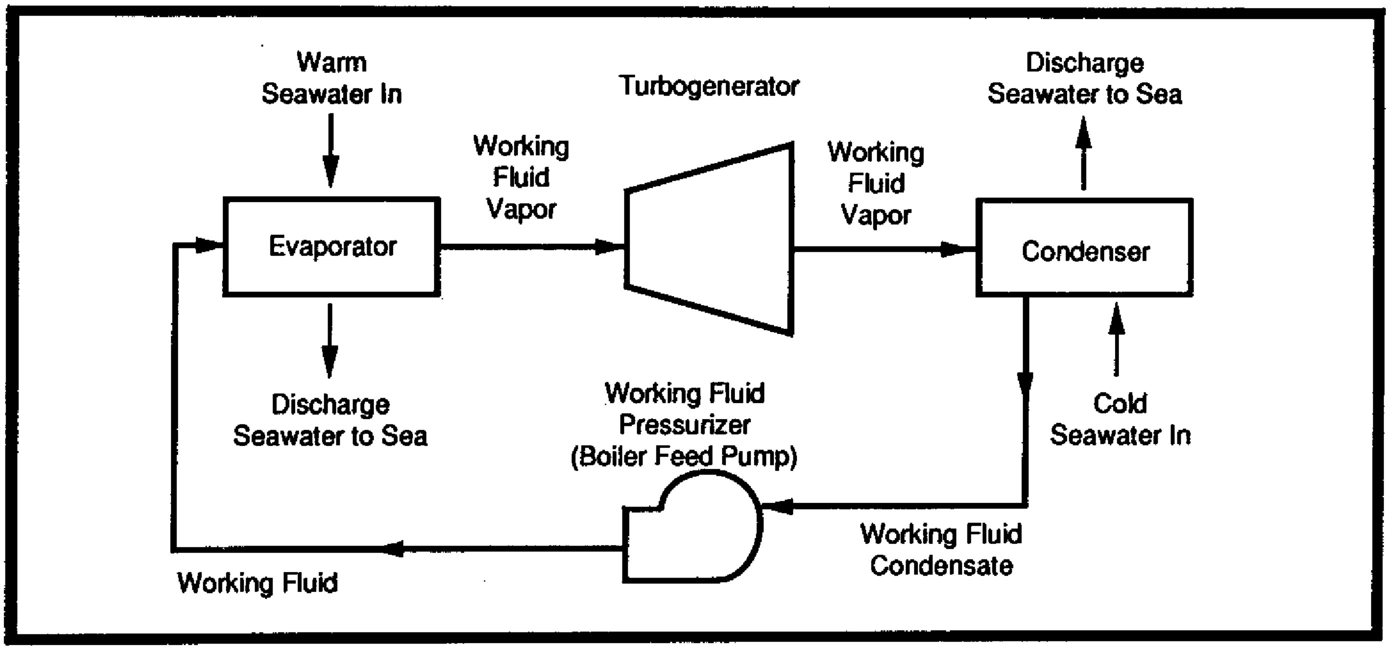


FIGURE 3

SCHEMATIC OF AN OPEN-CYCLE (CLAUDE-CYCLE) OTEC SYSTEM

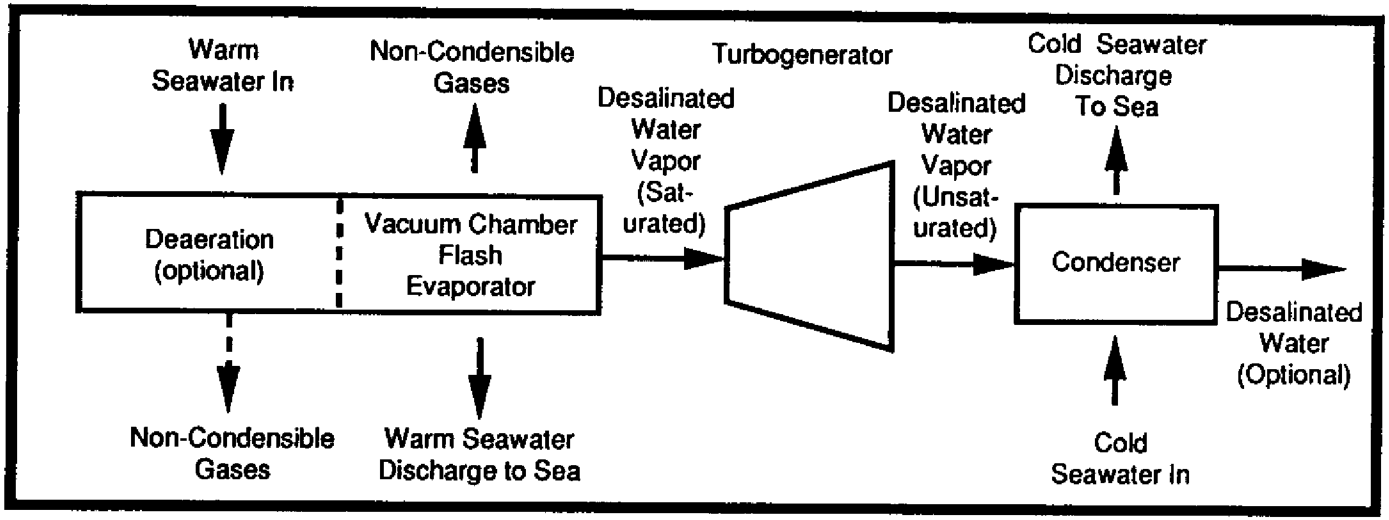


FIGURE 4
SCHEMATIC OF A HYBRID-CYCLE OTEC SYSTEM

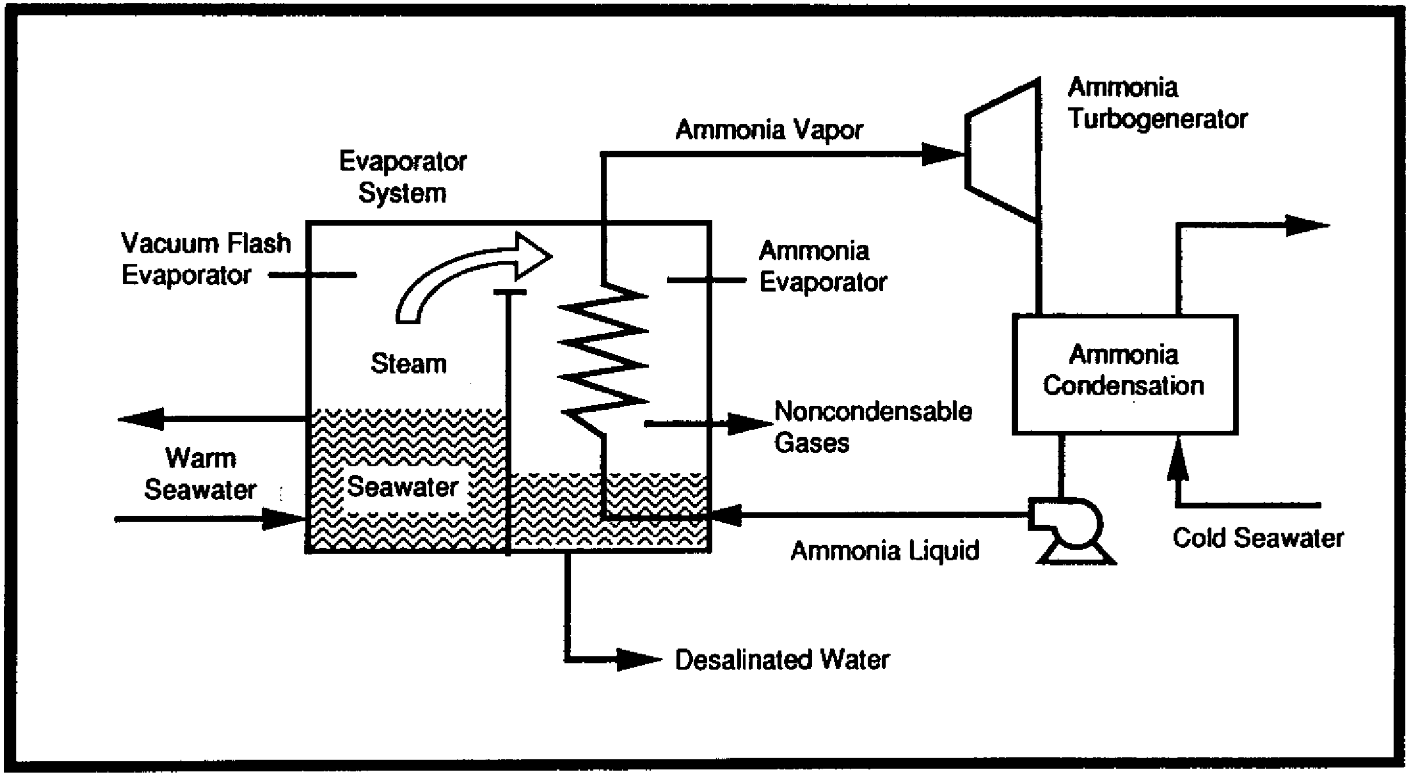


Figure 5.

CONTRIBUTION TO PLANT COST REDUCTION THROUGH HEAT EXCHANGER DEVELOPMENT

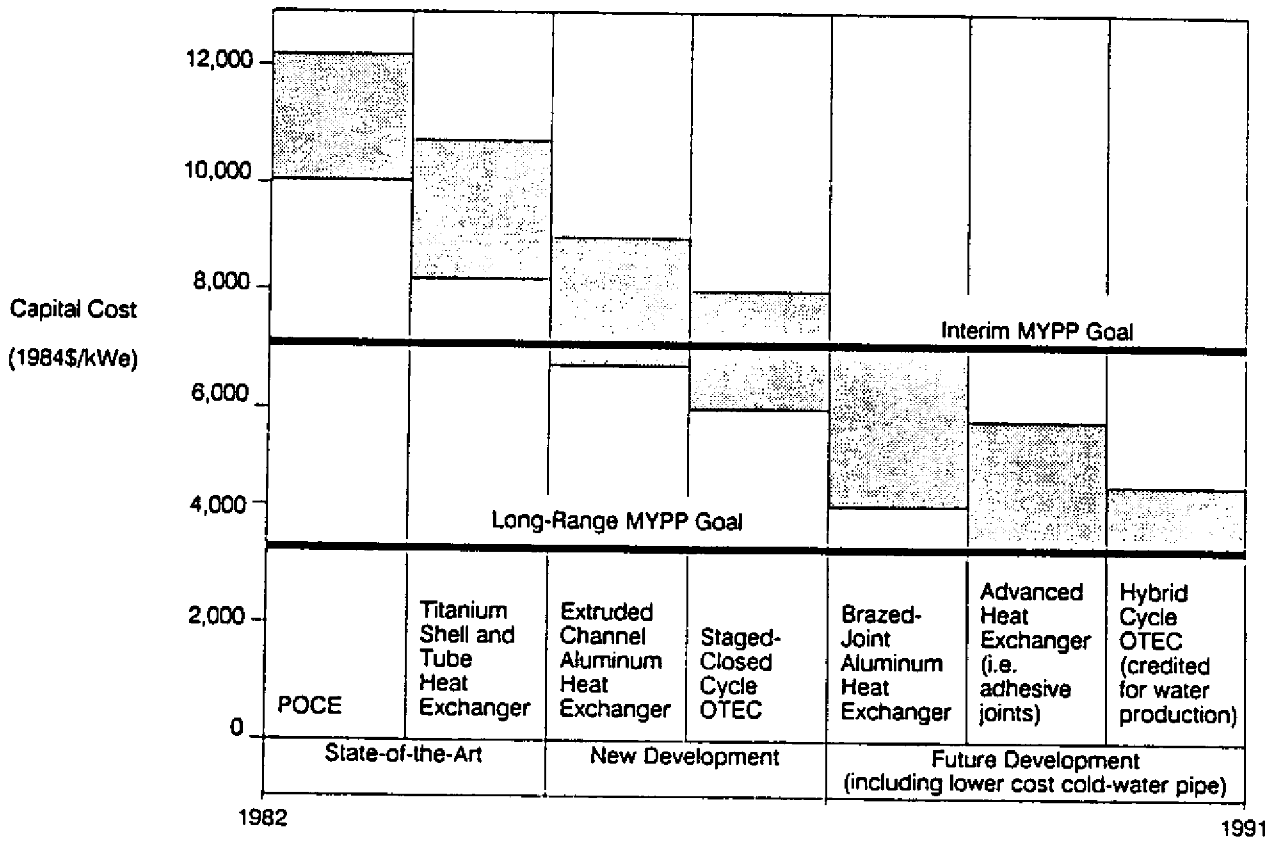


Figure 6.

PROGRESS IN BIOFOULING CONTROL

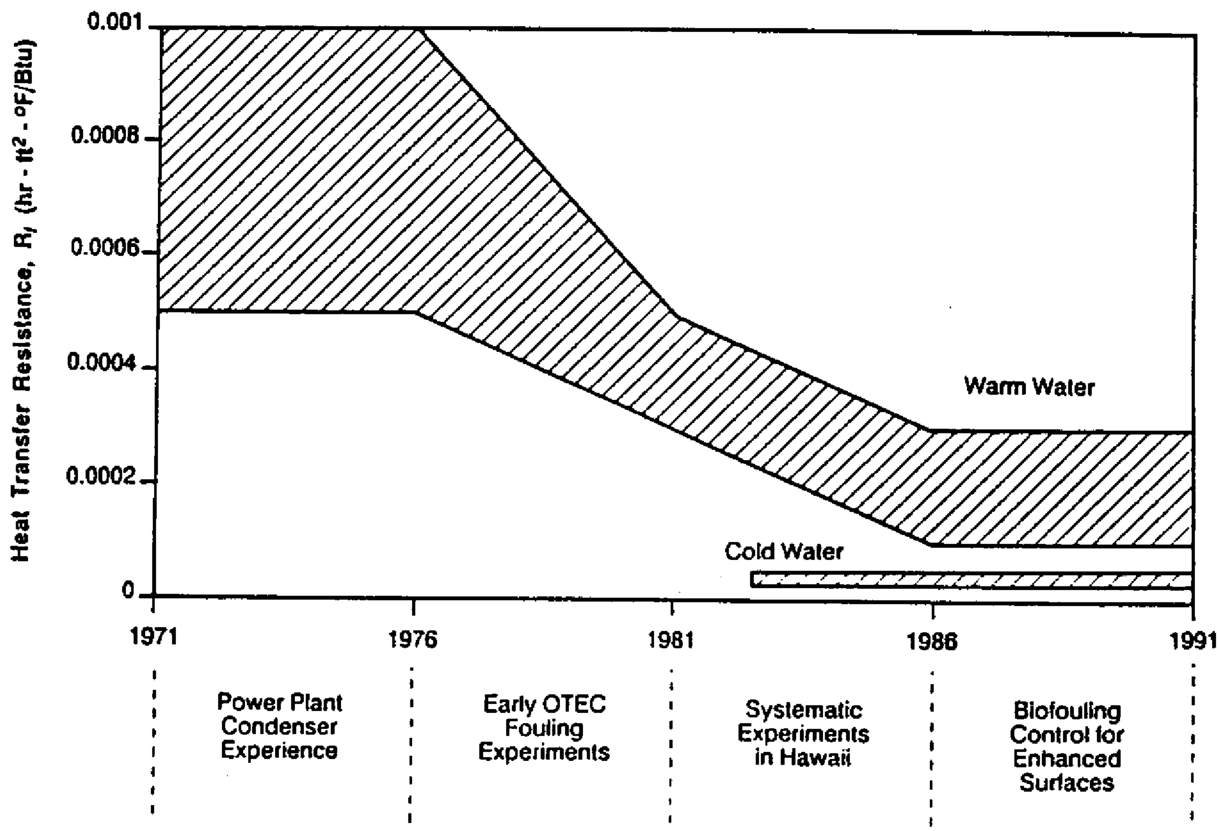


Table 1.

SHORT- and LONG-TERM COST GOALS *

	Present Technology	Interim Goal (Five-Year)	Long-Range Goal
Projected Capital Cost (1984 $/kWe)	9,680	7,200	3,200
30-Year Levelized Electricity Cost (constant 1984 ¢/kWh)	18	11	6

* MYPP Appendix B contains a detailed discussion of cost goal development, including levelized energy costs in constant and current dollars.

Table 2. WATER QUALITY DATA: SEAWATER AS DELIVERED TO NELH

PARAMETER		WARM Surface Seawater max	ave	min	COLD Deep Seawater max	ave	min
Salinity	o/oo	34.93	34.71	34.31	34.37	34.31	34.27
pH		8.34	8.24	8.04	7.64	7.55	7.45
Alkalinity	meq/l	2.36	2.32	2.25	2.43	2.38	2.34
$NO_3 + NO_2$	ug-at/l	0.50	0.20	0.05	41.70	40.00	38.20
NH_4	ug-at/l	0.70	0.50	0.20	0.76	0.42	0.06
PO_4	ug-at/l	0.20	0.14	0.03	3.16	3.04	2.85
Si	ug-at/l	31.00	4.21	1.80	72.00	79.00	85.00
TDN	ug-at/l	6.24	4.68	3.69	48.00	42.14	39.30
TDP	ug-at/l	0.50	0.34	0.19	3.26	3.07	2.91
D.O.	ml/l	10.09	7.25	4.85	3.93	2.38	1.33
TOC	mgC/l	1.20	0.91	0.51	0.99	0.58	0.07

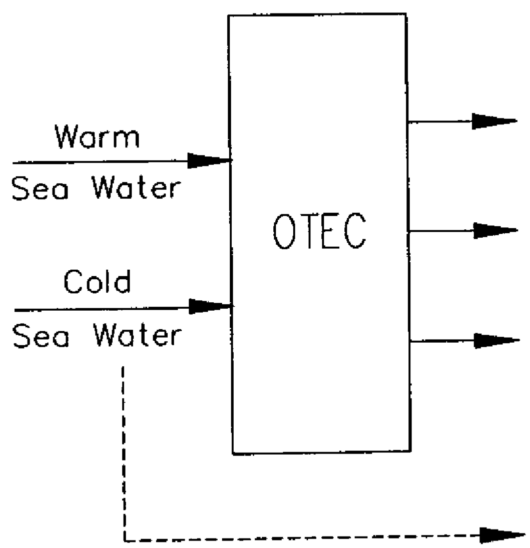
Table 3. OTEC CO-PRODUCTS CORRELATED WITH TEMPERATURE

Temperature °C	Co-Products
5	Air conditioning (primary)
6	Freshwater, air conditioning (primary)
7	Freshwater
8	Freshwater, strawberries, flowers
9	Brine shrimp, strawberries, flowers
10	Brine shrimp, oysters, clams
11	Pre-chiller, brine shrimp, abalone, salmon, trout
12	Pre-chiller, brine shrimp, abalone, salmon, trout
13	Pre-chiller, brine shrimp, abalone, salmon, trout, catfish
14	Brine shrimp
15	Freshwater prawns, brine shrimp
16	Freshwater prawns, brine shrimp, nori, lobster
17	Freshwater prawns, brine shrimp, nori, lobster, carp, puffer
18	Freshwater prawns, brine shrimp, oysters, clams, nori, lobster, carp, puffer
19	Freshwater prawns, brine shrimp, oysters, clams, lobster, carp, puffer
20	Mullet, freshwater finfish and prawns, brine shrimp, lobster, carp, tilapia, eel, squid
21	Mullet, freshwater finfish and prawns, brine shrimp, lobster, carp, catfish, tilapia, eel, ayu, squid
22	Mullet, freshwater finfish and prawns, brine shrimp, lobster, carp, catfish, tilapia, eel, ayu, squid, seaweed
23	Freshwater, mullet, freshwater finfish and prawns, brine shrimp, catfish, tilapia, eel, ayu, squid, seaweed
24	Freshwater, mullet, freshwater finfish and prawns, brine shrimp, catfish, yellowtail, tilapia, eel, crabs, squid, seaweed
25	Freshwater, baitfish, catfish, freshwater prawns and finfish, mullet, brine and marine shrimp, opihi, oysters, clams, eel, yellowtail, tilapia, crab, squid, seaweed
26	Freshwater, mullet, baitfish, freshwater finfish, threadfish, brine and marine shrimp, opihi, seaweed, clams, yellowtail, tilapia, eel, squid
27	Freshwater, mullet, catfish, baitfish, freshwater finfish, brine and marine shrimp, opihi, seaweed, clams, yellowtail, tilapia, eel, squid
28	Freshwater, freshwater finfish, mullet, baitfish, brine and marine shrimp, opihi, seaweed, clams, yellowtail, tilapia, eel, squid

TABLE 4

PACIFIC ISLANDS MULTIPLE-PRODUCT OC-OTEC PROJECT — PICHTR, Honolulu, Hawaii

TABLE 4. ESTIMATED SALES POTENTIAL FOR 1.5 MWe (NET) OC-OTEC PLANT ON A 6 HECTARE SITE



Product	Potential Annual Sales
Electricity (1.5 MW) ($0.24 per kwh)	$3.10 M
Fresh Water (800 k-gal/day) ($1.60-$6.40 per kilo,gallon)	$0.46 M - $1.84 M
Cold Sea Water for Mariculture* ($3.50 per GPM-month)	$0.36 M
Air Conditioning (300 room hotel) ($0.24 per kwh)	$0.30 M
Total	$4.22 M - $6.06 M

* This revenue source only represents the value of the cold water sold to business enterprises. The mariculture product values are largely unknown and could quite easily be ten times or more this value.

TABLE 5

RANKING 10/2/87	TOTAL SCORE ALL ROUNDS	PERCENTAGE OF MAXIMUM
N. MARIANAS	311	100%
TAIWAN	311	100%
GUAM	295	95%
PHI. LUZON	275	88%
PHI. MINDANAO	275	88%
BORNEO	268	86%
FIJI VITI LEVU	267	86%
CELEBES	266	86%
FSM POHNPEI	266	86%
NEW GUINEA	262	84%
A. SAMOA	261	84%
TAHITI	254	82%
NEW CALEDONIA	253	81%
PALAU	247	79%
FSM KOSRAE	246	79%
TONGA	245	79%
COOK ISLANDS	243	78%
FIJI VANUA LEVU	243	78%
MARSHALLS	241	77%
VANUATU	241	77%
SOLOMONS	237	76%
W. SAMOA	229	74%
FSM YAP	228	73%
TARAWA	226	73%
NAURU	224	72%
TUVALU	220	71%
FIJI OVALAU	217	70%
NIUE	195	63%

NOTE.- EXCLUDES ISLANDS NOT MEETING ESSENTIAL PRIORITIES

KE-AHOLE POINT AS A PRECURSOR MODEL OF GOVERNMENT-INDUSTRY-ACADEMIC OCEAN ENTERPRISE

by
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ABSTRACT

The Ke-ahole Point Natural Energy Laboratory of Hawaii and the subsequently established Hawaii Ocean Science and Technology Park are facilities of the State of Hawaii which were built as a test of a Government-Industry co-operative concept to commercialize the Natural Energy Resources of the County of Hawaii. The management model was designed to avoid the pitfalls of innovation development that have prevented the United States from commercializing the results of its own Research and Development. Fifteen years of operation have now demonstrated the success of this model. This paper describes the philosophy of management, the growth and development of the Laboratory and describes a few of the alternate development paths that have led to commercialization. The Laboratory and Science Park are to be merged this legislative year to permit a major increase in the scale and scope of resource development and commercialization. The prospects for these expanded developments are discussed in the context of competition from Japan and Taiwan and the technology transfer mechanisms that have heretofore favored these nations vis-a-vis the United States in the commercialization of new technologies.

THE KE-AHOLE POINT NATURAL ENERGY LABORATORY

In the early seventies the United States and the world believed that they were facing an energy crisis. As a result the Federal Government, State Governments, the National Academy of Sciences and many academic institutions conducted studies of various forms of alternate energy and the potential for the development of alternate energy resources. The State of Hawaii established a Governors Commission on Alternate Energy under the direction of Dr. John Shupe, the Dean of Engineering of the University of Hawaii. His committee identified wind, geothermal energy, various forms of solar energy and in particular ocean thermal energy as resources of the Hawaiian Islands whose commercialization appeared feasible, environmentally compatible with Hawaii, useful and economic. Accordingly the State sponsored a number of studies for the development of these resources. One of these included site selection studies to find an optimum location for research on deep ocean water as coupled with high solar insolation. Ke-ahole Point was selected as that site.

In independent but related studies, Governor John Burns of Hawaii, Senator John Ushijima the President of the Hawaiian Senate, Representative James Wakatsuki, Speaker of the Hawaii House of Representatives, and Mayor Shinichi Kimura of the County of Hawaii had agreed on informal plans for the development of the Kona (dry) Coast of the County of Hawaii. These plans envisioned a chain of visitor facilities (hotels and golf courses) interspersed with attractive environmentally related science and high technology parks. Their attempts to persuade private industry, acting on its own, to fund the development of such think tanks and industrial parks proved fruitless and they determined that the State would have to take the initiative to start the incubation processes so necessary to commercial development of new products. Accordingly, and without assurance of federal, academic or industrial support, these eminently wise politicians established the Natural Energy Laboratory of Hawaii (NELH) on a bleak and barren lava flow projecting into the ocean at Ke-ahole Point. It was deliberately located on land which was as close to the airport as would be required for logistic support of a successful economic venture, in close proximity to deep water and on a peninsula of land having one of the highest annual solar insolation in the world.

An independent state corporation was established which had exemptions from the normal procurement and hiring requirements of the State through the utilization of the statutory exemptions of another innovation of the State of Hawaii, the Research Corporation of the University of Hawaii. The governing board was at a level which matched the expectations of significance attached to this laboratory and included as working members the Mayor of the County, his chief development Officer, the Director of the Department of Land and Natural Resources, the Director of Planning and Economic Development, two of the University's most eminent professors (one of whom is here today) in the field of energy and resource development and the Governor's Marine Affairs Coordinator. The initial staff consisted of the Director and contract support from the Research Corporation. The Director, Dr. James Jones, was hired on a temporary basis and contingent upon the securing of projects for the Laboratory.

A number of significant boundary conditions were established for the Laboratory. Of cardinal importance was, and is, that the Laboratory would do no research itself and was, in fact, simply a facility. This prohibition was established to avoid competition or the threat of competition with the clients it hoped to attract. The Board now believes that this is an essential ingredient of any government facility which will be provided in support of the commerce and trade of the United States.

The second boundary condition is that the Board itself will determine from its own assessment of the probable direction of research leading to commercialization which facilities shall be developed by the State to induce researchers and commercial developers to conduct their enterprise at Ke-ahole. In addition the terms and conditions of the leases to clients include factors which relate to the Board's assessment of the risk and the potential of the enterprise.

Finally, all clients of the Laboratory must be engaged in some phase of the incubation process and must not employ the Laboratory as a convenient site for the conduct of already developed commercial processes.

With these principles clearly enunciated and established the Board commenced its management in 1974. The first task which was accomplished before any project was entertained was the conduct of all necessary environmental impact studies and statements and the obtaining of all permits which would be required to conduct research and development at Ke-ahole and in the ocean corridor which extended to seaward. Unfortunately we were not permitted to conduct a Federal environmental impact statement until specific projects had been authorized. This process was underway during a period when the Federal Government itself, having established a Department of Energy, was initiating vigorous programs in alternate energy including Ocean Thermal Energy Development.

The University of Hawaii, the TRW Corporation and the Carnegie Mellon Institute proposed that OTEC development take place initially at the land based facility at Ke-ahole Point. This proposal received short shrift in Washington and in lieu thereof the Federal Government authorized OTEC 1, a one megawatt power plant to be installed in a converted merchant ship. Technical experts at the University of Hawaii, in the State of Hawaii and in the Lockheed Missiles and Space company believed OTEC 1 to be an ill conceived project. Accordingly there was proposed that the State, Lockheed, Dillingham and Alpha Laval conduct a project called Mini-OTEC which would demonstrate net power at a minimal scale. Because of the wisdom of the State legislature in setting aside capital improvement funds for unspecified ocean energy projects, state funding was immediately available. In addition and of equal importance all environmental impact studies and assessments and all permits had been obtained provided that Mini-OTEC was conducted at Ke-ahole in 1979 just five years after the establishment of the Laboratory. Thus a period of only eighteen months was required to move from handshake to the production of net power from the ocean.

The availability of the Ke-ahole facility now being evident the Argonne Laboratory, the Solar Energy Research Institute in Golden, Colorado, and the Department of Energy employed NELH for the solution of the biofouling problem in heat exchangers utilizing warm tropical seawater and set in motion the mechanism for establishing a Sea Coast Test facility at NELH which would have included a large cold water pipe for both biofouling and energy experiments. This was to be a joint Federal/State endeavor with the assets reverting to either State or Federal ownership should one of the partners abrogate the agreement. On this basis the State constructed the laboratory and office building that now form the major building facilities at Ke-ahole.

In 1980 a reassessment of the national energy picture was made by the Federal administration and, in light of the apparent end of the energy crisis, the OTEC 1 project was terminated and the Sea Coast Test facility deferred in time. As a consequence Federal facilities reverted to the State and the prospect of a cold water pipe seemed very distant. It was then that the Board of NELH concluded that progress could not be made and the laboratory would founder unless a cold water pipe were constructed in the shortest period of time and at the lowest cost. Once again the legislature of the State of Hawaii supplied the capital funds for the installation of a 12-inch diameter cold water pipe and the authorization to bypass normal design and procurement processes. The pipe was thus completed in 1982 and dramatic changes in the life of Ke-ahole immediately ensued.

The availability of both warm and cold tropical sea water now permitted the NELH to pursue a number of parallel but quite different independent incubation paths that would all eventually lead to commercialization. These paths are now described in a sequence that demonstrates the relative participation of government and industry in this process and at the same time describes the component development of what will soon be a major resource system or systems.

<u>Example 1</u> State Facilities - Sea Grant - Investigator entrepreneur - Government Assisted Commercialization.

It had long been recognized by the Board and in particular by the Aquaculture Development Program of the Department of Land and Natural Resources that deep ocean water, because of its nutrient richness, its biological sterility, and its coldness, should be an ideal nutrient medium for marine plants and organisms. Working closely with the Sea Grant program a number of research programs were thus initiated. The first step was an assessment of the primary productivity of the deep ocean water. Nori, a filter feeding algae which was also of commercial value, was chosen. This is the seaweed which is employed to wrap Japanese sushi. Phenomenal production rates were experienced in these experiments with growth increases in biomass of 40-45% per day. Upon graduation, the student researcher, Mr. Steve Katase, started a small company for the commercialization of the nori thus produced. Utilizing a series of successful Federal loans and a partnership with a Japanese corporation, Mr. Katase has developed a commercially successful nori farm, which is expanding as rapidly as the roundabout process of development will allow. In addition to the nori, Mr. Katase is now producing ogo and will shortly add opihi (a Hawaiian delicacy shellfish to his operation).

Example 2 **Sea Grant - State Facilities - Executive Intervention Independent Entrepreneur**

The commercial aquaculture of cold water fish such as salmon and steelhead trout also seemed feasible and a researcher was found who had a window in his research program that permitted him time to develop these species. Unfortunately it was necessary to build facilities for these fish on an extremely short time scale. Those funding agencies having an energy mission refused to provide funds for what was deemed by them to be aquaculture. Our Federal Department of Energy has no problem with funding high energy nuclear physics as an 'energy' program but does not yet conceive of food as an energy fuel for the machine called Homo sapiens even though the technologies for the production of food and fuel are identical. It is therefore vital to the understanding of the success of the Ke-ahole point endeavor to appreciate that Governor Ariyoshi released emergency funds, which were otherwise unavailable, for the construction of these tanks. Governor Ariyoshi was personally involved as was Governor Burns and as is Governor Waihee in the developments at Ke-ahole. Such high level informed individual involvement is crucial if the United States expects to recover its lead as the world's leader in the commercialization of innovation. As a result of this Sea Grant program, techniques for the mariculture of a large number of programs have been developed.

Example 3 **Theoretical Innovator Sea Grant - Practical Innovator - Private Entrepreneur**

Perhaps the most significant program in terms of the understanding of the commercial potential of deep ocean water has been the Sea Grant strawberry project. Professor Sanford Siegal of the University of Hawaii had been supported under a Sea Grant project to examine various innovative ways to conduct agriculture in ocean coastal areas. He conceived of the notion of pumping deep ocean cold water through pipes embedded in the ground. This would make the ground cold and cause condensation in a manner which resembled trickle irrigation. The inefficiently produced water could thus be efficiently used and the deep ocean water which was employed could itself be used in other projects. Professor Martin Vitousek carried out the actual demonstrations and determined that strawberries and other spring crops and flowers could be produced all year long in the tropics by this method. After several years of careful development of varieties and species Vitousek has now joined forces with commercial developers for the construction of a one acre test plot. Plans for a five acre commercial pilot plot have already been approved and large scale production of fresh water spring crops should be feasible at about the same time as the development of companion power, freshwater and sea water protein projects.

Example 4 Independent Entrepreneur - State Facilities - Entrepreneur Facilities

The fourth example of an incubation process is that of the Hawaii Marine Farm, formerly the Hawaii Abalone Farm. In this instance the entrepreneur is a strong protagonist of free enterprise and has been for good and sufficient reasons highly critical of government efforts to regulate, control, compete with or dictate his modus operandi. His initial attempts to engage in the farming of Abalone were in Monterey, California. His technique is to grow California kelp in large tanks and to feed the kelp to abalone in confined cages. His initial technical problems were that the waters of California were not cold enough and required highly expensive refrigeration, that the surface waters were contaminated with disease and predator organisms and required expensive treatment and that the nutrient content of surface waters was inadequate. He deemed these problems as small when compared to the regulatory obstacles imposed upon him by the State of California. Indeed his initial interest in Hawaii was not in the deep ocean water, but with the prospect of State cooperation in the guarantees of his independence. His operation which began with the pilot tank of modest dimensions has expanded from two large kelp tanks to a four acre lake. Three other four acre lakes have been approved and will be built as rapidly as the roundabout process will permit and plans are in the making for expansion to the Hawaii Ocean Science and Technology Park (HOST). In addition he has installed two of his own cold water pipes and has plans for additional installations. He has now developed by processes which are proprietary to him effective and economic means for the culture of salmon, abalone, and sea urchins.

Example 5 Independent Entrepreneur - Entrepreneur Facilities - State Logistic Infrastructure - State encouragement to employ natural resources

The Cyanotech Corporation organized for the production of commercially valuable algae was initially interested in Ke-ahole because of the absence of rain (which would dilute the ponds) and the high solar insolation. Recognizing the limited availability of fresh water it was determined that a salt water algae should be developed. The initial algae chosen was spirulina which had not been previously successfully grown in salt water. Absolute purity was a requirement for the nutrient medium to assure the absence of competitor organisms that would smother the algae. In the time interval of less than two years the Cyanotech Corporation moved through a series of pilot ponds up to full scale commercial production. Algae species were expanded to include Dunaliella from which beta carotin is derived and an algal species which prevents cholesterol buildup. Fifteen acres are now in production with another forty under development. The NELH Board partially satisfied by the use of the purity but not the coldness or the nutrients of deep ocean water, encouraged the Cyanotech Corporation to explore other ways to employ the natural resource. They recognized that a major cost of production was CO_2 as fertilizer and it was also recognized that CO_2 was the combustion product in the exhaust of the butane burners that were used for algae drying. The use of the deep ocean cold water in a heat exchanger permitted fractional condensation recovery of the CO_2 from the heater exhaust and its substitution for commercially supplied fertilizer.

Example 6 Federal Government - Federal Laboratories - PICHTR

Subsequent to the administration re-evaluation of its alternate energy program, it was concluded that the Department of Energy would concentrate on development missions to further projects whose economic commercialization are sufficiently far in the future that they are beyond the horizon of industries capability to consider. The Department of Energy has thus been pursuing research which will lead to the commercialization of Open Cycle OTEC. Heat and mass transfer facilities which have been tested at various scales have already been described in this symposium. Biofouling tests conducted by the Department at Ke-ahole had already demonstrated the ability to eliminate biofouling from warm and cold heat exchangers for periods of at least five years. Associated with these experiments the DOE had reinstituted plans for a large cold water pipe. Funds which were then available would have limited the size of this pipe to 28" in diameter. It was then realized that the state was also intending to install a large coldwater pipe for its newly authorized Hawaii Ocean Science and Technology (HOST) industrial park. Through cooperative arrangements the State and DOE pooled resources for the construction of a single 40" diameter cold water pipe. At about the same time, President Reagan negotiated with Prime Minister Nakasone for the establishment of the Pacific Center for High Technology Research. This center is now assigned responsibility for the conduct of research at Ke-ahole leading to a 165 Kilowatt Open Cycle Demonstration plant. It is understood that other PICHTR DOE projects and DOE projects across the spectrum of high technology ocean research will be conducted at Ke-ahole. This includes Project Dumand, a program to install a cubic array of Cerenkov radiation detectors at a depth of 15,000 feet in order to measure the high energy neutrinos and muons that emanate from outer space. Plans for the construction of office and laboratory buildings for these and other DOE and PICHTR projects have already been included in the State capital improvement budgeting and planning process through the Department of Business and Economic Development.

<u>Example 7</u> Direct product application - State General Services

The Department of Accounting and General Services (DAGS) has direct responsibility for the construction and alteration of major capital improvements of the State. Included in this responsibility are the air conditioning systems design and construction for State buildings. Recognizing the potential of the deep ocean water for air conditioning and recognizing that the use of deep ocean water in a conventional heat exchanger as a substitute for the cooling apparatus in a conventional chill water air conditioning system did not require development, the DAGS carried out the design and installation of such a facility for the laboratory building at NELH. A dramatic reduction in air conditioning costs from over $500 dollars per month to approximately $130 per month was thus achieved. This application is now available for all new construction which has access to cold deep ocean water.

<u>Example 8</u> International Participation - Canada, UK

The Alcan Corporation, having conducted independent study of the application of Ocean Thermal Energy to aluminum producing tropical islands, initiated the development of alloys suitable for aluminum heat exchangers for both warm and cold water. The successful qualification of a number of these alloys has led to the design of economically fabricated, economically maintained aluminum heat exchangers. These are now undergoing tests at Ke-ahole and, if successful, will lead to a commercial capability for producing heat exchangers for closed cycle systems in the 100 to 500 kilowatt range.

<u>Example 9</u> International Participation - Japan

A Japanese aquaculture corporation has undertaken an investigation of the deep ocean water mariculture of Hirami, a popular flounder delicacy in Japan. These experiments have proceeded quietly, independently, and successfully. Although the details are not available, it is clear that the Japanese corporation is operating with the support and cooperation of the Japanese Fishing Agency and the support programs associated therewith. The smoothness and efficiency of their operation contrasts greatly with the difficulty that our American clients face in obtaining financial support from commercial lending agencies (just the difference in the cost of capital between U.S. and Japanese investors is enough to destroy any competitive advantage that United States producers might enjoy) and the great difficulty that our American clients face if they seek to carry out their operations in any locale other than Ke-ahole Point due to State and Federal regulation and permit requirements. These comparative advantage/disadvantages of American industry must be solved if the successful technical innovations at Ke-ahole are to be realized by American industry.

OTHER EXAMPLES

Other examples could be cited in the development of such marine products as opihi (a Hawaiian delicacy), lobster cultivation, the use of geothermal steam for industrial drying operations of fruit and lumber, coffee and cocoa, etc., but these examples are merely redundant and fail to demonstrate the synergistic effect of these independent operations. Although each project is independent, and in many cases, proprietary, the interdependence of facilities required for each project and the requirement for riparian use of the water resource for purposes of efficiency, has produced a community consensus on the use of the deep ocean resource in a systems mode. It has always been apparent that Ocean Thermal Energy System would require the use of the coldest water possible, but that the discharge of energy water would itself be at a temperature useful for cooling purposes. Thus the deep ocean water is, in general, employed in energy experiments at the laboratory in the temperature grange from 6° to 9° Celsius. The Open Cycle research projects and the heat and mass transfer facilities programs of the Department of Energy, SERI, Argonne and PICHTR are examples of this water use. Closed cycle experiments with aluminum heat exchangers by the Aluminum Company of Canada are other examples of promising and, in fact, successful developments in the use of the resource.

One of the most economically promising ranges for use of the deep ocean water is that associated with cooling in the range from 9° to about 13° Celsius. This is the range in which the now 'world famous' strawberry project produces a wide variety of spring crops. This year marks the transition from small test beds to a one acre experimental farm which has been authorized for 1989. In this range successful air conditioning of the laboratory building through the use of a simple deep water - chill water heat exchanger has been demonstrated. In addition, the deep water for a wide variety of chilling and cooling purposes has been demonstrated including the recovery of CO^2 from stack gases for use as an algae fertilizer. There is now proposed a fresh water condensate generator employing water in this range and many other ideas are surfacing.

In the range from 13° Celsius and above, the nutrient characteristics of the water have permitted the development of polyculture by the Hawaiian Marine Farms (formerly the Hawaiian Abalone Farm). The successful pilot production of salmon was achieved in the fall of the year and full polyculture of kelp, abalone, sea urchins and salmon at Hawaii Marine Farm. Similar expansion in scope and species is taking place with the successful harvest of nori which has been supplemented by the production of the seaweed ogo and will soon be further supplemented by the production of the Hawaiian delicacy 'opihi'. The Cyanotech Corporation is similarly expanding its production of spirulina, dunaliella and other exotic commercially useful algae.

The rapid growth of almost every one of these commercial algae has exceeded expectation and as a consequence the spillover into the HOST park will take place sooner than anticipated. Recognizing the penumbral nature of projects in the last stage of incubation and the first stage of profitable commercialization and the dilemma as to location in NELH under its terms and conditions for operation or its location in HOST under differing terms and conditions, a merger of these two organizations has been proposed for consideration by the 1989 legislature. Limited joint venture between the two facilities leading to the merger is already in progress.

Of greatest significance are the proposals on the National and International level for the development of total systems concepts. A significant number of systems development proposals have been received for demonstration and evaluation at Ke-ahole. International programs in this regard which will probably be developed in whole or in part elsewhere were revealed at the International Ocean Technology Congress which was held in Honolulu last month. These include well developed plans by the Japanese OTECA (Ocean Thermal Energy Conversion Association), developing plans by Taiwan, the developing program of the United Kingdom (Alcan/Marconi), and renewed interest in France and the European community.

The prospects for the NELH/HOST concept under an integrated management are bright. It is indeed to early to conclude that the Ke-ahole experiment in Government/Industry/Academic cooperation is an unqualified success. It is too early to conclude that the success that is achieved will be limited to overseas corporations and nations/states, although the trend is unmistakably present. It is far too early to conclude or suggest that the Government /Academic /Industry team of the United States will once again "snatch defeat from the jaws of victory." This conference is evidence that such will not be the case and that Ke-ahole may indeed be a precursor of that end result which we will achieve - the development of ocean enterprise for the mutual benefit of the United States and the world.

OFFSHORE GARBAGE PROCESSING IN THE NORTH ATLANTIC

by
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A.T. Kearney, Inc.

ABSTRACT

Although the burning of municipal garbage at sea is not known to be practiced anywhere in the world, at least three different Municipal Solid Waste (MSW) ocean incineration concepts have been advanced in the U.S. since the mid-sixties. They involve: (1) nearshore burning on ships; (2) nearshore burning on platforms; and (3) offshore burning on ships.

Despite legal bans on at-sea incineration of noxious liquid wastes, industrial wastes, and sewage sludge, there is currently no regulatory prohibition against ocean incineration of non-hazardous MSW. However, because of staff cuts and competing priorities, the U.S. Environmental Protection Agency has not been willing to allocate the resources necessary to process and issue an MSW ocean incineration permit (but such a permit may not be necessary for burning on a nearshore or offshore platform).

Given the mounting MSW management crisis in many parts of the country and the upward spiral of MSW management costs, there appear to be no insurmountable economic, technical, or environmental barriers to implementing any of several ocean incineration options. The primary barriers are political and regulatory.

INTRODUCTION

Shipboard incineration of hazardous liquid wastes has been carried out in Europe since 1969. Ten single-shot burns have occurred since 1974 in the U.S. in the Gulf of Mexico, plus three more off the Johnston Islands in the Pacific. However, recent events, both domestically in the U.S. and internationally, make the future of this technology uncertain at best.

At the international level, the Eleventh Consultative Meeting of the London Dumping Convention (LDC) approved a resolution in October 1988 agreeing "to take all steps possible to minimize or substantially reduce the use of marine incineration of noxious liquid wastes by 1 January 1991." The parties also agreed to revisit the issue early in 1992 "with a view to proceeding towards the termination of this practice by 31 December 1994."

In the U.S., the Environmental Protection Agency (EPA) announced in late 1987 that it was halting work on new ocean incineration rules and that it was suspending, for at least two fiscal years, its ocean incineration regulatory program (citing budget pressures and competing Agency priorities). Even more definitively, amendments to the U.S. Ocean Dumping Law (the Marine Protection, Research, and Sanctuaries Act--MPRSA), approved by Congress in late October 1988, prohibit the "ocean dumping" of "industrial waste" after December 31, 1991. The Conference Committee report indicates that this ban covers all alternatives which "require a permit" under the MPRSA. Since ocean incineration is subject to MPRSA permitting, this prohibition apparently covers incineration at sea of industrial waste.

The door has not, however, yet been slammed on incineration at sea of non-hazardous municipal solid wastes (MSW)--although it does not appear that MSW ocean incineration has ever been carried out, to date, anywhere in the world.

This paper addresses the feasibility and merits of MSW incineration at sea.

THE LEGAL STATUS OF MSW INCINERATION AT SEA

Internationally, the LDC, and presumably the Oslo Convention within the North Sea, have called for a worldwide reduction and cessation only in the at-sea incineration of noxious liquid wastes. The burning at sea of non-noxious solid wastes remains legal, subject to the divergent domestic programs of individual LDC contracting parties.

Within the U.S., EPA has taken the position* that, although the FY 88 and FY 89 suspension of ocean incineration regulatory activities "only applies to those activities concerning liquid hazardous wastes..., no funds are available to complete the various projects that would be needed to establish a regulatory program for the incineration of solid waste at sea." Despite the lack of any formal EPA determination that regulations specifically addressing the particular case of ocean incineration of municipal waste are necessary as a prerequisite to permit processing and issuance, that is implicitly the Agency's position. However, even if a permit application could be immediately filed, it would still be necessary to allocate EPA staff resources to review and process the application. It would also be necessary, under the MPRSA, for EPA to formally designate an approved ocean incineration site at which burn activities could take place.

Conceivably, with hazardous liquid waste incineration at sea precluded domestically and constrained internationally, EPA will be better able to focus resources on developing the more modest regulatory program required to cover MSW ocean incineration. On the other hand, the prohibition on hazardous waste incineration might well make it more difficult to gain EPA support for ocean incineration of solid waste.

It should be noted that EPA's existing Ocean Dumping Regulations and Criteria (40 C.F.R. Parts 220-229) authorize the issuance of permits for incineration at sea (Subsection 220.3(f)) "only as research permits or as interim permits until specific criteria to regulate this type of disposal are promulgated, except in those cases where studies on the waste, the incineration method and vessel, and the site have been conducted and the site has been designated for incineration at sea in accordance with the procedures of Sec. 228.4(b)." Although the burning at sea of New York Harbor driftwood has been authorized utilizing interim permits under this authority, it seems unlikely (at least as long as EPA's claimed budget emergency persists) that MSW incineration at sea could ever satisfy the "Catch-22" requirements of this provision. (They are "Catch-22" requirements because no prudent applicant would invest in an incinerator ship without an approved permit; but without a ship it would be virtually impossible to meet the requirements for a permit.)

EPA is currently in the process of revising its general Ocean Dumping Regulations and Criteria. Among the changes reportedly in the works is elimination of the category of

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* June 7, 1988, Letter from Rebecca W. Hanmer, Acting Assistant Administrator for Water, U.S. Environmental Protection Agency, to Kenneth S. Kamlet.

"interim" permits. If this is done, one must wonder what the impact will be on the ability to burn driftwood offshore. One must also wonder how shipboard burning of ship-generated garbage will be handled (i.e., under MARPOL Annex V). Although such burning appears to be permissible under the LDC as a routine operational discharge, the MPRSA exempts only fuel burning incidental to vessel propulsion from permit requirements.

EPA could simplify its exertions regarding all of these activities (i.e., burning of MSW, driftwood, and ship-generated garbage) by following the lead provided by the LDC. Specifically, Regulation 2(4) of the LDC "Regulations for the Control of Incineration of Wastes and Other Matter at Sea" (adopted as an Addendum to Annex I of the Convention) specifies that "incineration at sea of [non-toxic] wastes or other matter [i.e., not containing specified 'black' or 'grey' list constituents]...shall be subject to a general permit" (emphasis added). Thus, the LDC seems to authorize (nay, to require) resort to a simplified "general permit" mechanism for non-hazardous wastes proposed for incineration at sea.

If EPA truly wished to conserve scarce staff resources, it would consider incorporating as part of pending ocean dumping regulatory revisions provision for authorizing non-hazardous at-sea burning under "general permits," as specified in the LDC.

THE NEED FOR MSW INCINERATION AT SEA

There is a pressing need in the U.S. for new and innovative ways to safely manage growing quantities of non-hazardous municipal solid waste. This need is driven by several factors:

1) The large and growing output of MSW;
2) The obstacles to developing new MSW landfills and incinerators;
3) The diminishing capacity of existing MSW facilities;
4) Rapidly rising MSW disposal costs.

The recently issued Draft Report of EPA's MSW Task Force ("MSW Report")* abundantly documents these problems.

We currently generate about 158 million tons of solid waste a year (MSW Report, p. 8). This is enough to "fill a convoy of 10-ton garbage trucks, 145,000 miles long...over half way from here to the moon" (id., p. 8). To make matters worse, however, the per capita rate of generation has been increasing --from 2.65 pounds per person per day in 1960, to 3.58 pounds per person each day in 1986 (id., p. 12). "Last year's international wanderings of the barge Mobro 2000, forlornly searching for a last resting place for garbage from Islip, New York, graphically illustrated the capacity shortages in populous communities" (id., p. 12).

"Everybody wants us to pick it up, and nobody wants us to put it down," has been described as the "First Law of Garbage" (MSW Report, p. 8). The last thing many Americans want in their neighborhoods "is a landfill, incinerator or recycling center--all of which [they associate] with noxious odors, possibly dangerous pollution, and noisy

* U.S. Environmental Protection Agency. Sept. 1988. The Solid Waste Dilemma: An Agenda for Action (Draft Report of the Municipal Solid Waste Task Force, Office of Solid Waste; #EPA/530-SW-88-052).

traffic" (id., p. 8). As a result, very few new facilities of these kinds have been constructed in recent years.

The MSW Report estimates (p. 8) that "one-third of the nation's landfills will be full within the next five years [i.e., by 1993]." Other facilities are closing because "their design and operation do not meet Federal or State standards for protection of human health and the environment" (id., p. 14). The MSW Report notes that, as long as communities which lack their own waste handling capacity are able to ship wastes across State or county lines to areas with available capacity (the "waste flight" phenomenon), the incentive may not exist "to build new, environmentally sound facilities and adopt better management practices" (id.).

The MSW Report points out that disposal costs, in some American cities (such as East Lyme, Connecticut), "have soared to more than $100 per ton of waste because of long-distance hauling and high landfill and incinerator 'tip' fees" (id., pp. 12, 18). Incinerator ash disposal costs can add $30 to $35/ton to the costs of waste management. These costs are highly site-specific. Disposal costs in Massachusetts, Connecticut, and New York, for example, are far, far higher than they are in Texas. Although not highlighted in the Report, the high and rapidly escalating costs of MSW management create opportunities as well as problems. Specifically, they may make innovative technologies feasible and cost-effective which hitherto have been ruled out as uneconomical.

The MSW Report places heavy emphasis on what is referred to as "the integrated waste management hierarchy" (pp. 18-20). Under this hierarchy, source reduction and recycling are viewed as "the preferred options for managing solid waste" (p. 15), with incineration and landfilling "to be used only when the preferred options are unavailable or insufficient" (id.). The Report embodies the EPA goal of "managing 25 percent of the municipal solid waste through source reduction and recycling by 1992" (pp. 3, 23). It is clear, therefore, despite the Report's preoccupation with source reduction and recycling, that other waste management practices will continue to be necessary to safely and effectively handle the remaining 75 percent of the waste stream.

Right now, 80 percent of the nation's MSW goes to environmentally questionable landfills, while only 10 percent each goes to recycling or incineration. This high level of landfilling is clearly untenable and cannot be sustained. Historically, nearly 20 percent of the high-priority Superfund National Priorities List sites were once municipal landfills, and more than 20 percent of the country's active landfills are on EPA's partial inventory of "open dumps." A startling 85 percent of MSW landfills lack liners and 95 percent have no leachate collection system.

IS THERE A ROLE FOR OFFSHORE PROCESSING OF GARBAGE?

In this country, where so much MSW goes to substandard landfills, where available landfill capacity is rapidly diminishing in many areas, and where source reduction and recycling can only partially narrow the gap between production and capacity, it makes little sense to downplay incineration or to dismiss incineration at sea as an option, without strong and persuasive reasons.

The MSW Report tends to place incineration on a par with landfilling and a giant step down from source reduction and recycling. It does concede, however, that "incineration is useful in reducing the bulk (although not all) of municipal waste and can provide the added benefit of energy production" (p. 19). While not risk-free, the Report acknowledges that "a state-of-the-art incinerator that is well operated should not present a significant risk to human health and the environment."

Although three of the presentations at the public meetings held by the Task Force commented favorably on MSW incineration at sea as an option worthy of consideration, the MSW Report makes no reference to this technology.

While incineration at sea cannot be considered universally preferable to incineration on land, it does appear to be advantageous where one or more of the following considerations obtain:

- It is deemed undesirable to locate an incinerator (or waste-to-energy facility) in the midst of a densely populated metropolitan area.
- Suitable land is not readily available for a land-based incinerator.
- It is desired to service multiple, moderately scattered localities none of which could individually afford the cost of building a waste-to-energy facility or to transport MSW overland to a regional land-based facility.

It does seem clear, however, that MSW incineration--whether on land or at sea--will almost always be preferable to disposal in landfills.

One of the six objectives for a national agenda for action to solve the municipal solid waste dilemma identified by the MSW Task Force was: "Improve the safety of municipal solid waste combustion in order to protect human health and the environment" (MSW Report, p. 25). While technical improvements in the efficiency of combustion or the efficacy of pollution controls are equally applicable to at-sea and on-land incineration, it should be recognized that the increased distance from population centers afforded by the at-sea option should itself dramatically reduce any potential impacts on human health.

KEY FEATURES OF THE OFFSHORE OPTION

Shipboard incineration of garbage is not a new concept. From March 1965 through June 1969, grant support was provided by the U.S. Public Health Service and by predecessors to EPA's Office of Solid Waste, for studies of shipboard garbage incineration by the Harvard School of Public Health and the University of Rhode Island. These studies concluded that the long, narrow shape of rotary kiln incinerators is well adapted to ship installation, and that such incinerators are capable of high efficiency waste reduction. It was hypothesized that the heat release from the incinerators could be used to operate the ship's services. The deck of the ship would support the incinerators and hull would store unburned wastes. The ship could load at the end of each day from storage silos at dockside and proceed out to sea where it would burn the waste far from land. Also investigated was the feasibility of disposing of the resultant incinerator ash in designated offshore sites. A 1972 publication summarized the results of these studies.*

The City of New York Planning Commission reportedly gave serious consideration during this timeframe to the use of ocean, as described in a 1966 report.**

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* First, M.W., ed. June 1972. Municipal Waste Disposal by Shipborne Incineration and Sea Disposal of Residues. Harvard University School of Public Health, Boston (U.S. EPA UI-00557).

** Michaels, Abraham. 1966. Feasibility Study on a Waterborne Incinerator (City of New York Planning Commission).

More recently, as reported in the September 19, 1987 Boston Globe, a proposal was put forward by Massachusetts Senate President, William Bulger, to burn trash at sea in an incinerator built on an offshore structure resembling an oil rig (which could be as large as three acres in size). The plan, originated by Wheelabrator Environmental Systems of Hampton, New Hampshire, calls for building an offshore rig on stilts driven into the ocean floor 6 to 10 miles out to sea. (Engineering of the platform would be done by Rust International in Birmingham, Alabama.) An incinerator plant would then be constructed, towed out to the platform, and hoisted with giant cranes atop the platform. Daily loads of garbage would be barged out to the plant, with transmission lines laid underwater to send electricity from the plant back to shore.*

Another variation on the theme was developed by Ocean Incinerator Services, Inc.--a joint venture of Hvide Shipping, Incorporated (of Fort Lauderdale, Florida) and individual New York lawyers. The OIS concept** hinges on the use of a very large vessel (more than 0.2 miles long, 180 feet wide, and 90 feet deep)--equivalent in size to a very large or ultra-large crude carrier; incineration 100+ miles offshore; the vessel remaining on-station for about 30 months at a time (with operating personnel rotating on 30- to 60-day cycles); the use of up to eight 500-ton per day rotary kiln ("O'Connor process") incinerators (the process is proprietary to Westinghouse); the use of state-of-the-art air pollution controls (i.e., a dry scrubber to neutralize acid gases, and a fabric filter or electrostatic precipitator to trap particulates); shipboard processing of incinerator ash into stable concrete-like blocks for barging back to shore for beneficial use on land; pre-screening of refuse, with extraction and recovery of recyclables; closed transport and transfer of refuse to ships in water-tight, enclosed shuttle barges (each with a capacity of 5,000 tons), with conveyors for shore-to-barge transfers and enclosed pneumatic or vacuum systems for barge-to-ship transfers; and resource and energy recovery, including use of trash-burning energy to supply the ship's power needs, power for material transfer operations, and power for ash processing.

PROS AND CONS OF OCEAN INCINERATION ALTERNATIVES

What are the advantages and disadvantages of the ocean incineration concepts described above? They embody three divergent approaches: (1) Nearshore Burning on Ships (the Harvard approach); (2) Nearshore Burning on Platforms (the Wheelabrator approach); and (3) Offshore Burning on Ships (the OIS approach).

The primary advantage of the closer-to-shore alternatives is reduced transportation (and associated fuel) costs, with some simplification of waste handling logistics. The nearshore platform approach offers the further potential benefit of being able to transmit useful electric power back to shore. The platform approach also has the dubious virtue of being subject to uncertain regulatory jurisdiction. The Marine Protection, Research, and Sanctuaries Act regulates transportation for the purpose of ocean disposal, as well as disposal from a vessel (and has been deemed to cover air emissions from an incinerator ship). While the ship-mediated transport of refuse to the platform could be regulated under

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* See also, unpublished paper, dated December 17, 1987, by Wendy L. Woods, Massachusetts Institute of Technology, "UROP Report: Political Response to the Sludge Burning Platform Suggestion for Boston Harbor."

** Kamlet, K.S. and B.S. Sowrey. 1988. Off-Shore Incineration of Municipal Solid Wastes. In: Hazardous and Industrial Waste (Proceedings of the Twelfth Mid-Atlantic Industrial Waste Conference), pp. 31-40, M.M. Varma and J.H. Johnson, Jr., eds. Hazardous Materials Control Research Institute, Silver Spring, MD.

the MPRSA, it is by no means certain that air emissions from an offshore platform could be viewed as subject to MPRSA controls--any more than could emissions from an incinerator placed on an offshore island.

It is not even certain that stationary source air pollution controls would apply to burning on such a platform, although such regulation could be rationalized under authority conferred by the Outer Continental Shelf Lands Act to treat activities linked to the seabed of the continental shelf as subject to the same legal requirements as their counterparts on dry land. Because ambient air quality standards don't typically extend offshore, regulation under the Clean Air Act would probably require at most following Best Available Control Technology (BACT) guidance applicable to land-based MSW incinerators.

Similarly, although State Coastal Zone Management Act authorities undoubtedly would cover shore-based MSW handling and loading activities, as well as transport through State territorial waters, they would not be likely to apply directly to burning activities on a platform (or ship) more than three miles offshore.

The most serious negative associated with nearshore options--whether involving platforms or vessels--is their very proximity. At six miles, burning activities (and, certainly the incinerator plume), would probably be visible from land. Under fair weather conditions, these activities might still be visible even further offshore. Whether or not an emissions plume actually impinged on land, public criticism and pressure would doubtless be heavier, the closer these activities occurred to where people live, work, and recreate.

Offshore burning on ships, as proposed by OIS, has the virtues of minimizing any risk of plume impingement on land, and being far removed from most human activities. Such activities would also not be directly subject to Clean Air Act regulation (although, amendments have been offered in the U.S. Congress which could alter this situation). Transfer of electric power to land from incinerator ships operating 100+ miles offshore is almost certainly infeasible. However, opportunities do exist for considerable front- and back-end energy and resource recovery and source reduction.

As a practical and political matter, whether or not technically or legally required, any MSW ocean incineration operation, whether nearshore or offshore, and whether ship-borne or platform-based, will probably need to install BACT-like air pollution controls.

CONCLUSION

1. Ocean incineration of municipal garbage is technically feasible, using rotary kiln (and possibly other) incinerator designs.

2. It can be carried out in both nearshore and offshore environments, both on ships and on platforms (limited only by the depths at which fixed platforms can be constructed).

3. With the application of BACT-like air pollution controls, the potential risks of MSW ocean incineration to human health will clearly be less than for counterpart land-based incinerators, and will diminish with distance offshore. Ecological risks should be no greater than for coastal incinerators and should diminish with distance from the coastal zone.

4. Although MSW processing costs increase with increased offshore transport distances, the increase should not be as great as for transportation on land. Rapidly rising MSW management costs make offshore incineration competitive with land-based alternatives in

many areas, especially in the northeast. In other areas, the competitive advantage of land-based alternatives will rapidly diminish with time, as the capacity shortfall becomes more acute and the costs of disposal and management on land continue to rise.

5. The most significant constraints on the implementation of offshore garbage processing technologies are public opposition, the fear of public opposition, and associated political and regulatory inertia.

CONVERSION OF GULF OF MEXICO NON-HAZARDOUS SHIP GENERATED WASTES INTO ARTIFICIAL REEFS ABOARD OFFSHORE PLATFORMS

by
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EXECUTIVE SUMMARY

This paper will begin to explore the feasibility of the concept of upgrading non-hazardous shipboard wastes by converting them into artificial reefs and other valuable products aboard offshore petroleum structures located in the Gulf of Mexico. Very preliminary research of the concept indicates that the collection of ship-generated wastes at a few selected offshore locations is more economically practical than either retrofitting existing vessels for waste processing or separating ship wastes into three or four separate receiving containers onshore at upwards of an estimated 18,000 shorebased terminals in the Gulf of Mexico. Initial research also indicates the need of creating long lasting plastic artificial reef fish habitat. Mariculture ventures associated with the reefs will help offset the problems of loss of natural reef habitat, overfishing, pollution, increased demand for fish products, and high levels of US fish imports. Offshore waste conversion facilities will meet both the objectives of the recently adopted Annex V of MARPOL and the long standing objectives of the Department of Health in preventing importation of agricultural threats. If the concept and a demonstration pilot project prove feasible for non-hazardous shipboard wastes, the offshore facilities may be used to process existing flotsam and jetsam, beach litter and eventually, municipal solid and liquid wastes. It is hoped that the concept's "push-pull" economic engine, fueled by fees provided by producers of maritime waste and by profits from mariculture ventures, will both reduce future illegal dumping of solid wastes dumped into the Gulf and current levels of renegade trash. If the concept proves feasible in the Gulf, it may prove applicable to other US locations and countries.

BACKGROUND

A series of seemingly unrelated environmental problems, economic constraints, and legislative mandates may combine to create a fortuitous opportunity. Preliminary research indicates that it will be profitable to convert the Gulf's costly pollution problem of persistent plastics into a mariculture operation.

This hope is based on two simple assumptions:

1) pollution can best be defined as a "resource out of place" and,

2) pollution will continue to increase if the cost of noncompliance remains less than the cost of compliance.

The worst kind of non-hazardous ship-generated wastes are generally considered to be plastics because of their persistence in the marine environment. This serious pollution disadvantage of durability becomes a distinct environmental and economic advantage when the same plastic wastes are used for artificial reefs. Some experts have estimated that much of the existing stock of plastic trash in the oceans will still be with us a millennium from now. Other experts claim only 500 years.

Estimates also vary widely on the amounts and sources of plastics and other wastes in the ocean, their specific classifications, their rates of accumulation, their ultimate fate and effects, etc. If some of the Office of Technology Assessment's estimates of yearly plastic input into the world's oceans are reduced into smaller units, about 8 plastic bottles are being added every second. The worldwide fishing community adds another 11.5 pounds of fishing related plastics per second through lost nets, gear, and packing material.

Due to the oceanographic currents in the Gulf, much, if not most of the flotsam and jetsam entering Gulf waters ends up on the beaches of Texas. One study conducted in conjunction with the Center for Environmental Education's "Adopt a Beach" Program concluded that an estimated 100 pounds of trash lands on each mile of Texas beaches per day. Texas city, county and state governments spend $70 million per year to clean the state's beaches.

Not all of the trash on Texas beaches is due to international ships nor even to all vessels. Virtually every segment of society makes its own significant contribution. Fortunately, studies on the precise source, types and amounts are of little value to the concept under consideration. It is enough only to recognize that vessels have contributed and it is now illegal to continue. Unfortunately, legal mandates do not solve problems. Compliance does and compliance grows only as the cost on noncompliance grows. As solutions to pollution increase in cost, the incentive to pollute increases. As a generality, any alternative to overboard discharge is economically unattractive to shipping interests.

ANNEX V OF MARPOL

In 1973, the International Maritime Organization (IMO) recognized the growing problem of marine pollution from ships by overboard disposal of shipboard wastes. They adopted the International Convention for the Prevention of Pollution by Ships, better known as the MARPOL treaty for Marine Pollution. The treaty, amended in 1978, has five clauses involving pollution issues from oil and hazardous chemical dumping to solid waste disposal at sea. Annex V, concerning the dumping of plastic debris by ships, had to be ratified by at least 15 of the world's countries controlling at least 50 percent of the shipping fleet tonnage in the world. By late 1987, 27 countries had ratified the treaty but they represented only 41.85 percent of the world's tonnage. Then, both the United States with 4.0 percent and Russia with 5.8 percent of the world's tonnage ratified the treaty. Their combined tonnages put the treaty in force.

Annex V of MARPOL 73/78 basically does the following (Figure 1):

- prohibits the ocean disposal of all plastics
- prohibits the disposal of other floating garbage within a specified distance of the nearest coastline, and
- designates certain special areas where no garbage dumping is allowed except comminuted food wastes at least 12 miles from shore.

In all probability, the Gulf of Mexico will become designated a special area as soon as appropriate shore side waste receiving facilities are in place. Cuba and Venezuela would like the special area to include the Caribbean and to also encompass oil sludge and other noxious liquids. According to Regulation 2 of MARPOL, "The provisions of this Annex shall apply to all ships." This includes cruise liners, commercial fishing vessels and recreational boats. Although public sector vessels are excluded, there is an Executive Order that directs the Government to lead in environmental matters.

MARINE PLASTIC POLLUTION ACT

On December 30, 1987, President Reagan signed into law PL-100-200, including Title II, the Marine Plastic Pollution Research and Control Act of 1987. It is the national implementing legislation for MARPOL's Annex V. Among other things, it requires that:

- ports and terminals shall provide facilities to receive mixtures of wastes from ships or seagoing ships including those wastes which contain oil or noxious liquid substances;

- regulations shall be prescribed to assure the adequacy of these receiving facilities and certificates of acceptability shall be issued to those ports and terminals which comply;

- ships may be denied entry to those ports and facilities that are required to have adequate reception facilities but which do not;

- ships may be inspected to verify whether they have disposed of their garbage in violation of Annex V;

- certain ships may be required to maintain refuse record books and shipboard management plans.

The Coast Guard began the implementation process on June 24, 1988 when they published an Advance Notice of Proposed Rulemaking. Among other things, the Coast Guard's final regulations must address the legitimate concerns and missions of a wide array of local, state, and federal agencies including the Departments of Agriculture, Commerce, Defense, Energy, Interior, State, Transportation, and the EPA.

The Department of Agriculture's Animal and Plant Health Inspection Service (APHIS) has the mission of preventing foreign pests, insects, and pathogens from entering the US. The agency does not allow ships from foreign ports to enter US ports unless food wastes and food containers are either sterilized by steam or incinerated and the residue transported to an approved USDA landfill. Of the 73,000 vessels that docked in US ports in 1986, only 3 percent left some garbage at the dock.

The Coast Guard must also address the safety and economic concerns of both shippers and operators of dockside facilities. Testimony by one shipline at the Coast Guard hearings in Houston last fall claimed retrofitting costs of over $125,000 per vessel. Some Gulf ports have already concluded that the problem of waste management belongs to the individual terminals within the port complex. As noted earlier, there may be up to 18,000 individual terminals in the Gulf of Mexico.

Once at port, the treated food wastes, non-hazardous ship generated wastes, oil wastes, and other noxious wastes must be disposed of in separate receiving facilities at each terminal or port. The difficulties of maintaining the integrity of each waste is generally acknowledged by the Department of Health and others.

The Coast Guard has also acknowledged the virtually insurmountable challenges of enforcing the law. They are continually being asked by Congress to accomplish more tasks but with tighter budgets. Considering all of their other missions, inspection and enforcement of shipboard wastes can't realistically be considered as one of their top priorities.

Assuming the problems of maintaining the integrity of the wastes can be maintained, then the food and food container residues must be transported to approved Department of Health landfills. Currently, there is only one site in Texas, near Galveston.

Proper disposal of wastes, even non-hazardous wastes, is expensive. The National Solid Wastes Management Association created a report published October 18, 1988 entitled Landfill Capacity in the U.S.: How Much Do We Really Have? They concluded, "Without question then, a solid waste management crisis exists in the U.S. today." Part of their conclusion comes from the following facts and projections:

- Since 1978, an estimated 14,000 solid waste landfills--70 percent of those operating at the time--have closed.
- EPA projects that more than 2,000 of the 6,500 landfills presently operating will close within five years. This will cause an overall yearly capacity loss of 56 million tons from the current base of 131 million tons of discards.
- At current construction rates, additional landfill space will provide only 20 million tons annually.
- Even if recycling and waste-to-energy combustion were to be implemented on a significant scale, over 131 million tons must still be buried in landfills.
- Although private landfills represent only 15 percent of the total, they include about half of the nation's remaining capacity.
- Estimated life expectancy of landfills in many states is limited. EPA has projected that two Gulf states, Alabama and Florida, have between 5 and 10 years before all landfills have been filled (Figure 2).

The National Solid Wastes Management Association has made estimates (Figure 3) for the planning, acquisition, development, and monitoring costs of building a 100-acre 20-year double liner landfill with 30 years of monitoring that meets current regulatory requirements. Even without other waste management costs such as bonding or insurance, transportation costs, tipping fees, etc., the average cost per acre to dispose of non-hazardous wastes is about $870,000. This is about $20 per square foot. Some prime residential real estate in Houston costs less. Real estate acquisition costs are less than 2 percent of the total.

According to a recent survey at 80 sanitary landfills, the average tipping fee was $20.36, up 51.6 percent from 1986.

PLASTIC ENHANCEMENT

Useful plastic products can be produced from shipboard waste at offshore facilities using existing technology and equipment. Typically, wastes are shredded to particles less than 8mm in diameter and fed into a worm-screw compressor. The high pressure of the worm screw creates temperatures that melt the plastics. No outside heat source is applied. The molten wastes are then forced into molds of various designs. Wastes go in the far end and extruded material at the rate of 400 tons per day comes out the other end. One of the limiting factors for more widespread use of these units in the United States is lack of demand for the plastic timber and lumber.

An offshore facility converting non-hazardous shipboard wastes and other raw material to valuable products will attempt to maximize bulk. This will allow the maximum production of plastic lumber, artificial reefs, breakwaters, beach stabilization devices, and other structures.

Incineration of wastes at sea is not the intent of the concept and in fact, is counter to its objective. A primary purpose of onshore incineration is to reduce solid waste volume by 70-90 percent, thus allowing landfills to function longer and more economically. Nonetheless, some air emissions will be emitted during the endothermic processing of some materials such as paper, edible residues, and rags. Although emissions are not desirable, most would agree that emissions should not occur near heavily populated areas.

Part of the cause of the waste crisis in America is due to the NIMBY--Not In My Back Yard--philosophy. At least one state has banned the construction of any new incinerators. Other states are considering banning underground injections and landfarming. The ban on ocean dumping is finally becoming a reality. Discharges into fresh water are being regulated ever more stringently. Capacities of new landfill sites are not keeping pace with those being closed. Recycling and waste minimization are popular, but limited, alternatives to handle the national waste problem. The offshore waste enhancement concept appears compatible with NIMBY concerns.

POTENTIAL WASTE CONVERSION LOCATIONS

Most vessel traffic, be it international, recreational, US Navy, cruise liner, SCUBA, fishing, or domestic commercial, has a positive correlation with population centers. Figure 4 is a NOAA Gulf of Mexico Coastal and Ocean Zone Strategic Atlas map that shows the traffic patterns and volumes of international vessel traffic entering the Gulf. There are only 13 major ports in the US and 5 in Mexico.

Figure 5 shows the traffic flow and volumes generated within the Gulf. The volume indicators are different from the previous graph.

Figure 6 shows the Shipping Safety Fairways (SSF), anchorages, and other navigational considerations in the Gulf. Approximately 50 percent of the international vessel traffic in the Western and Central Gulf past the area where the SSFs from Beaumont and Houston converge.

Figure 7 shows the major petroleum structures in the Gulf. Of the approximately 4000 structures, about 600 are considered major by criteria set by the Minerals Management Service. Until the price of crude dropped, about 100 platforms a year were being installed and about 50 were being removed. Currently, about 100 are being removed each year and about 100 are going in. The installations, however, are mainly in established fields in fairly shallow waters. Interestingly, when this figure is overlaid with any of the three prior ones, there is a strong correlation between platforms and SSFs. That is, many existing facilities would be readily available to become the collecting and processing facilities for both shipboard and municipal wastes.

RIGS TO REEFS

It is generally acknowledged that virtually every hard substrate in the Gulf of Mexico serves as marine habitat. It is also generally recognized that the amount of natural reef habitat in the Gulf is quite sparse due to the tremendous amounts of sedimentation being emptied into the Gulf by the Mississippi River and the accompanying subsidence. Consequently, the best fishing in the Gulf in terms of size and diversity of keepable catch is found around platforms. Platforms provide substrate from the bottom of the water column to the surface and consequently, recruit benthic, migratory, pelagic, and demersal species. It has been estimated that platforms provided 50 percent of the reef habitat in the Gulf.

As the price of oil and gas declines, and as fields are depleted, platforms cease being assets to their owners and become liabilities. Within a year after a platform ceases to produce "paying quantities", the structure must be cut 5 meters below the mudline, removed, and the area restored to its prior condition. These removal requirements are found in the Geneva Convention of 1958 on the Continental Shelf, the Outer Continental Shelf Lands Act, and the regulations of the Minerals Management Service.

Approximately 70 percent of the oil reserves remain in the ground at the time operations cease and the structure is removed. More hydrocarbons could be recovered if economics allowed. Retention of a structure in place would allow an operator to divert planned removal funds to operational funds. Extended production has obvious profit, tax, and employment benefits.

The cost of removing a structure is based upon many factors and contingencies. The most significant factors, however, are size of structure, water depth, distance from shorebased support facilities, and weather. Estimated costs of removing structures in the Gulf range from $50,000 to $90 million. The National Research Council estimated the total cost of removing all 5482 Gulf structures through the year 2020 to be $7.5 billion.

There are an estimated 6000 structures around the world. The International Exploration and Production Oil and Gas Forum estimated removal costs to approach $50 billion. The International Maritime Organization, the same organization that sponsors MARPOL, is still conducting meetings on how best to treat extant structures. One recognized way is to find legitimate alternate uses such as artificial reefs or Rigs to Reefs. Another justification is to find another subsequent bona fide use such as waste enhancement. The state of Louisiana, via their Louisiana Artificial Reef Initiative, has already accepted title to 5 obsolete structures, 3 of which came from Texas. In return for Louisiana accepting title, the petroleum companies have donated about $600,000 as partial compensation for their salvage savings. The number of companies showing interest as potential donors is growing.

ARTIFICIAL REEFS AND MARICULTURE

The Japanese were the first to discover the benefits of artificial reefs and have not relinquished their lead yet. In the late eighth century, a Japanese fisherman noticed a decline in harvest around a shipwreck. He crafted a bamboo cage, filled it with rock and sank it. His catch improved.

In the last few years, the Japanese have invested the equivalent of several hundreds of millions of dollars in artificial reefs. Their basic reef building components are cubes of 1 and 1.5 cubic meters. Their reef design and complexes are quite varied depending upon reef location, species, and age class. Their basic component is the cube as shown in Figure

8. When stacked, a cube complex has a remarkable similarity to offshore production structures. In contrast to many US reef scientists who are still arguing whether artificial reefs attract or produce fish, the Japanese concentrate most of their research efforts on existing artificial reefs in hopes of further improving mariculture productivity.

The productivity of reefs can vary significantly depending upon many factors including reef design, location, and orientation, water quality and parameters, species, age class, etc. The Artificial Reef Development Center of the Sport Fishing Institute researched their files to determine the productivity of these cubes. The Japanese have been able to produce 16 to 20 kilograms of fish mass per cubic meter per year. From these artificial reefs alone, they now produce more than the entire North Sea catch.

In contrast:

- All US fisheries of commercial and recreational interest are being harvested at or beyond their limits to sustain their population.
- About 80 percent of US fish consumption is imported. Fish products are the third greatest US import product exceeded only by illegal drugs and oil.
- Per capita fish consumption is currently about 17 pounds per person and is projected to increase to 40 pounds by the turn of the century.
- Fish products are the only edibles not Federally inspected.

TYPICAL FACILITY CONFIGURATION

Figure 9 shows a structure constructed in 1979 about 13 miles offshore Galveston. The facility has one oil well and one gas well. The produced oil was stored in the tank and was offloaded periodically by vessel. The gas was injected into a nearby trunk gas line that ran to shore. For a period of time, the operators were considering the feasibility of using the complex as a pilot project test site for the offshore waste enhancement concept.

Figure 10 is one artist's conception of the same facility after modification for waste enhancement. At one time, consideration was being given by one of the partial owners to use this facility as a NSF pilot project. It was anticipated that much of the additional space at the structure complex would be devoted for waste processing and research.

The small containers on the top of the platform and on the back of the supply boat are in scale and approximately represent the volume of compacted non-hazardous wastes generated daily by international vessels transiting the Gulf. The trash containers portrayed on the supply boat would have originally been on the back of a "honey-dipper" barge that collected the wastes from international vessels, or other vessels, in port. Each of the waste containers could be modified with heating equipment to sterilize the food wastes with steam heat. The containers could also be equipped with positive latches and seals to retain all cargo in case of mishaps such as collisions, overboard washings or barge sinkings.

POTENTIAL EXTENDED APPLICATIONS

If the enhancement of shipboard wastes into artificial reefs, plastic lumber, beach stabilization devices, etc. proves feasible on a pilot project basis, the scope of the raw material basis could be enlarged. A logical first extension would be the collection of ocean flotsam and jetsam as it periodically collects along rip tides and wind winnows. The collecting devices could be existing oil skimming barges. Another extension would be the enhancement of debris collected on beaches. A third extension would be the use of non-hazardous household trash from adjacent coastal municipalities.

A glance at the potential of processing coastal community wastes looks interesting. If the municipal solid wastes from Houston were diverted for only one year from landfills to offshore, a reef complex of approximately 25,000,000 individual one cubic meter artificial reefs could be developed in a space approximately one mile by one mile by 40 feet high. If only 3 kilograms of fish filets were to be produced per year per cube (not the 16-20 produced by the Japanese) at a value of only $1 per pound, the Ocean Enterprise Initiative would generate some $165,000,000 mariculture dollars after the first year and each year thereafter for 500 to 1000 years. The amount of harvest would probably be much greater if the City of Houston's waste waters were treated and used to enhance the reef complex. By way of reference, some of Houston's sludge is now being shipped to Florida for placement on citrus groves. Other shipments are going to grain fields west of Houston.

Several government entities are giving increasing thought to the need to encourage artificial reef development and mariculture initiatives. There is no incentive for private dollars to be spent for public use. The Gulf of Mexico Fisheries Management Council, the entity that establishes fishery regulations including season, limit, size, etc., has been approached with this concept and the need for "Special Management Area" protection around artificial reefs. The South Atlantic Fishery Management Council has already created several "private reefs" with the blessing of the Small Business Administration, NOAA, Department of Commerce, and others.

CONCLUSIONS

Under the proper circumstances, one or more of the 4000 Gulf structures might be suitable for multiple use or sequential use as waste enhancement facilities. The advantages and concerns to all segments of society, including the shipping community, the oil companies, state and local government, and the general public must be thoroughly considered and evaluated. Some of the main advantages and concerns of the Ocean Enterprise Initiative participants are:

Advantages

- donations of funds and multi-million high-tech facilities from oil companies
- ample supplies of cheap energy
- choice of several offshore locations near the sources of much of the marine and coastal pollution
- NIMBY

Concerns

- current lack of start up funds
- liability
- fears of pollution
- unknown cost of collecting and processing garbage at sea
- profitability of mariculture venture
- structure maintenance
- final disposal/fate of offshore facilities

The advantages should need no further elaboration. The concerns, however, could delay or eliminate further evaluation of the concept and/or initiation of a pilot project. They are the classic concerns recognized by Dr. James Dailey in his presentation on bridging "no-man's land" in research.

Reasonable parties will not want to participate in the pilot project if they perceive problems of potential liability. This includes concerns about leaching of heavy metals, air pollution, bioaccumulation, human health and safety, etc. Dr. Michael Champ will address these concerns.

It is a fact of life that virtually everything done offshore costs more money than if done onshore. This workshop will begin to determine if, and for what period of time, this historical truism will be true with enhancement of shipboard wastes and other coastal wastes. In the evaluation, it may be prudent to also evaluate the economics of processing wastes offshore from northeastern US communities like Philadelphia that already have more serious waste problems than Gulf coastal communities.

It may be that the US is not ready to fully address all of its fisheries problems nor to test apparently feasible solutions to non-hazardous wastes. Until private ownership of artificial reefs and mariculture is encouraged and protected, there will be no economic engine available to drive the NSF concept.

Each platform has a finite life. When its maintenance costs reach too high a level, the endeavor should terminate. The question then revolves around the ultimate fate of the structure. If the platform was the focal point for some of the artificial reefs either created by waste enhancement or of other obsolete platforms, it makes good sense that the structure should be left in place as additional reef material and to protect the existing ecosystem. The costs of leaving a structure in place are small compared to the costs of total removal. Thus, a portion of the original donation by the oil company to the pilot project managers should be sufficient for this predictable expense.

SUMMARY

The durability of persistent plastics in the oceans is now considered to be a major pollutant problem. This trait of durability can hopefully become a benefit as plastic wastes are converted into artificial reefs. The adoption and enforcement of Annex V of MARPOL prohibiting overboard discharges will change a 4000 year old tradition and create an opportunity to test the concept of waste enhancement at sea. The "tipping fees" provided by the shipowners to the offshore waste operator coupled with income from mariculture facilities should provide the economic engine needed to reduce plastic pollution of the seas.

Figure 1. MARPOL 73/78 Annex V Summary of Garbage Disposal Restrictions.

Garbage Type	All Vessels Except Offshore Platforms & Associated Vessels: Outside special areas	All Vessels Except Offshore Platforms & Associated Vessels: ** In special areas	*** Offshore Platforms & Assoc. Vessels
Plastics - includes synthetic ropes and fishing nets and plastic bags	Disposal prohibited	Disposal prohibited	Disposal prohibited
Floating dunnage, lining and packing materials	Disposal prohibited less than 25 miles from nearest land	Disposal prohibited	Disposal prohibited
Paper, rags, glass, metal, bottles, crockery and similar refuse	Disposal prohibited less than 12 miles from nearest land	Disposal prohibited	Disposal prohibited
* Paper, rags, glass, etc. comminuted or ground	Disposal prohibited less than 3 miles from nearest land	Disposal prohibited	Disposal prohibited
Food waste not comminuted or ground	Disposal prohibited less than 12 miles from nearest land	Disposal prohibited less than 12 miles from nearest land	Disposal prohibited
* Food waste comminuted or ground	Disposal prohibited less than 3 miles from nearest land	Disposal prohibited less than 12 miles from nearest land	Disposal prohibited less than 12 miles from nearest land
Mixed refuse types	****	****	****

* Comminuted or ground garbage must be able to pass through a screen with a mesh size no larger than 25 mm.

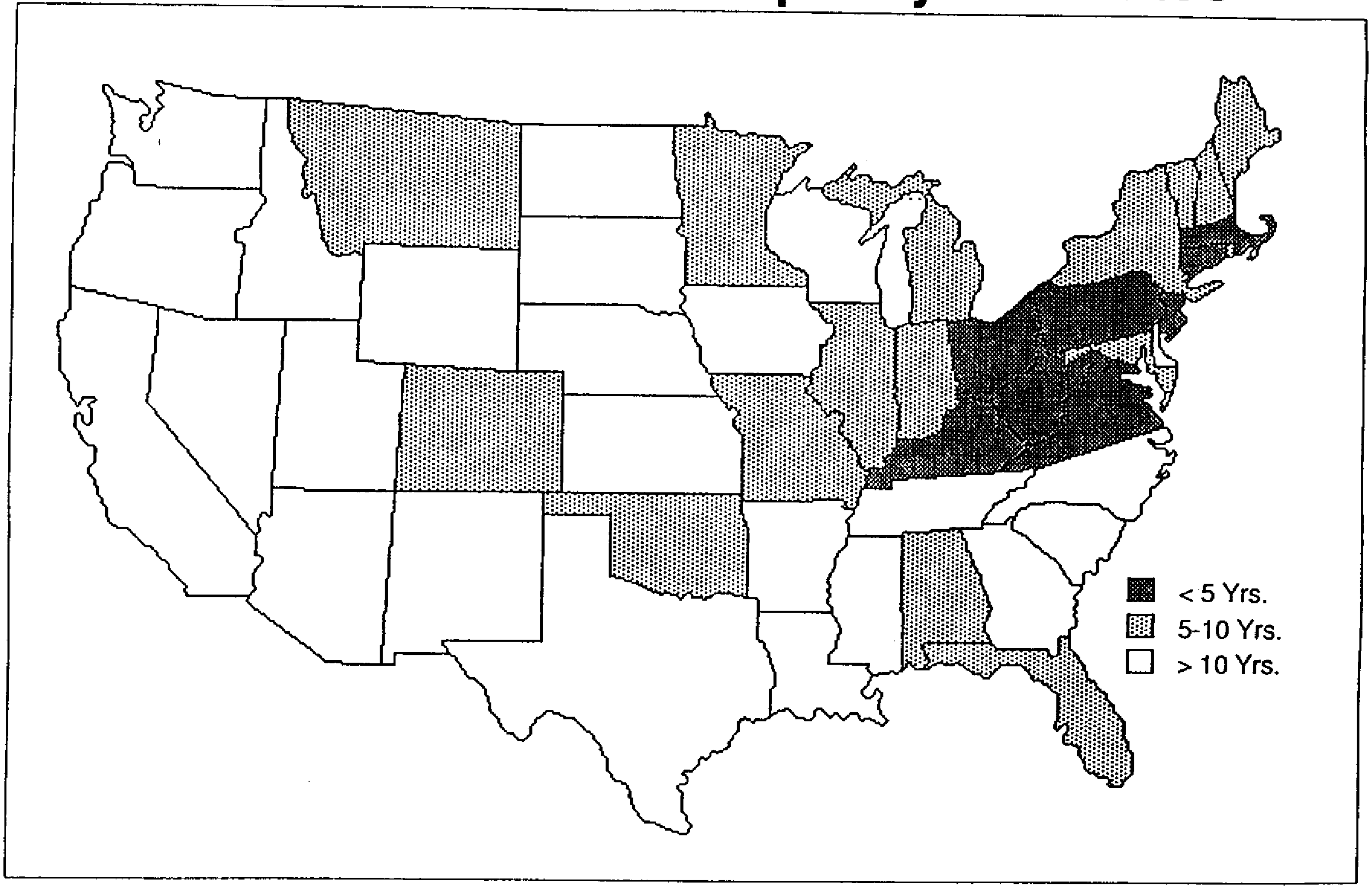
** Special areas are the Mediterranean, Baltic, Red and Black Seas, and Persian Gulf areas.

*** Offshore platforms and associated vessels includes all fixed or floating platforms engaged in exploration or exploitation and associated offshore processing of seabed mineral resources, and all vessels alongside or within 500m of such platforms.

**** When garbage is mixed with other harmful substances having different disposal or discharge requirements the more strigent disposal requirements shall apply.

BILLING CODE 4910-14-C

Remaining Staff Landfill Capacity Estimates



Source: National Solid Wastes Management Association

Figure 2

ENSR

Estimated Landfill Construction Costs*

Site Characterization	$ 175,000
Preliminary Development	2,605,000
Final Development	63,726,950
Environmental Management	7,040,000
Post-Closure	13,404,000
	$86,950,650

*100 Acres, 20 Year Fill, 30 Year Monitor, Double Liner

Source: National Solid Wastes Management Association

Figure 3

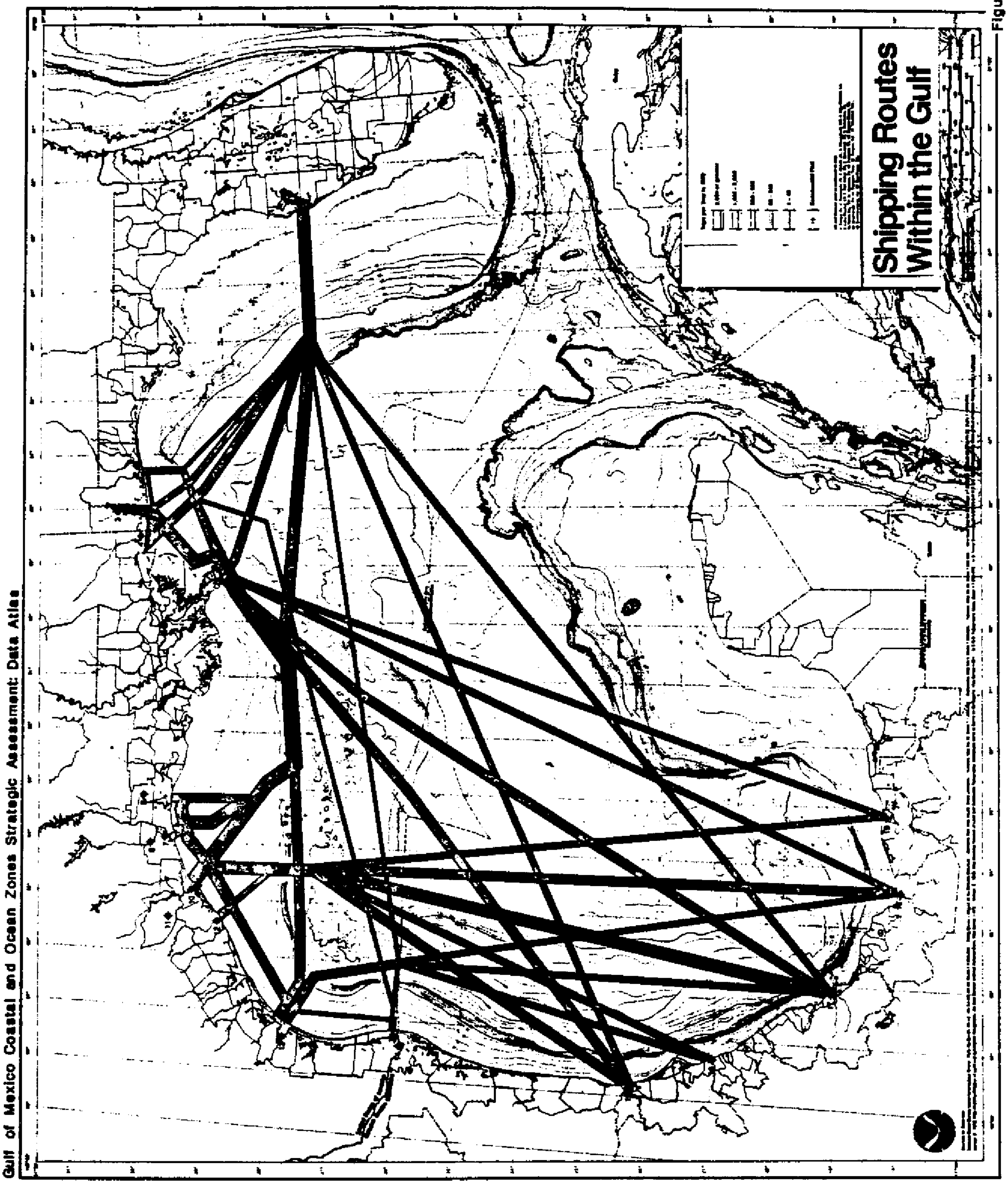

Gulf of Mexico Coastal and Ocean Zones Strategic Assessment: Data Atlas
Shipping Routes
Within the Gulf

Figure 4

Gulf of Mexico Coastal and Ocean Zones Strategic Assessment: Data Atlas

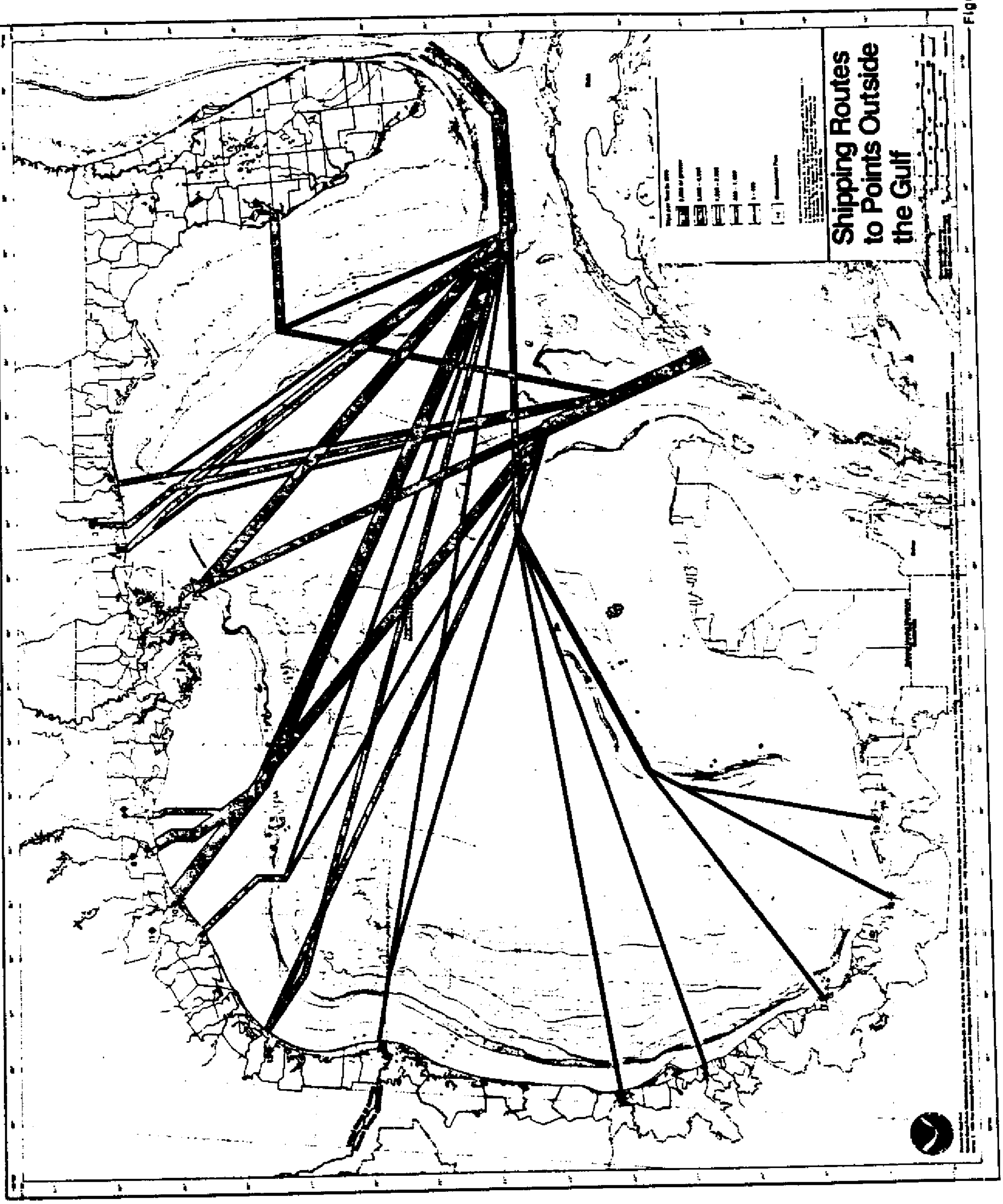
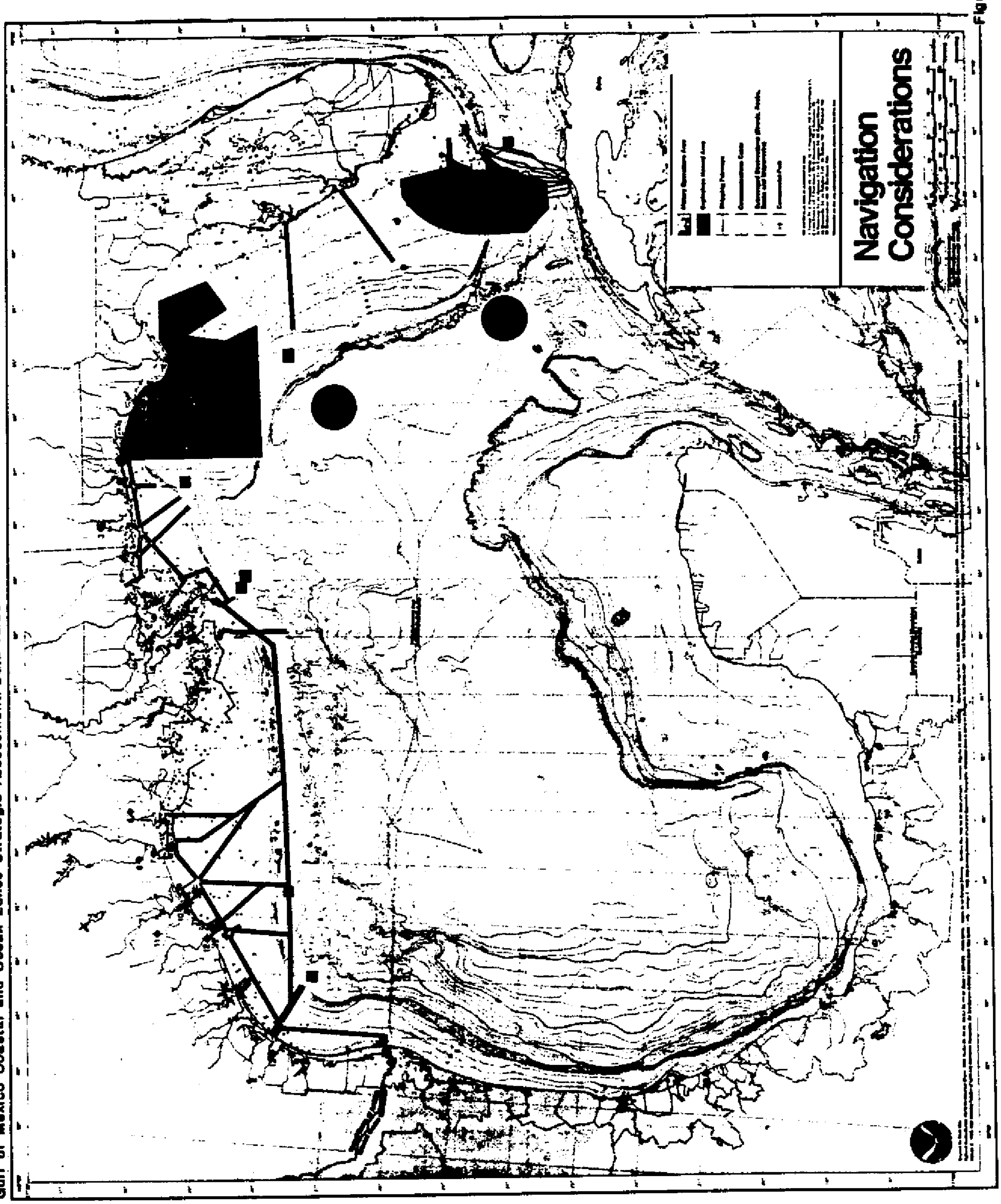


Figure 5

Gulf of Mexico Coastal and Ocean Zones Strategic Assessment: Data Atlas

Figure 6



Gulf of Mexico Coastal and Ocean Zones Strategic Assessment: Data Atlas

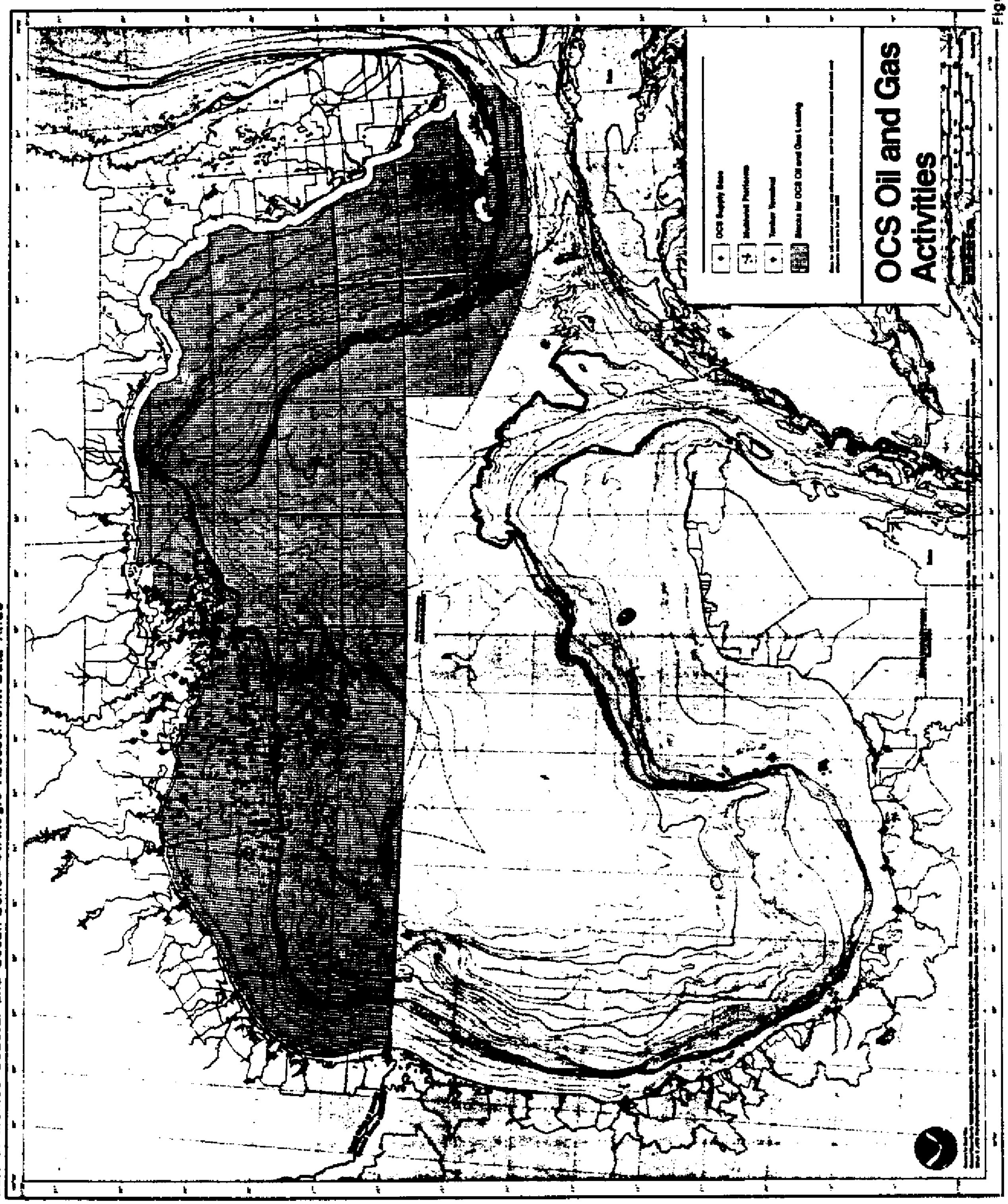
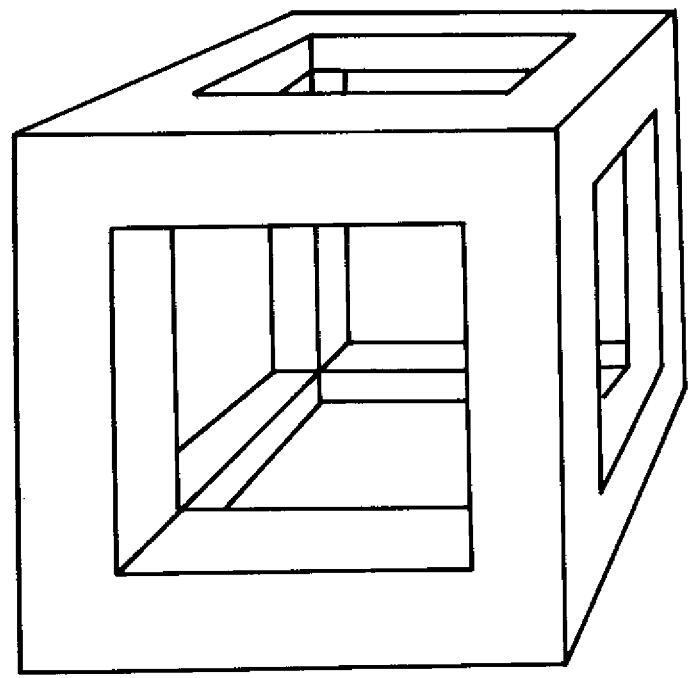


Figure 7

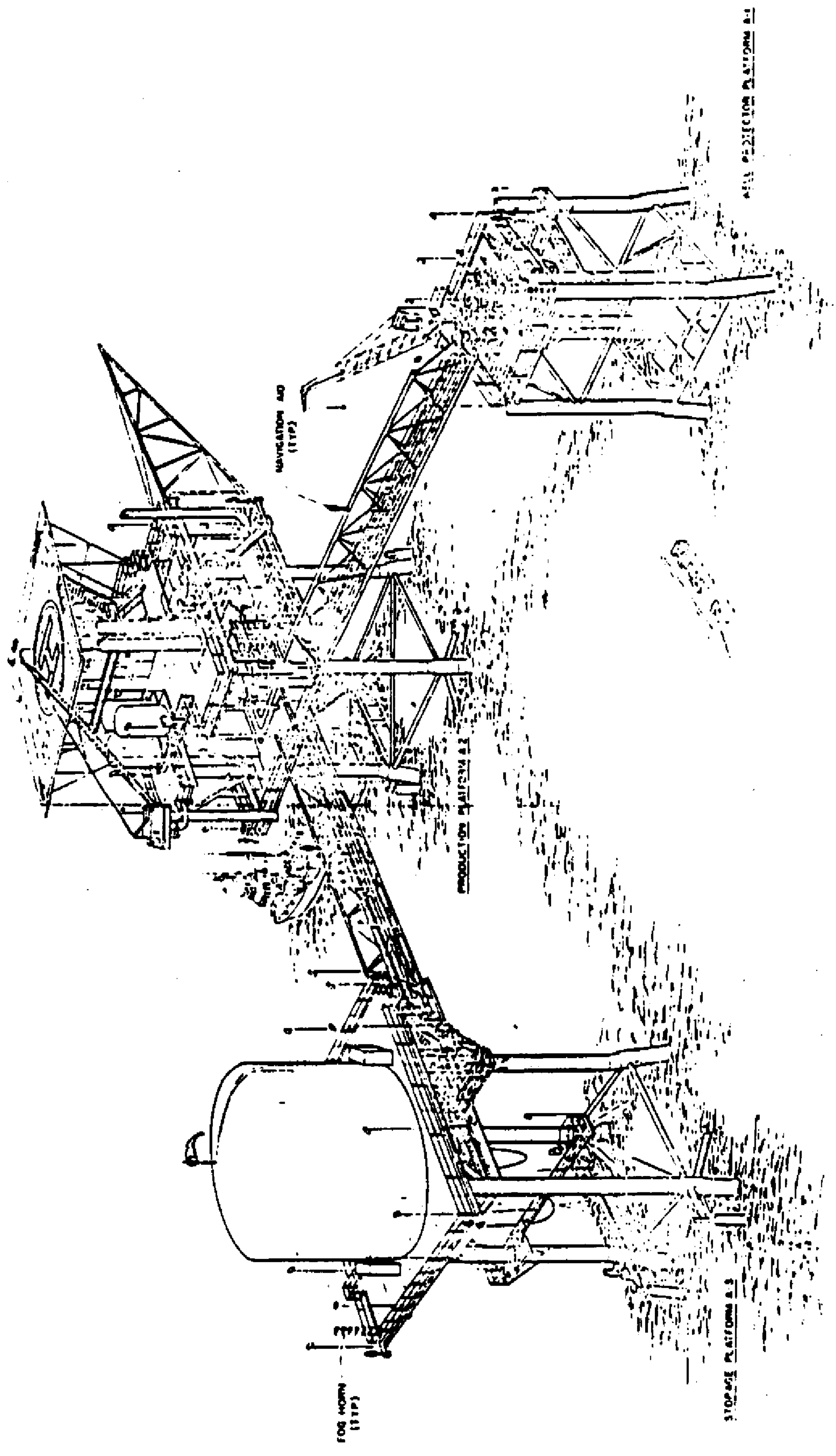
Artificial Reef Cubes



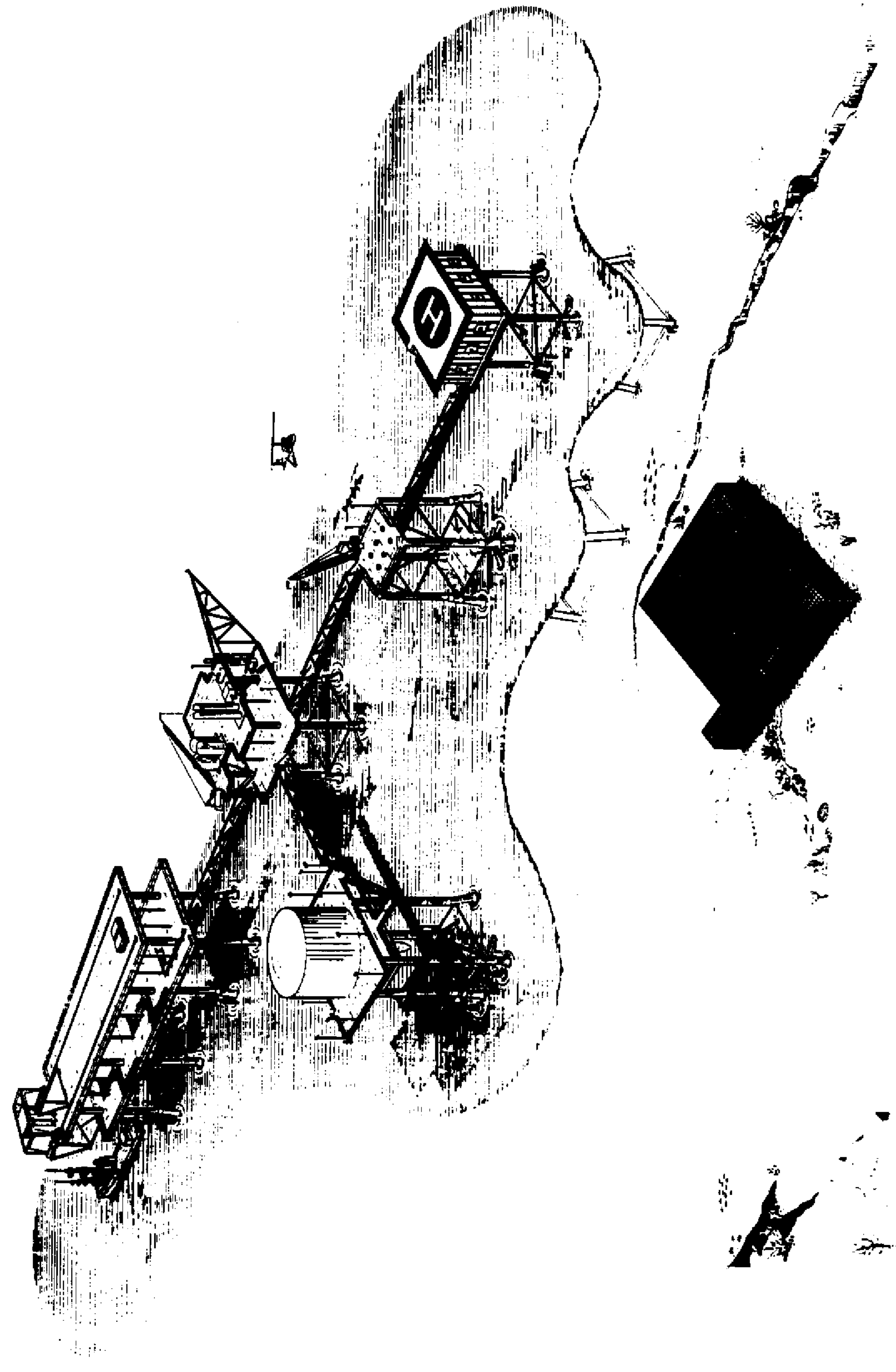
1, 1.5, 2-5 m cubes are produced in this style for regular and large reefs

Figure 8

Figure 9



PRESENT
GALVESTON 144-L COMPLEX



FUTURE DEMONSTRATION PROJECT COMPLEX

Figure 10

CONSIDERATIONS FOR SUBSEABED STORAGE OF SEWAGE SLUDGE WASTE UTILIZING DEEP DRILLING TECHNOLOGIES

by
Melvin N.A. Peterson
Chief Scientist
National Oceanic and Atmospheric Administration

ABSTRACT

Significant environmental hazards have been identified with disposal of sewage sludge, including potential contamination of the Nation's surface and groundwater supplies, degradation of our air quality, and marine pollution. These and additional adverse environmental consequences will become even more severe as treatment facilities double their output by the year 2000. Other factors such as increased industrial activity and regional population increases will produce extreme local problems.

This paper recommends investigation of an alternative sludge disposal method. It calls for drilling, or reaming, into soft near-shore sediments of the ocean floor, inserting waste into the bottom of the hole, and refilling the top portion with displaced sediments. The procedure could potentially isolate waste for geologic time.

Calculations indicate this method could solve a significant portion of the Nation's coastal sludge disposal problem while providing long-term safeguarding of our environment. At the very least, the proposed method represents a possible interim approach pending technological advancements in waste disposal, including proper segregation of toxic components from the massive waste stream.

INTRODUCTION

One of the most pressing problems facing the Nation is disposal of waste from the sewage treatment process. Our 15,300 publicly owned treatment works (POTW's) output over 6 million dry tons of sludge annually, with our coastal states producing over one-third of this total. Experts predict that by the year 2000, the amount of sewage sludge produced annually will exceed 13 million dry tons (EPA, 1984). This will pose an acute problem for coastal states as our population migrates to coastal regions.

Sewage sludge has the potential of causing serious environmental pollution problems. It contains human waste, excess nutrients (e.g., nitrogen, phosphorus, and calcium), pathogens (e.g., viruses, bacteria, and parasites), heavy metals (e.g., lead, mercury, and cadmium), and toxic chemicals. The exact composition of sludge varies with the nature of the source community and its degree of industrialization.

Present disposal methods include landfilling, land application, incineration, ocean disposal, and marketing and distribution (as a soil conditioner). Serious problems have been associated with all these methods, including contamination of the Nation's surface and groundwater supplies, degradation of air quality, and marine pollution.

The increase in sewage sludge production, its potentially harmful effects on the environment, its effects on the aesthetic value of coastal investment property, and problems related to present disposal methods make the issue of sewage disposal one of national significance. We need to examine new solutions to this critical problem.

This proposal recommends an alternative sewage sludge disposal method that calls for 1) drilling or reaming a few hundred feet into soft near-shore sediments of the ocean floor, 2) inserting waste into the bottom of the drill hole, and 3) refilling the top portion of the hole with sediments to cover the waste.

Using this procedure waste would be buried in geologically stable strata, essentially isolated from the surrounding marine environment. Initial evaluation indicates that this method could solve a significant portion of our coastal sewage sludge disposal problem while, at the same time, safeguarding our environment.

The National Oceanic and Atmospheric Administration (NOAA) has a mandated role in the monitoring, research, and applied scientific aspects of ocean disposal of sewage waste through the Marine Protection, Research, and Sanctuaries Act of 1972. In addition, NOAA's stewardship responsibilities with respect to the Nation's living marine resources require active participation in projects that reduce ocean pollution.

PROPOSED ALTERNATIVE DISPOSAL METHOD

Sewage sludge disposal by drilling or reaming, insertion, and burial in the thick, accumulating continental margin sediments offers an alternative to present methods. This approach has potential to isolate and contain toxic chemicals and heavy metals in the sludge for geologic time. The proposed method, in its present form, has not been designed to address either concentrated toxic chemical or radioactive waste disposal problems.

Proposed Disposal Operations

A drill hole about 40 inches in diameter and approximately 400 feet in depth would be made in unconsolidated sediments at a preselected offshore site. A 200-foot length of density-adjusted sewage sludge would be introduced into the drill pipe and forced to the bottom of the pipe with pressurized sea water. It would then be inserted in the hole while the pipe was withdrawn a corresponding length. The drill pipe would then be further withdrawn from the upper 200 feet of the drill hole in such a way to ensure maximum disturbance of surrounding sediment causing the hole to fill. The result would be a slug of waste weighing approximately 20 tons buried under 200 feet of continental margin sediments, isolated potentially for geologic time.

Waste Density

To ensure that the inserted waste does not rise due to buoyancy effects, it will be necessary to adjust its density to slightly exceed that of surrounding sediments. An initial estimate is that a specific gravity of 1.7 or greater should be adequate. This can be modified, if necessary, based on site specific sediment density studies. Compaction will also increase density. Dry sewage sludge normally has a specific gravity of 0.98 to 1.02 after sludge treatment; therefore, additives may be needed to achieve the desired density. This, in fact, provides an opportunity to further enhance the value of the proposed disposal sludge ash, fly ash, or contaminated dredge spoils to obtain necessary density. In a sense, this would address two problems with one solution.

Impact on the National Problem

In light of the large amount of sewage sludge generated in the United States, the question arises as to whether the proposed disposal method would have a significant impact in solving the problem. Some reasonable assumptions and estimates can be made to answer this question which take into account present offshore drilling capabilities and proposed operating methods. The following assumptions are made for estimation:

- unconsolidated sediments in which drill holes can be reamed, washed or easily drilled to 400 foot depth,
- single stroke drilling operations capable of a 400 foot stroke without making or breaking threaded pipe connections, and
- a working year of 320 24-hour days to allow for weather and maintenance.

Under these conditions drilling and inserting a 200-foot slug of waste into a drill hole each 30 minutes should be achievable. This would result in 48 holes per day, each containing 20 tons of density-adjusted sludge, or a total of 960 tons per day. Allowing for the specific gravity adjustment factor from 1.02 to 1.7, the total dry sewage sludge injected each day would be approximately 576 tons. The New York/New Jersey metropolitan area generated around 700 dry tons per day of sewage sludge in 1980 (NJ, 1980). Therefore, operating under the single stroke scenario, the proposed method could effectively dispose of a significant portion of this output.

With engineering design and drill modifications it is possible to conceive of a double sludge emplacement capability for a single rig using a symmetrical, cantilevered drilling configuration with balanced loads. This would permit approximately 96 holes to be drilled per day and increase total density-adjusted sludge emplacement capability to 1920 tons.

A potential site 10 nautical miles square, using a grid spacing of 50 feet between holes, would provide for more than 1.4 million drill holes. This is roughly equivalent to about 45 years operation for a single drill platform, even using the double cantilevered-balanced rig method for drilling. The actual pattern of drilling would depend on sediment character, drill pipe diameter and other factors, but the estimate is a valid first approximation.

These simple calculations illustrate the reasonableness of the proposed method and its potential impact on the sewage sludge disposal problem.

Drilling and Sludge Emplacement

Since proposed sewage disposal operations would be in unconsolidated sediments, drill holes could be readily made either by drilling and washing using sea water as a drill fluid, or by gravitational penetration using a modified drill string.

Drilling and washing operations can be done with present technology using either a single or dual-concentric drill string. A single drill string is a single drill pipe which, in proposed operations, would be around 40 inches in diameter, down which sea water would be pumped as a drilling fluid. A dual-concentric drill string consists of two drill pipes, one inside the other and connected by septa, with sea water pumped down the outer space between the pipes during drilling operations. The outer pipe for proposed operations would have to be more than 40 inches in diameter to accommodate the 40-inch inner pipe. With either of these alternatives, sediment from the drill hole would be displaced into the water column and around the drill hole itself as drilling occurred.

Using gravitational penetration, a single drill string, again about 40 inches in diameter, would be employed. In this case the bottom of the drill string would be fitted with a flapper or clamshell valve to prevent sediment entry during operation. The drill string would require a specially-weighted drill pipe above the bottom 400 or so feet to accomplish sediment penetration while still keeping the remaining drill string in tension. The possibility exists for obtaining additional reaming action to make the hole by using modified drill pipe cross-sections.

An advantage of using gravitational penetration is that it largely eliminates the sediment displacement and dispersal problem encountered in drilling and washing operations. Obviously, the technique is highly dependent on local geological conditions, such as the degree of sediment compaction and penetrability. These factors will be important criterion in the site selection process. In actual operations it is possible that a combination of washing and drilling and gravitational penetration would be used. At this stage of the proposed program, simple gravitational penetration and reaming would be the preferred method.

Once the hole was completed with the drill string in place, sludge loading would begin from the drill platform. As conceived, the density-adjusted sewage sludge would be a stiff but deformable mixture allowing it to be cylindrically shaped or packed into handling cylinders either during shore-based handling and transport or even on the drill platform. Due to its consistency and density, the waste will be unlikely to migrate into surrounding sediments and water. The approach presents a fully controlled procedure as contrasted with methods such as pumping slurries. Accidental environmental contamination during transport, handling, and sludge emplacement will also be less likely using density enhanced sludge than if a less dense slurry were used.

Consideration will have to be given to making the cylinder diameter of the density-adjusted sludge slightly less than that of the drill pipe used for injection. This, or some other means of reducing friction between the sludge and drill pipe, may be necessary for ease of emplacement in the drill hole bottom. At the same time, it may be necessary to introduce drill pipe constrictions or use internal drill pipe vanes to ensure that the loaded waste charge remains in place until pressure injected.

Once in the drill string, the full 200-foot charge of waste would be covered with a plug to eliminate backwash, and pressurized sea water would be used to push it to the drill hole bottom. The drill pipe would be simultaneously withdrawn at the same rate the waste, in the form of a paste, was inserted. Methods of inducing the desired collapse of sediment to fill the hole and isolate waste must be designed, as necessary, for the specific disposal site.

Transport and Handling

For ocean drilling and burial to be a viable alternative, handling and transport processes must be examined in detail for efficiency at every step from output at the POTW to burial in the drill hole. This includes: 1) transport from the POTW to the marine loading facility, if they are not collocated; 2) transfer to the marine vessel as well as the type of vessel used for transport to the drill platform; 3) transfer onto the drill platform; and 4) physically transferring the sludge to the drill hole itself.

Since economics is important in terms of the dollar cost per ton of dry sewage sludge handled, maximum use must be made of existing technology at every stage of the process. An important question is the point at which density adjustment and cylindrical shaping of the sewage sludge should occur, since this has bearing on all steps of the transport and handling process. Special additives, such as hardening agents, could be introduced at this point in the process.

Both density adjustment and physical waste shaping operations on any large scale will require a stable operating environment, so a land-based site is preferable. The POTW appears to be the last site to accomplish these processes for several reasons. This site is already established as the location for handling sewage in the social and environmental setting, so additional approvals may not be required. Also, a strong candidate for a density additive is incinerated sludge ash, which is generated at some POTW's, eliminating the need for overland transport.

Since storage facilities for incinerated sludge ash already exist on site at many POTW's, it would only be necessary to provide additional storage for other additives used at the POTW, rather than provide for these and sludge ash at a new location. There are also advantages to accomplishing waste shaping (probably in specifically-designed transport/handling cylinders) at an early stage in the handling process. Waste containment will minimize potential for environmental contamination during subsequent handling and transport. Correct sizing of the containment/shaping cylinders will further facilitate transport and handling operations using existing barges, rail, vessels, cranes, and derricks, so these considerations should occur early in the activity sequence as well. For all of these reasons the POTW would seem a logical choice for density adjustment and waste shaping. We strongly favor the use of pre-shaped charges contained in special handling cylinders. In addition, the substantial handling and discharging equipment needed will eliminate any possibility of "short-dumping" waste.

BUSINESS/COMMERCIAL CONSIDERATIONS

Disposal of sewage sludge is an expensive operation. For example, the Mayor of New York City recently testified before Congress on sewage sludge disposal problems in his municipality. He stated that it would take at least 10 years and $213 million to construct a land-based compost system to service New York City. An additional $60 million would then be needed annually to operate it. The Mayor also said an incineration system would take 15 years and $477 million to construct, and $49 million each year to operate. In addition, he noted that the city recently spent $41 million to build ocean-going barges to move sludge dumping from the 12-mile site to the 106-mile site (Nautilus Press, 1988).

The proposed disposal method will also be expensive; however, potential environmental benefits of this method make it a reasonable alternative to present methods.

A number of possible models for implementing the proposed sewage sludge disposal program can be hypothesized. As NOAA gains broad support for the program, details of the business/commercial aspects will become better defined and alternatives easier to examine.

One possible model for commercialization would begin with NOAA promoting Federal/state/congressional/industry program interest. NOAA would then enlist support from these groups to help finance a feasibility study and pilot project. Once NOAA had established the program's technological merit and commercial potential, the program would be transferred to the private sector.

Once started, the government, through the Federal Technology Act of 1986 (P.L. 99-502), could provide technological assistance in the form of laboratory resources (personnel, services, and property--but not money) for collaboration with outside organizations. In short, technology transfer could be used by an outside organization to solve technological problems in which Federal laboratories might have special expertise (e.g., sludge density enhancement, methane production, or environmental monitoring).

Investment of oil industry monies and venture capital are possibilities for providing program start-up funding. In addition, the offshore oil drilling industry could be useful in providing technological support. Once start-up funds have been identified, and technological problems addressed, commercial operation could be supported directly by POTW's utilizing resulting disposal services. At this time, likely candidates are the New York/New Jersey municipalities now seeking alternative sewage disposal approaches.

Four phases of commercial development are:

1. **Feasibility Study.** This phase would be financed largely by the Federal government. The request for proposals (RFP) would be in the form of a fixed price contract. A cost-effectiveness analysis would be an essential element of the feasibility study. In addition, recommendations relating to pre-disposal drilling operations, drilling/reaming methods, a pilot project, and site selection would result from the study. Small scale laboratory studies to test sludge rheological properties will be done during this phase of the project.

2. **Research and Development.** This phase could be financed in part by commercial industries and in part by the Federal government. This potentially involves use of the Federal Technology Transfer Act, which authorizes Federal laboratories to enter into cooperative research, development, or engineering agreements with other Federal agencies, state or local governments, and the private sector. Specific engineering and environmental problems could be contracted out. Pre-disposal (dry) drilling operations and a pilot project would be major components of the R&D phase.

3. **Construction.** Design, development, and construction of sludge handling containers and sludge packing equipment will be necessary. Engineering examination and modifications may need to be made to available transport and handling facilities, both onshore and on a candidate drilling platform. This would be the most expensive phase of the program, requiring investment capital. The oil industry, common stock, and venture capital could be used to finance construction.

4. **Program Operations.** This phase should be operated on a contract basis by the private sector, using long-term (5 year) renewable fixed price contracts. Financing for the operation would come from users (POTW's) of the disposal site. Environmental monitoring expenses would be shared by users, operators, and the Federal government.

CONCLUSIONS AND RECOMMENDATIONS

The NOAA workgroup that investigated issues related to a proposed alternate method for sewage sludge disposal concludes that this approach has merit, and steps should immediately be taken to develop external support. The workgroup identified technical issues that require additional study and recommended a feasibility study and pilot project to satisfy information needs.

Conclusions

1. The growing sewage sludge disposal problem is one of critical national concern and merits investigation of alternative disposal methods.

2. The proposed method of sewage sludge disposal is a reasonable alternative to existing disposal methods, and steps should immediately be taken to develop external support for the program.

Recommendations

1. That a detailed investigation of this alternate disposal method be initiated. This requires developing program support, initiating a feasibility study, and implementing a pre-disposal drilling project and a pilot project.

2. That the feasibility study address specific technical issues such as:

   a. Sludge mixing, hardening, and transport
   b. The insertion/isolation process
   c. Methane production/retardation
   d. Migration/diffusion processes
   e. Engineering design
   f. Environmental effects and benefits
   g. Geological site selection
   h. Sediment dynamics
   i. Environmental Impact Statement requirements
   j. Pilot project and pre-disposal drilling/reaming scenarios
   k. Legal considerations

3. That a detailed cost-effectiveness analysis and business plan be included in the feasibility study along with simple pre-disposal laboratory studies.

4. That funding be located to conduct the feasibility study and simple pre-disposal laboratory studies.

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CONCEPTS FOR STRUCTURING OCEAN VENTURES

by
Clifford E. McLain
Consultant

INTRODUCTION AND BACKGROUND

The US has supported a long and continuous development of marine science, engineering, and operational capability which has characterized the US presence in the Ocean since WWII. At the end of that war, the US was the clear leader in almost all elements of marine technology, resources, and equipment. The US merchant marine, which was greatly expanded during the war, was in a position which would support a significant maritime transportation industry. Subsequent growth in technology, and the establishment of a strong academic basis for the marine sciences, reflected a growing awareness of the importance of developing an understanding stewardship of the national ocean assets. The formation of the National Oceanic and Atmospheric Administration, following the recommendations of the Stratton Commission report in 1970, was intended to provide a national focus for the applied aspects of oceanic as well as atmospheric science and technology. In 1983, President Reagan declared the US Exclusive Economic Zone (EEZ), in effect almost doubling the area of the US in claiming the ownership of the economic assets of the ocean within the zone. The EEZ was intended to support a new age of ocean economic development and the realization of vast new assets for the US economy.

And yet, in retrospect, has there been any significant change in the role of the ocean and its assets in the national economy? It can be argued that, in addition to the traditional ocean and coastal uses of past millennia--transportation, seafood, and recreation--there has been added only one new economic sector of importance: that of offshore oil and gas. In all of the other prospective benefits of the ocean, although research and even prototype development activities have been consistently and in some cases vigorously pursued, no significant new economic contributor has yet developed. In the October '88 Silver Anniversary issue of the *MTS Journal,* which offers a whole compendium of articles on the state of ocean affairs, an insightful review of US marine policy is provided by Lauriston R. King and Feenan D. Jennings of Texas A&M. They have characterized the three decades of ocean policy since 1959 as: Formative (1959-69), Stewardship (1970-80), and Decline (1980-90). Significantly, they see no new effort which would alter the conditions of the past eight years. They do observe that some of the great hopes of the 1970's for new economic benefits have been great disappointments, most notably in the case of seabed hard minerals.

If important economic assets are actually present within the EEZ and the US has a demonstrable need for these assets, why has the economic use of these assets remained unrealized? Over the past decade, the private sector in general has argued that Federal support was necessary to solve the problems of exploration, technology, and proof of economic practicality. The Federal government, in turn, has tended to argue that it is up to the private sector to undertake the developmental and economic risks, since theirs is the principal economic benefit under a private enterprise economy. The success of the development of offshore oil and gas is pointed to as an example of how the government should provide the regulatory environment, and industry support the exploration, development, and production. If this is indeed all that is required, then the establishment of the EEZ should have created a policy environment in which the private sector would have been able and willing to enter into the development of many new ocean asset areas.

The EEZ declaration was signed in March 1983, almost six years ago. Yet no new developments seem to be in the process of occurring, let alone accomplished and in profitably economic operation. Indeed, in the context of the US Territorial Seas, it can be argued that there had always been a policy environment in which an economically attractive and practical development of ocean assets could have occurred. Some believe that the lack of development of new ocean enterprise is merely an indication that the ocean really does not offer new assets of practical economic value in today's national and world economic structure, else the private sector would have indeed entered into the development of these assets. Seafood, transportation, offshore petroleum, and recreation remain the staples of the ocean contribution to national assets and economy because they are the only areas which now provide a practical opportunity for gainful economic development.

THE NEED FOR AN OCEAN ENTERPRISE STRUCTURE

The easy argument might well be that there has been no significant new economic ocean development because there are actually no opportunities, once the practical economic realities are considered. This paper proposes a different argument, however. It suggests that there are many ocean enterprise areas in which, on the basis of technology and market economics alone, profitable enterprise might be developed now, but that there are many constraints to development which are neither technical or economic and which are peculiar in many ways to the ocean alone. This peculiarity derives from the fact that the national ocean, as defined by the EEZ and the Territorial Seas, is universally regarded as being owned by the entire public. This public owner constituency has been increasingly insistent that its rights and concerns be recognized and protected. These constituency constraints are real, and they severely affect the ability and interest of the private sector in any developmental consideration of a new ocean enterprise.

There are additional technology and financial constraints which are also real. These constraints must be considered on their own merits, and also in the context of the ocean constituency constraints hinted at above. In a normal developmental private sector venture, the essential elements of risk which must be considered are those of technology (can it be done?), general profitability (will the general market price range of the product allow a profit to be made?), and the specific market projections (where, specifically, will the product be sold and at what volume and price?). On this basis, the investor balances the risk that the venture project will be successful in producing a product that will meet the market specification at a profit against the projected return from sales to that market if the project is successful. Ideally, the initial sales will be already arranged under a contingent contract agreement.

A typical example is in the oil/gas industry. In an ideal oil/gas venture, the primary risk is whether a successful well will be realized. If oil is obtained, the market returns are calculable. The key, of course, is that the investor tries to reduce risk by all means, and wishes to keep essential risk within areas where the investor at least *thinks* that risk is understood, if not eliminated. The investment decision is then made on the basis of the balance between risk and return on investment. If the risks are perceived as high, a very high return on investment will be required to induce the private sector to invest. If the risks are believed to be well understood (again, the oil/gas industry is a good example of this), they will be taken in the context of the current and projected market as a basis for return on investment. This is the basic formula for private sector involvement in any venture enterprise.

The basic problem for private sector initiatives in ocean enterprise projects is that, in addition to the normal risks of technology and market, the investor must face constraints imposed by the operating environment of policy, regulation, and other ocean stakeholders and users with requirements that may either actually or appear to conflict with the new investment enterprise. These additional constraints appear as risks to the investor. If these risks cannot be quantified in some manner, so that a balance of risk versus return can be estimated, there is no way that a logical investor would be persuaded to undertake the enterprise project. Therefore, recognizing that the national ocean (EEZ and Territorial Sea) is a public asset engendering user and stakeholder claims from a wide variety of public constituencies, and that the constraints derived from this fact are real, the ocean enterprise structure must be designed to resolve and balance these constraints if it is to be at all successful in encouraging private sector participation. In addition, the ocean enterprise structure must be effective in addressing the fundamental constraints of technical risk and the marketplace (economic return commensurate with risk).

THE SUGGESTED STRUCTURE--A PARTNERSHIP

It is the suggestion of this paper that the only structure with a fair chance of success (not necessarily a guarantee--some problems resist solution in any form) is that of a *public-private partnership of interest.* The basis of the partnership is a private sector team (or a single private sector entity), operating in partnership with responsible government agencies. The other ocean stakeholders and users are also represented as *partners* in the project. If this approach is to be at all effective, the partnership will have to be real. That is, the benefits derived from the successful development and operation of the project will be *shared by all partners in some manner proportionate to their contribution to the enterprise.*

In the case of private sector investors in finance and in kind, this shared partition is easily determined. In the case of governmental responsibility for leasing or otherwise providing access to the particular ocean resource required for the project, the partition of returns is specified in the lease contract and may also be well defined. How about those ocean users and stakeholders which do not consider themselves well represented under the governmental royalty or leasing arrangements? The seafood industry is a good example. Their contribution may be a perceived loss of fishing territory due to the spatial occupation of lucrative fishing area by the enterprise project. The partnership should provide some formula for demonstrating a proportionate return to fishermen from the new enterprise which will provide them a return on their investment, which in this case may be represented by a permanent or temporary relinquishment of fishing territory and consequent loss of catch. As an example, the offshore oil and gas industry has set up mechanisms for the compensation of fishermen for loss of fishing territory due to oil/gas operations. These mechanisms have been fairly successful in developing an acceptance of offshore oil and gas operations by fishermen in a typical situation of conflicting ocean space uses. This paper proposes a much more active structure which seeks to provide all of the partnership elements a specific objective role in support of partnership objectives, and with clear agreement as to the benefits to each partner from the success of the project.

It may be observed that the implications of this type of structure are likely to be quite complex. Isn't there a simpler approach? The thesis of this paper is that while simpler structures can be defined, and in fact constitute the majority of our current regulatory environment for ocean development, they are not likely to work for most new ocean enterprises. Why is this? The answer is that these simpler systems by their very structure ignore and leave out many of the important constituency relationships that obtain in the assignment of publicly owned assets to any particular private or public interest.

An excellent example is provided in the past attempts of the Dept. of the Interior to encourage development of seabed hard minerals under the Outer Continental Shelf Lands Act (OCSLA). This act has so far been an effective vehicle to offshore oil/gas development but singularly unsuccessful in encouraging hard mineral development. The variety of specific reasons for this have been well rehearsed at the various biennial EEZ symposia, in testimony before Congress (particularly at hearings in support of the Lowry Bill, HR 5464 in 1986), and at the workshops and studies sponsored by the University of Virginia Center for Ocean Law and Policy, headed by Prof. John Norton Moore. OCSLA is, in effect, a provision for a simple contract for development between the Department of Interior Minerals Management Service and the developing contractor. Its problems are typified by the various injunctions against lease sales sought by state and local governments, primarily on the basis that they have been left out of the deal, in one way or another. These state governments argue that they should have some role in the arrangement because, although they may not have legal jurisdiction, they are impacted by operations and thus, in effect, contribute value (or lose value) to the undertaking. The National Ocean Industries Association (NOIA) has correctly defined this problem in their Pro-Lease program, which seeks to establish a better understanding and appreciation of the leasing process and how it benefits the various concerned stakeholders who feel left out, as well as providing these constituencies with an informal means of becoming better coupled with the current leasing process.

It can be argued that the few current hard mineral operations in public ocean waters have effectively entered into a form of partnership. In the relatively simple environment of Territorial Seas, the development is able to deal directly with the concerned state. In these few hard mineral instances, the developers have striven successfully to establish an effective partnership, at least in intent, through information sharing and cooperation with all concerned constituencies in their region of operations. An excellent example of the effectiveness of this approach is that of the Western Gold (Inspiration Mining) operations with the Bima dredge on the placer deposits in the vicinity of Nome, Alaska over the past three years.

ELEMENTS OF AN OCEAN ENTERPRISE PARTNERSHIP

The Public Interest

The basic argument of this paper is that the ocean and its resources pose a peculiar environment for economic investment and development, one that is quite different from the general entrepreneurial experience in dealing with land based assets and property. The oceans are entirely in the public domain, their assets shared by all, the actions and effects of the development of any of its assets are the concern of all, and affect all of the perceived stakeholders in the ocean. In other words, there is no concept of private property in the oceans in the popular sociopolitical structure of the US. Therefore, it is argued that programs and projects with the objective of entering into any new development that has not been occupied from time immemorial by the traditional ocean user areas of transportation, seafood, and recreation must meet the test of public and political opinion by incorporating a balanced and combined interest of all self perceived stakeholders in the ocean, if they are to be accepted as a part of the national socio-economic structure.

Continued extension and operation of the user area of offshore oil and gas is a special case of this argument. The current US offshore oil and gas industry has developed under a set of regulations which are believed to work well by the US Department of the Interior and which have been accepted by Congress and the courts, proven through years of experience. The industry itself has been willing to invest in the costly development and expansion of this new area with essentially no direct Federal financial support, although appreciably assisted by tax policies which encourage such investment. This particular ocean enterprise area, the only new ocean use of significant economic impact, is however coming under increasing fire from other ocean stakeholders. Offshore oil and gas development is seen to threaten perceived ocean stakeholder interests without directly representing those interests within its own structure. The court actions and injunctions brought against offshore oil and gas lease developments, and the state initiatives to further limit offshore leasing in the state controlled territorial sea and beyond, are indicative of a general perception of a public right to have a stronger role at all levels in the determination of the appropriate development of this resource.

This argument suggests that, in order to accommodate the fundamental perceived right of ownership in the ocean of all of the ocean stakeholder claimants, the proper structure for ocean enterprise areas is that which offers a *partnership participation* of the various ocean stakeholders in the development and economic operation of the enterprise.

Governmental Entities

The public interests in publicly held assets are, of course, the direct subject of the responsibilities of governments of all levels: local, state and Federal. Each level has developed its own set of laws and regulations regarding the uses and protection of these assets, and each has its own constituency to which it is responsible for its policy and actions in its management of these assets. Going from the local to the national level, the complexity of the governmental constituency varies from what may be a relatively simple makeup of interests and perceptions at the local level to the full complexity of the US sociopolitical structure at the national level. The state level is a mixture of the two. It will reflect the full scope of the interests of its citizenry, which are probably almost as varied as that of the national level, but balanced by concerns which are focused on the regional characteristics of the state and its neighbors.

Each governmental level will do its best to discharge its responsibilities as these are seen to be dictated by its constituency. However, it might be argued that, at each higher level, those responsible for policy and its implementation may often by further separated from the realities of the wants and desires of that constituency. At the local level, each element of the local constituency has a ready access to the county council, the local regulatory staffs, the mayor, and other officials. At the state level, direct constituent interactions are more difficult. Organizations representing the interests of constituency groups tend to dominate the interface and assume the primary responsibility for making constituency desires known to government. At the Federal level, there tends to be a great deal of separation between direct expression of constituency concerns and the operating departments and agencies. Certain agencies will tend to respond to the particular constituency interest groups which are primarily the source of the authorities and responsibilities of that agency, and to pay less attention to the other interest groups which may claim a stake in the authority area of the agency, but which are not directly the subject of its authorities. Thus, at the Federal level, Minerals Management Service in Interior tends to direct most of its attention to the operating economic constituency which is the direct subject of its regulatory authority. In the case of offshore mineral development in federal waters, this is of course the oil/gas and minerals industry. The focus of environmentally concerned constituency groups tends towards those Federal agencies with responsibilities which directly address their interests: NOAA and EPA, for example.

All of the foregoing is very general and rather obvious. The problems arise from the unavoidable complexities of establishing a new enterprise in an area where interests and responsibilities are perceived at many governmental levels, and where a rather wide range of constituencies see themselves as affected by the enterprise project--often just because it is occurring in an arena where all have a justifiable interest: the ocean. It is just this area of multiple stakeholder interest, and multiple and sometimes overlapping governmental responsibilities and concerns, which tends to daunt many private sector development efforts. These projects are seen as being far too complicated and uncertain to merit the risk and time needed to establish an operating basis of rule and policy which may or may not be favorable to a practical economic enterprise operation, *even if on the basis of technology and world or local market position alone, the enterprise should be entirely practicable.*

If these diverse governmental interests are to be organized at all, it would seem that the organization must be through some form of a partnership structure, since all of the concerned governments at all levels will themselves perceive that they are and ought to be representatives in, and regulators of, the enterprise, since they all have a stake in the ocean asset. The concerned governments must be partners.

Intellectual and Institutional Elements

The basis of scientific and technical knowledge and capabilities which would be required to make the proposed ocean enterprise project practical in a physical and economic operational sense lies in the work, the information, and the expertise of the scientific and engineering institutions working in the enterprise arena: the ocean. These intellectual and institutional elements include government and private laboratories, colleges and universities, supporting national organizations and agencies such as the NSF, and the NAS/NAE, and interest group organizations and institutions which collect information, represent constituency interests, and in many cases perform research in their respective areas of interest.

To ignore this basic source of information and technology would, of course, be impossible, if the enterprise project is to be regarded as technically sound. But the function of these bodies extends beyond that of being a source of technological assistance. They themselves, through their own continuing programs and research and development objectives and agendas, have an important stake in the same asset: the national ocean and the Territorial Sea. Therefore, these organizations will perceive that they have a particularly important stake in the effects and outcomes of any proposed operational enterprise in their area of interest. Further, these interest areas are often a reflection of general public interest in particular ocean assets, and thus are responsive to the ocean constituencies. The organized elements of the constituency recognize this, and support the institutional elements both as a means of furthering their own interests, and as the sources of reliable information and understanding related to these interests which they can trust.

Finally, these same institutions see the work necessary to explore, develop, and operate an ocean enterprise project as an important opportunity to gather new information, and perform new research and development, which otherwise would not be possible. They thus have a dual reason for wishing to participate: the opportunity to accomplish what otherwise would not be possible, and the desire to understand the effects and operation of the enterprise project on behalf of their own intellectual interest and that of their constituencies. Their opposition to the planned enterprise project would be a formidable obstacle for any private sector developed to overcome. Conversely their ability to support the project on the basis of their understanding, their data, and their trustworthiness as seen by their constituencies, would be an invaluable asset. The concerned intellectual and institutional elements also need to be involved in the partnership.

Ocean Users

Any new ocean enterprise project will in most cases have to take place in the same ocean areas and occupy or use ocean assets in space and time which are already in use by one or more existing ocean users. These users will be the traditional ocean industry operators (transportation, seafood, recreation, offshore oil/gas), the various ocean research activities, and more rarely, the national defense. These users may claim to have rights of prior use and tradition, as well as the rights derivable from their own set of regulations, licensing, and agreements, which already govern and permit their operations in the ocean as an entirely public property. The new enterprise will have to accommodate or suitably recognize other user rights, including the right of equal access to the balanced stewardship of the ocean resources on behalf of its public ownership. Of course, each user is itself a part of the overall constituency of ocean ownership, so that any specific access of present users may be regarded as a balance between ocean owner constituencies which have a specific and gainful use of ocean resources, and those which do not, but which support the retention of other ocean resource values of importance to them (such as natural resources and marine life, scenic beauty, recreational activities, and a natural environment as a valuable asset in itself).

The current ocean users whose activities will significantly overlap or will be perceived as being affected by the activities of the new ocean enterprise project will want to assure themselves that the new project will properly take into account their own interests. These current users are in most cases constituency interest groups in themselves, and often play an important role, particularly at the state and national governmental levels, in representing their interests in policy, regulation, and public fund support. It will often be the role of government, at the appropriate level, to provide a management and regulatory framework for the reconciliation of differing demands and requirements of these various users in creating a basis for the new ocean enterprise project. At the same time, the most effective way of both answering the concerns of current users and allaying their fears of suffering economic impact as a result of the new enterprise project will be to make them partners in the new project as well.

The Private Sector

The private sector is of course the basis of partnership formation in any new ocean enterprise project which is to be an effective contributor to the economic fabric at a local, regional, or national level. Its components are those of finance, exploration and development, and operation. All of these may be combined in a single business entity, or the makeup derived from a partnership of private sector interests fulfilling each of the component functions. Local and national private sector financial organizations and resources may be required for many new enterprise projects due to size alone, and the desire to spread risk. Several individual industrial and business organizations may be required in one form of teaming arrangement or another to assure a complete set of capabilities for the realization of the objectives of the new enterprise project. The requirements for structure within the private sector will be at least as varied as the potential new enterprise projects themselves.

Another consideration for the organization and makeup of the private sector team, as the basis for the partnership structure, will be that of supporting a basis of trust in the other partnership elements. The private sector team must be perceived as both collectively and individually worthy of the trust and cooperation of the other partnership elements, or they will rightfully refuse to be members of the partnership, and if not members, then potentially objectors, to the methods or objectives of the project, or to the private sector team if not to the project itself.

The private sector team will also have to consider the basic requirement for disposal of the public ocean assets: that all constituency elements have an equal opportunity for access to these assets, and that the ownership constituency, represented by the governments which exercise owner rights on behalf of their constituencies, must be assured that access has not been unfairly granted, and has been granted with an eye to deriving just value for the owner constituency from the access rights which have been granted. Examples of these concerns are: leasing terms (selling too cheap? inappropriate royalties?), competitive award methods, and lease provisions protecting the access rights of project developers once granted.

An advantage of the partnership approach is that it may provide a relatively low risk basis for the private sector element of the partnership to fulfill these fair access requirements in the context of the other ocean user interests, and so as to provide a way for the other essential elements of the partnership to join in its structure without conflict of interest. This is often best done by a competition of proposals between potential private sector development groups, wherein the private sector proposals themselves incorporate partnership structures and operational plans for evaluation in the competition. The selected competing team and plan then determines the basis for structuring the full partnership. The selection process itself will, of course, be the responsibility of the agencies of the appropriate government level, state or Federal.

The importance of private sector enterprise is, of course, that no ocean enterprise will be an effective contributor to the local or national economy if not soundly based on private sector commercial operation. Even projects of primarily public service and support interest (waste treatment, floating airports and harbors, ocean power) must all be economically supportable in terms of the value which they render the society they serve balanced against the cost, and the revenues in commerce and industry which they support. Public work projects, which in themselves do stimulate the local or regional economy in which they are undertaken, nevertheless do not in themselves establish a positive new element in the national economic fabric. The private sector team is the underlying basis of the partnership, and establishes the value of the partnership and its structure for any of its other elements.

THE SUGGESTED OPERATING STRUCTURE FOR OCEAN ENTERPRISE

The writer has offered the foregoing, and embarrassingly long, discussion of the underlying considerations for any attempt to bring about a new ocean economic enterprise as a justification of the recommended approach to the Ocean Enterprise organization as an effective incubator vehicle for ocean enterprise developmental areas. This recommended structure is that of a somewhat complex partnership. The basis of the partnership is, however, quite simple: to incorporate the interests of all concerned ocean stakeholders with those of the Federal and state governments in suggesting and supporting the proposed areas of economic development. Why must the partnership be complex? The ready answer is: because the ocean user and stakeholder interests are themselves complex, and this complexity is mirrored in the suggested organizational structure. Actually, the suggested structure is really not that complicated, since it embodies all of the basic principles of venture capital management and the structure of partnerships. These are: due diligence as to definition and reduction of risk on behalf of the investors and partners, establishment of a formal relationship between all elements deemed essential for the successful completion of the organizational objectives, and the definition of a means of establishing value for each of the supporting participants in terms of their contributions to the operation of the organization.

The basic Ocean Enterprise operating concept is that of an organization which is funded under a partnership support between government and the private sector. Although initially supported by direct funding, it seeks to establish itself through a permanent endowment, based on initial direct funding, but fed and increased through a return on its investment derived from successful new ocean enterprise ventures which it has launched. Thus, in establishing an incubator project, Ocean Enterprise also provides for the repayment of its initial investment with provision for gain through royalty provisions from the subsequent success of its developments. In this way, Ocean Enterprise is proposed as a self supporting and self endowing entity, eventually disposing of any requirement for continuing Federal or outside capital support for its incubator operations.

An overall operating structure for the Ocean Enterprise organization which is proposed for consideration is illustrated in Figure 1. The following sections describe each of its elements and their interrelationships in the functioning of the organization as a whole.

Funding Resources and Operators

These organizations provide the basic financial and management underwriting of the Ocean Enterprise organization. There are three appropriate sources of funding: interested cooperating ocean industries, appropriate supporting governmental agencies, and interested private foundations. The Ocean Enterprise program which they support must directly address the objectives which each of these source types may believe to offer as a realistic and appropriate opportunity for return on their investment: for industry, an opportunity to participate in the establishment of a new ocean economic enterprise in which they may later be able to participate on a profitable basis and from which they may derive new technology; for governmental participants, the opportunity to realize important socioeconomic objectives with which they are charged by their constituencies, and with the advantage of using leveraged funds; for private foundations, the opportunity to achieve their particular foundation objectives, also using leveraged funding. As the primary sources of funding, these elements are also the principal owners of the Ocean Enterprise organization. It is anticipated that they would be severally represented on the Board of Directors of the organization, and that talent for the Technical Advisory Board might be drawn, in part, from their resources.

Sponsoring Organizations

The sponsoring organizations are an important element of the Ocean Enterprise structure for two primary reasons. First, these organizations serve as a vehicle to assuring the participation of all important elements representing the various ocean users and stakeholders in the development of new ocean enterprise projects. Second, the participation of these organizations serves to validate the technical and socioeconomic soundness of the Ocean Enterprise projects through the participation of the best national and regional technical and scientific resources as partners of the Ocean Enterprise. These sponsoring organizations will appropriately include: technical and scientific societies, major organizations representing ocean users and stakeholders, and important governmental elements. The sponsoring organizations structure may include governmental agencies who are also among the Ocean Enterprise funding resources and operators. The sponsoring organizations will be represented on the Technical Advisory Board and some sponsoring organizations may also be asked to be represented on the Board of Directors of Ocean Enterprise.

The Board of Directors

This body, in the normal practice of incorporated entities, will be the governing body of the Ocean Enterprise structure. It will be selected to represent and to encompass all important elements of the partnership of ocean interests and economic development capabilities which will be vital to the successful realization of any of the new ocean enterprise project objectives. As previously noted, the board will draw membership from two sources of participating partners: the funding and operating organizations, and the sponsoring organizations. In addition, it will also draw members from appropriate national areas of importance to the overall success of the Ocean Enterprise idea. These areas include: private sector finance, Federal and state political organizations, academia, and noted individual experts on matters relating to Ocean Enterprise operations. The Board of Directors is an important element in the early establishment of a valid political, financial, and technical respect for the Ocean Enterprise objectives and developments, amongst all ocean users and stakeholders and by the national sociopolitical structure.

A Technical Advisory Board will be an important element in the successful operation of the Ocean Enterprise. It will have two important functions. Its foremost function will of course be that of assuring the technical and scientific excellence of each Ocean Enterprise project. Its secondary function, which is also highly important, is to provide an additional vehicle for participation in the activities, evaluations, and decisions of the Ocean Enterprise by important elements among the ocean users and stakeholders who may not be represented through the Sponsoring Organizations or directly on the Board of Directors. This Technical Advisory Board will provide a primary mechanism for coupling with the major academic marine science and technology centers, and with important academic programs.

Projects and Operations

Thus equipped with a broad basis of derived financial, technical, and policy support, the Ocean Enterprise program itself may be undertaken. Again, referring to the lower portion of Figure 1, it is suggested that the projects undertaken and supported by Ocean Enterprise may be of three, interrelated types. These are: R&D projects which are directly supported by Ocean Enterprise with the objective of developing critical technology for transfer to developing economic enterprises, incubator projects in which the Ocean Enterprise program directly addresses the problems of establishing a new economic entity within the ocean related economic sector, and projects with cooperating industry where the technology will support a new development within an existing ocean industrial presence. Examples of each type of project are given below.

R&D Projects

These projects will support Ocean Enterprise objectives in areas where a fundamental technology problem exists which must be solved before an economically practical project could be undertaken with near term promise of operational success. In this type of project, it is suggested that Ocean Enterprise would contract directly with appropriate R&D resources, including academic and institutional, for the practical application R&D necessary to bridge the gap between the known technical and scientific basis for the project, and the operational development needed for practical and profitable operation of the project as an enterprise. Again, it is highly important to emphasize that the role of Ocean Enterprise is to assist in the establishment of practical and self sustaining enterprise, and not to compete with others in the basic or applied engineering sciences. In undertaking any R&D project, Ocean Enterprise will first establish the specific incubator or cooperating industrial application of the technology to be developed and proven under the

R&D project, and will set up a specific process for the transfer of technology to that application, once proven. In this way, the use of R&D projects will place Ocean Enterprise in a similar position to that served by venture capital in such structures as R&D partnerships, wherein the returns to the R&D investors are to be based on royalties from the specific licensing of the practical application of developed technology to an operating enterprise which will profitably introduce the new technology to a predetermined specific marketplace.

The following is offered as an example of a possible Ocean Enterprise R&D project: The economic development of potential gold bearing placers in the US Territorial Seas may be in part critically dependent upon the ability to extract very fine gold from the placer concentrate. The use of gravitation techniques alone may miss too great a fraction of the total gold content, rendering the placer developmental operation wasteful and uneconomic, as well as potentially reducing the value of a public asset for future development. Older methods of amalgam extraction cannot be tolerated because of the risk of mercury contamination. New, highly efficient, environmentally acceptable methods of fine gold extraction are needed, if such enterprise developments are to be of sufficient economic promise and practicality that the state and Federal government support of their development will be encouraged and private sector investment in a new development justified. Ocean Enterprise might undertake an extraction technology development task, as a prelude its partnership with cooperating industries to establish new, acceptable placer mining operations where none were previously thought to be practicable. Under such a project, application agreements and programs with cooperating industry would be sought as a prerequisite for undertaking the project.

Incubator Projects

The principal objective of Ocean Enterprise is the establishment and support of new ocean enterprise projects, which may be anticipated to develop into self sustaining economic enterprises which contribute significantly to the ocean based economic sector. Therefore, the initiation and support of incubator projects is conceived as the principal operating mechanism of the Ocean Enterprise organization. In this type of project, Ocean Enterprise will establish a specific project, perhaps first on a pilot plant basis, for the demonstration of functional and economic practicality in performing a service or producing a product of significance to a national or regional economy. The need for incubation will largely be determined by analysis and inspection: The proposed enterprise project must fulfill a need with measurable and predictable economic benefit. A market for the project must be specifically identified and quantified. The risk factors applying to the project must be such that it is clear that industry and the private sector, on its own, and without the support and risk sharing of other important partnership elements, will not be willing or able to undertake the development on their own and under existing conditions of policy and public perceptions. Under these circumstances, the broad partnership basis which Ocean Enterprise can bring to the problem must be the basis for predicting success. Each Ocean Enterprise incubator project will have its own partnership structure, combining all important elements of the social, political, and economic considerations which are affected by the project. An individual set of investors, teamed with Ocean Enterprise support, is assembled to finance the project. The appropriate structure for the project may be that of a partnership, a joint venture, or a separate corporation with appropriate ownership. But in each alternative, the requirements of a meaningful and cooperative partnership relation must be preserved among the participants and the concerned ocean user and stakeholder elements.

A suggested general structure is illustrated in Figure 2. In this illustration, the new enterprise project is supported by participating industry, responsible for its developmental and operational stages, by local and national financing sources, by participating governmental levels having policy and jurisdictional responsibilities for the enterprise operations, by academic institutions from which important technical and intellectual assets can be derived, and from representative elements of the other users of the resource which must be shared with the new enterprise. The entire structure is designed to address and answer questions and concerns regarding the stewardship and protection of the shared resource (the ocean), and the balance between the desired social and economic benefits of a successful enterprise, and the risks and sacrifices which it may pose, or be perceived as posing, to the interests of the other ocean users and stakeholders.

An example is discussed more fully in the next section, that of the establishment of an offshore waste treatment facility using an oil/gas platform facility as the basis of operation. In this case, the cooperating industries would be those of waste management, the oil/gas industry, industrial engineering operators, and sea transport companies. Participating governments would include Federal and state interest in the control of commerce, the regulation of waste management, and environmental and health protection. Technical and scientific assets would be obtained through the participation of appropriate academic and governmental research and scientific organizations such as Texas A&M, NOAA, and EPA. Other ocean users and stakeholders would be represented both through the participation of Ocean Enterprise as the incubator supporter, and through specific cooperating partnership participation.

Cooperating Industry

A third type of project may also be considered under the Ocean Enterprise charter, that of assisting an existing cooperating industry in the establishment of a significant new economic ocean development. In this case, Ocean Enterprise would enter into a cooperative agreement, possibly a joint venture, with one or more interested cooperating industrial partners, who would provide joint financial support for the enterprise project, along with Ocean Enterprise. The test of an appropriate project will again be that of demonstrable socioeconomic benefit, but one in which the industry itself is rationally constrained from independent development by the risks posed because of the use of shared ocean assets, policy and regulation, and the technical uncertainty of bridging the gap between the state of developed technology which permits the estimation of success, and the demonstration of practicality in a commercial economic sense. This structure will be inherently simpler than that of the incubator projects, and the Ocean Enterprise organization will itself in most cases provide the partnership relations necessary to establish the level of risk and participation required for a rational private sector investment to establish the new enterprise area.

An example in this area may be that of the development of an ocean thermal energy conversion (OTEC) plant. In this case, most elements of the technical risks have been addressed. A consortium of industrial partners might approach Ocean Enterprise for the joint support of a prototype power production facility. This endeavor might be supported by one or two parallel R&D projects for the resolution of remaining technical issues (cold water pipes and inexpensive heat exchanger designs are two possible areas from which technology transfer might be made to the project). Ocean Enterprise would assume the role of establishing an appropriate risk environment, through its participating organizations and representatives, under which the market for the power product could be established and supported by a group of participating governmental and private sector entities. These commercial or public power opportunities may well exist outside of the US and if so, would constitute an export market for US products.

AN EXAMPLE OCEAN ENTERPRISE INCUBATOR PROJECT STRUCTURE

As a specific example of the detailed type of structure which might be required, and desired, for an Ocean Enterprise incubator project is illustrated in Figure 3. The example project is an offshore waste treatment plant which uses otherwise uneconomical natural gas, produced at an offshore platform, to process waste at very high temperatures, producing a ceramic like solid residue, and water and carbon dioxide as the vent gasses. The processing operation is collocated on the gas production platform. Applications (and markets) are to marine generated waste, municipal wastes, and waste disposal contractors.

Referring to Figure 3, the Ocean Enterprise organization enters into partnership with interested private investors (which can include operating industries) and governments (Federal, state, and local, as may be appropriate) to spread and reduce financial risk, and to incorporate governmental concerns and regulatory interests as a direct part of the project. Operating partners in the project are the States and Federal agencies which may participate in the regulation and operation of the project, industrial operators, and shipping operators. Cooperating partners are other ocean users and interest groups and academic resources. These cooperating partners may assist in the project either through a contribution in kind, or under a support contract from the project itself, in order to accomplish specific tasks of importance for which they have the information and expertise.

An example ocean user participant is the seafood industry and appropriate governmental organizations concerned with fisheries, such as NMFS. The seafood industry has several interests which are both affected and served by the project: First, it will be concerned about possible pollution and deleterious effects on seafood production and harvesting. Secondly, the seafood harvesting industry faces a waste disposal problem (in the Gulf of Mexico, for example) in the new regulations against ocean dumping and the requirements for disposing of retained waste at ports or other suitable stations before being allowed to dock at US ports. Finally, one application of the residue output of the project may well be to produce permanent concrete or ceramic forms which would enhance seafood populations and significantly improve and extend the variety of catches. All of these elements argue for the active participation of the seafood industry and its related governmental agencies in the project.

The Ocean Enterprise incubator waste treatment project may be organized among its participants as a corporation, a partnership, or as a teaming agreement. It may easily start out in one form (a teaming agreement between industrial partners, for example) and, with the success of a prototype operation, then engender the establishment of a joint venture or separate corporation for continued operation and expansion. Other corporations and enterprises may well develop in this area with the demonstration of practical economic success under the incubator project. The creation of a new vital competitive ocean based industry would signal the most successful outcome of the Ocean Enterprise incubator process.

A proposed operating structure for the incubator project is outlined in the lower half of Figure 3. For any necessary development, the waste treatment project will use one or more R&D contracts to resolve any remaining technical problems not within the capabilities of the operating partners. This R&D project may result in patentable technical property which will be owned by the project and can be assigned or used to generate royalty income. It should be noted again that each Ocean Enterprise project will be so structured as to yield returns (through what are essentially royalty arrangements) to the Ocean Enterprise organization, providing a basis for self endowment towards the restoration and building of its incubator fund for reinvestment in the development of other suitable ocean enterprise projects.

With the complete definition and design of the prototype operating system to be supported under the incubator project, installation and operating contracts are let to a team of industrial organizations, forming the operating organization and system. In this example, it is suggested that this team consists of the oil/gas industrial owners of the platform, a facility operating contractor supporting the waste treatment facility itself, and a facility contractor to build and maintain the waste treatment alterations to the platform. With use, the platform owners will receive leasing fees for the use of the platform and will sell (or contribute as an investment in kind) the natural gas used in the waste treatment process to the project.

Once in operation, using organizations (customers) may consist of shipping wishing to dispose of retained wastes, municipalities and other governments having waste disposal requirements, and waste contractors needing a disposal facility to service their own contracts. These users all pay fees to the project for waste disposal. In addition, the project produces residue products with potential value which may produce additional revenues. These revenues are used by the project to continue the operation and to evolve from the incubator phase into a fully self sustaining business venture or other appropriate structure (the facility could be run as a public utility, for example). Not shown in the illustration is the additional potential that excess power produced by the operating facility could be sold to local or regional power nets. Royalties are paid by the project back to Ocean Enterprise in return for its incubator investment. These royalties contribute to the self endowment of Ocean Enterprise as a resource for its future incubator projects.

CONCLUSION

The very short conclusion of this rather lengthy descriptive discussion of Ocean Enterprise constraints and structures is that the only efficient mechanism for reconciling the elements of the rather complex interactive environment which exists for the development of ocean assets is that of a partnership. The partnership must be a real and binding cooperative effort on the part of all concerned elements of the Ocean Enterprise development and the ocean stakeholder community. The assets of the ocean, as a universally recognized arena of public ownership, are not lightly assigned to particular economic purposes, whether of a commercial or of a public utility character. Even the traditional ocean uses of seafood harvesting, recreation, and shipping are coming under increased scrutiny with regard to the stewardship of the ocean resources at the behest of ocean stakeholders. Offshore oil and gas is meeting increasing resistance to an extension of its developments. Yet, on the other hand, the national and regional economic conditions are such that it will be imperative that important resources in the national ocean be used wisely to augment dwindling, and in some cases nonexistent natural resources, and to strengthen national and regional economies.

Ocean enterprise is a way around or out of the constraints. The structure for the way is one which espouses and demands the teamwork of all concerned parties to and stakeholders in the ocean. This is the essence of the partnership approach. It is a somewhat complex solution for the resolution of a quite complex set of issues and interests. Simpler solutions have not to date been successful. The partnership approach can be an effective strategy for achieving the Ocean Enterprise objectives.

Figure 1: A Proposed Structure
for
The Ocean Mission Enterprise Organization

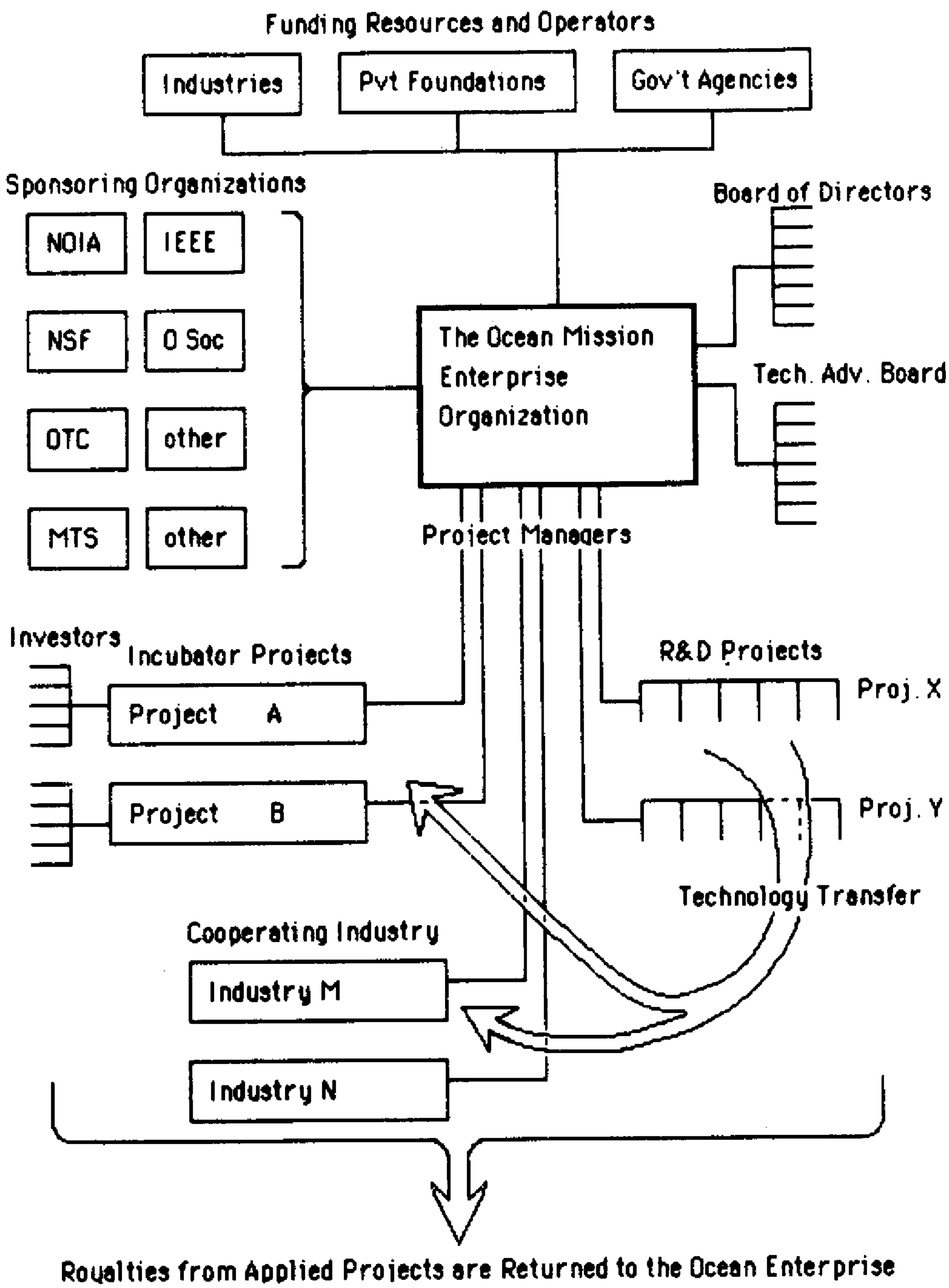
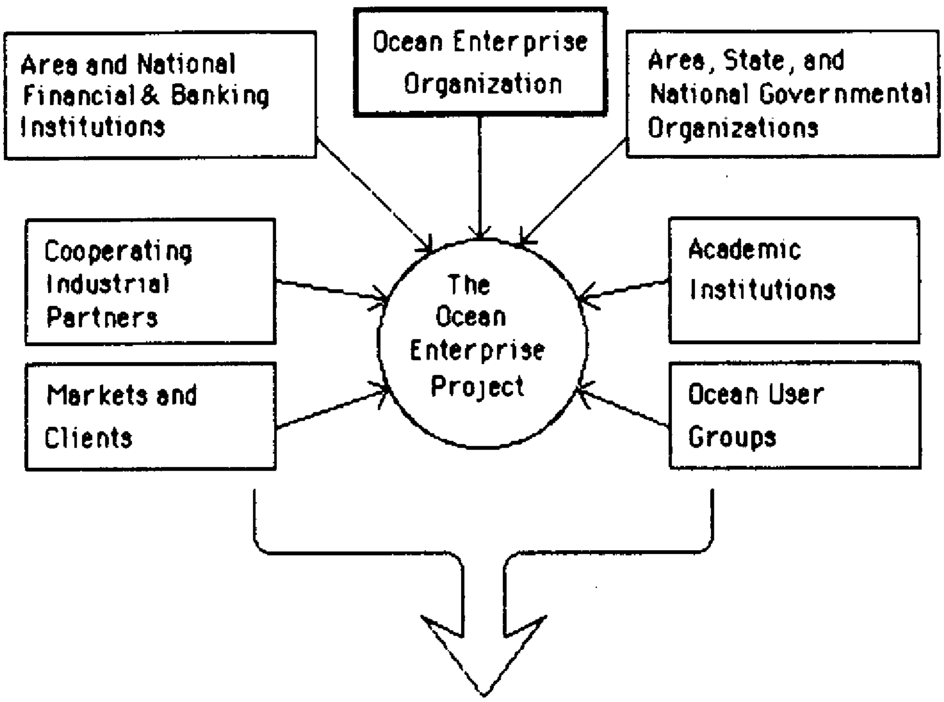
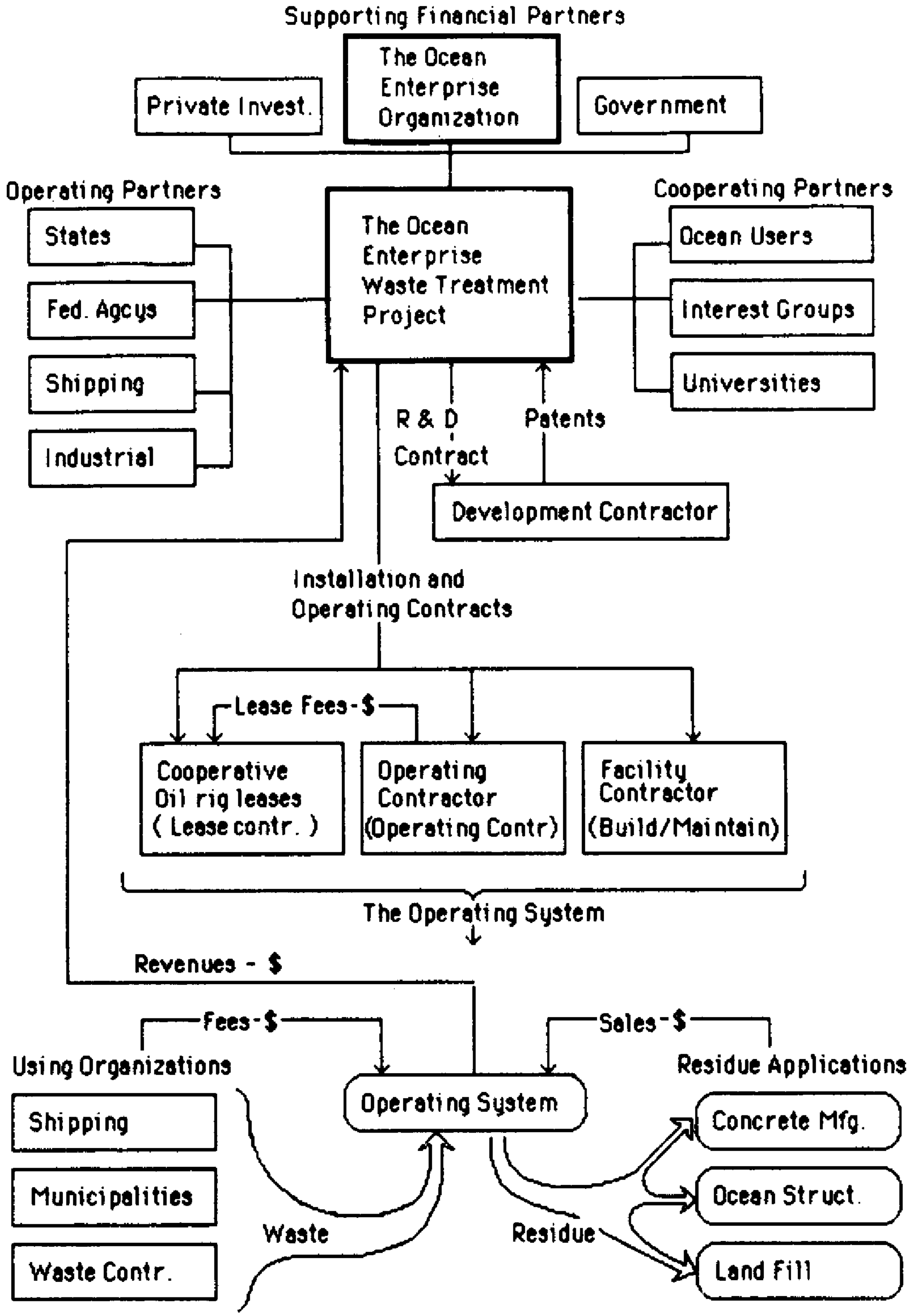


Figure 2. Ocean Enterprise
General Incubator Project Structure



The Ocean Enterprise Objectives

Figure 3: A Proposed Structure
for
An Ocean Enterprise Waste Treatment Project



LEGAL CONSIDERATIONS FOR THE ADVANCEMENT OF OCEAN ENTERPRISES IN THE UNITED STATES EXCLUSIVE ECONOMIC ZONE: NEW WAVES AND OLD RIPPLES OF LEGAL UNCERTAINTY

by
David C. Slade, Attorney

ABSTRACT

The United States Exclusive Economic Zone (EEZ) is nearly 6 years old. Nonetheless, beneficial use of EEZ resources remains limited to traditional activities such as fishing, oil and gas development, and navigation. New uses, such as marine hard mineral mining, offshore waste treatment, mariculture, and ocean platforms (coastal airports), and others, remain inhibited. The background materials for this workshop list the limitations of "leadership, infrastructure, venture capital and technology" as stifling of new ocean enterprises. In addition, another major limitation must be included--an uncertain and volatile legal environment. Old ripples in the fabric of ocean law remain troubling, while new fundamental questions of legal interpretation have recently arisen. The 1988 Presidential Proclamation extending the United States Territorial Sea, for international purposes, from 3 to 12 miles is certain to reopen the policy debate over State/Federal jurisdiction and control of these resources, among other questions of law and policy. Congress should address these questions of ocean governance. Further, there are strong precedential arguments that Congress is constitutionally required to confirm the Proclamation.

Prior to congressional action on this score, even with leadership, shore and sea based infrastructure, capital and technology, these fundamental legal and policy questions will stifle investment in new ventures because of the risk inherent in such a shaky legal environment.

Any future Ocean Enterprise concept, no matter how it is structured and enacted, must be a part of a new, emerging national ocean policy and legal regime.

INTRODUCTION

The United States is currently at a juncture in national ocean law and policy. In the last eight years three major ocean pronouncements have been issued that collectively define this juncture: the United States withdrawal from the United Nations Law of the Sea Conference (1981), the establishment of the United States Exclusive Economic Zone (1983), and the extension, for international purposes, of the United States Territorial Sea from 3 to 12 miles (1988). Without debating whether these moves were good or bad policy, the fact remains that taken together, significant legal uncertainty exists for new ventures desiring to function within the U.S. EEZ.

Other troubling legal questions exist in the current body of federal legislation governing offshore activities. These questions arise in large measure because Congress has designed ocean legislation activity by activity, medium by medium. In other words, we have fishery laws, offshore oil and gas laws, marine mining laws, marine mammal laws, marine pollution laws, etc. Little or no legislative guidance exists to resolve conflicts between these various ocean uses. More importantly for this forum's interests, *little legislative guidance exists to promote enterprises other than these specific interests.* New ventures (as described in the background materials) fall through the cracks of current federal ocean law.

Prior to looking at the federal level, though, the State perspective must be borne in mind. The land-based support, as well as the offshore portions, of any new offshore venture must comply with State law. The following highlights the coastal States interest in offshore ventures, but is not meant to be an analysis of State law on the subject.

COASTAL STATE INTEREST IN OCEAN ENTERPRISES

Any new commercial venture that could generate jobs for the State's citizenry while resolving some of society's problems, e.g. garbage disposal, obviously is of direct interest to the coastal States. But this is not the full extent of the States' collective interest. A State, and its communities, will be "the recipient of the costs and benefits, both economic and non-economic, of development in the EEZ of its shores."[1] States "oversee the ports, harbors, and shore space that are essential to ocean development. Physical linkage inextricably couples the shoreland to the sea."[2]

The strains and pressures on State coastal resources has been described well in the congressional history of the Coastal Energy Impact Program. When considering the impacts on a State of an offshore oil and gas project, *even when there would be no direct landing or pipelines from the project to the nearest coastal State,* Congress noted that along would come

> the need for new housing and public services (such as water and sewer, police and fire protection and waste disposal). Expanded education facilities, health care, and a whole range of other activities will be necessary. This will put serious strains on the State tax base. In addition, new facilities related to offshore production will arrive, such as onshore operations bases, offices, cement and mud suppliers, warehouses, tool rental companies, helicopter pads, dockage, wireline companies, gas lift companies, logging and perforating companies, machine shops, trucking firms, supply stores, downhole equipment companies, diving services and others. The combined effect of all these facilities and increased population will be to create major impacts, regardless of whether [Outer Continental shelf] oil or gas is landed in the area.[3]

It is clear that offshore mining, offshore airports, or offshore garbage incineration would encompass a similar list of impacts. Equally clear is that coastal State involvement and approval is key to the success of the Ocean Enterprise concept.

FEDERAL LEGAL RESTRAINTS AND UNCERTAINTIES: A NEW WAVE AND OLD WRINKLES

A. A new Wave of Legal Uncertainty: The Territorial Sea Proclamation

On December 27, 1988, President Reagan issued a presidential proclamation extending the United States' Territorial Sea, for international purposes only, from 3 to 12 miles.[4] This move, in essence, answered one question, and raised thousands.

The answered question can be framed as whether Soviet nuclear submarines must remain 3.1 or 12.1 miles offshore of Pearl Harbor. The answer is now 12.1. The thousand questions raised concern statutory interpretation of the full body of federal law in light of the Territorial Sea Proclamation. In turn, however, all of these questions emanate from one fundamental question of constitutional law, a question being asked by congressional legal counsels, State attorney general offices, industry, public interest groups and others. The question: Does a president have the authority to override congressional intent with a presidential proclamation? Restated in two parts, the question is: Did Congress ever use the term "territorial sea" with the intent that the scope of the associated law would expand if ever the United States Territorial Sea was extended? And if so, can a President override this congressional intent with a proclamation?

The term "territorial sea" is used roughly 75 times in several dozen laws spread throughout the 50 titles of the United States Code.[5] In only two instances (that I am aware of) does Congress define the term "territorial sea" as an ocean zone extending only 3 nautical miles.[6] The remaining uses of this term go undefined. Did Congress, when using the undefined term "territorial sea," intend the term to mean only the 3-mile belt of ocean? Or did Congress intend that if the U.S. territorial sea were extended, the associated legislation's scope would likewise be extended?

The U.S. Justice Department, in a legal analysis of the implications of an extended territorial sea by presidential proclamation, examined only one statute (CZMA) and concluded that this federal law would not be affected by the proclamation.[7] Many disagree with this conclusion. Nonetheless, this Justice Department analysis did not claim to be either the final word on the question, or fully comprehensive of the entire body of U.S. ocean law.

The Territorial Sea Proclamation purports to leave unchanged the domestic (federal) legal status quo (see attachment). However, it seems difficult to imagine that, when enacting legislation within the last 36 years, Congress did not use the term "territorial sea" without full appreciation of the ongoing United Nation negotiations on the law of the sea, starting back in the 1950s. The United States signed the 1958 Convention on the Territorial Sea, wherein international law recognized the right of a coastal nation to proclaim a territorial sea. But the 1958 Territorial Sea Treaty fails to provide for the maximum breadth of this zone. This has left the question open ever since, and nation after nation started asserting broader and broader territorial seas.[8]

Starting in 1968 with the Third Conference on the Law of the Sea (LOS), wherein the United States fully participated until the summer of 1981, the question of the internationally recognized breadth of the territorial sea was openly debated. In fact, when the United States withdrew from the LOS conference in 1981, it held the negotiating position that a nation could legitimately claim a territorial sea of 12 miles.[9] During the 14 years of negotiations, which eventually resulted in the 1982 LOS Convention, it was clear that the 3-mile limit of the U.S. Territorial Sea was not the norm; 12-nautical miles was the practice of most coastal nations. The Conference finally agreed on 12 miles, and this breadth eventually became the recognized limit in the 1982 LOS Convention.[10]

Given the awareness of Congress of these negotiations over a 14 year period, and the U.S. negotiating position on the question, it simply cannot be concluded, without much further analysis, that in each of the 75 or so instances of the use of the term "territorial sea" without further defining it, Congress did intend, in the likelihood of a U.S. expansion of its territorial sea, that the scope of the associated law would likewise expand. This is especially true of the laws enacted in the 1970s and 1980s.

In any event, law by law, the question arises: Did Congress, by using the term "territorial sea" without further defining the term, intend the scope of the associated legislation to expand if the U.S. territorial sea were extended? And if so, does the President have the authority to override this congressional intent with a proclamation? At this point, no one has the answer. But it is apparent that vexing statutory interpretation problems will arise throughout the entire volume of the United States Code.

The history of similar presidential actions should also be borne in mind. In 1947, President Truman issued his OCS Proclamation asserting U.S. "jurisdiction and control" over the outer Continental Shelf.[11] But, it is important to note, Truman declined to resolve the domestic question of ownership of the submerged lands, and acted only to assert the United States' claim over the OCS as against all other nations.[12] This is essentially the same approach President Reagan took in the Territorial Sea proclamation. As against all other nations, the United States now asserts territorial sovereignty out 12 nautical miles. The Reagan Proclamation, however, purports to leave the domestic federal law at its *status quo ante*.

The result of the Truman Proclamation was six years of Congressional debate over the legal and policy questions raised by that proclamation (in addition to the 1947 Supreme Court case *United States v. California*). Given the myriad of legal and policy questions raised by the Territorial Sea proclamation, it is foreseeable that a similar period of congressional debate can be expected.

1. A Sampling of Questions raised by the Territorial Sea Proclamation

In many of the instances of the use of the term "territorial sea" only academic questions are raised. However, some troubling legal and policy questions are raised, some of which are briefly reviewed here. It should also be borne in mind that the meaning of other terms used in the U.S. Code, such as "high seas," "continental shelf" or "in the United States" could be affected by the definition attached to the term "territorial sea". The implications for statutory interpretation caused by these secondary associations is beyond the scope of this paper. Nonetheless, real world issues could arise, most probably in the area of taxation.

a. Coastal Zone Management Act (CZMA)

The CZMA defines the term "coastal zone" as extending "seaward to the outer limit of the United States territorial sea." There is direct legislative history to the fact that Congress was very aware that the territorial sea could be expanded out to 12 miles, and such an extension would likewise extend the "coastal zone."[13] Nonetheless, Congress defined the term "coastal zone" in terms of the "territorial sea" rather than defining it in terms of the seaward boundaries of coastal states as provided in the Submerged Lands Act, as it had been defined in companion bills.

b. Fisheries

1. Foreign Fishing

From almost the beginning days of this nation, foreign fishing has been banned within the U.S. territorial waters. Now, however, the question arises: Can the U.S. ban foreign fishing in the waters between 3 and 12 miles? If so, under what authority, seeming that the Fisheries Conservation and Management Act allows for some foreign fishing in this ocean belt. If we cannot ban foreign fishing in the U.S. territorial sea (which was extended for international purposes only, which should include foreign fishing), isn't this a tremendous reversal of domestic policy?

2. Continental Shelf Fishery Resources

The Fishery Conservation and Management Act defines the "Continental Shelf" as that seabed "outside the area of the territorial sea."[14] What then, is the status of the benthic and bottom-dwelling fishery resources defined as "continental shelf fishery resources" between 3 and 12 miles? Note also, that the Deepwater Ports Act uses the same definition of the term "continental shelf."[15]

c. Outer Continental Shelf

The OCSLA defines the term "outer Continental Shelf" as meaning those submerged lands "seaward and outside" of State submerged lands *and* which "appertain to the United States and are subject to its jurisdiction and control."[16] But land within the territorial limits of the United States is not land that "appertains" to the United States; it is *in* the United States. Further, the congressional intent in the OCSLA was to enact legislation granting the United States jurisdiction and control over submerged lands outside of U.S. territory. Otherwise, President Truman need not have issued his 1947 OCS Proclamation.

d. Narcotics Interdiction Jurisdiction

Given this country's deep interest in interdicting drugs before they "enter" the country, what now is the jurisdiction of the U.S. Coast Guard? Does the Coast Guard have enforcement powers out to 12 miles? If so, does it have the budget to do so?

e. Jurisdiction of the National Transportation Safety Board

The National Transportation Safety Board (NTSB) is required to "investigate...any major marine casualty...occurring on the navigable waters or territorial seas of the United States."[17] Is the NTSB now required to investigate marine casualties occurring from 3 to 12 miles out to sea? Is the NTSB now authorized to do so? Should the NTSB be so required or authorized?

2. Is Congressional Legislation Required?

After Truman's 1947 OCS Proclamation, the House Judiciary Committee concluded that "legislative action is necessary to confirm and give validity to" President Truman's 1947 OCS Proclamation, and that it was "necessary that the Congress make such an assertion on behalf of the United States."[18] Even if Congress is not required to act, given the numerous interpretational questions raised with the Territorial Sea proclamation, in addition to the policy implications, Congress should act.

B. Old (Troubling) Ripples in Federal Ocean Law

A few ripples in current federal ocean law exist, ripples that only serve to exacerbate the development of new ocean enterprises. One of these ripples, as discussed, is the resource by resource approach of Congress for ocean legislation that stifles any ocean enterprises that don't clearly fit within the scope of any particular law.

The following is a brief summary of a few new ventures that are being stifled by ripples in current federal law.

1. Marine Hard Mineral Mining

The mining of hard minerals is being stifled by, among other things, the legal uncertainty surrounding the venture. The Department of the Interior, through a Solicitor's opinion, has taken the position that the 1983 EEZ Proclamation extended the scope of both the OCSLA and the Department's jurisdiction out the full 200 miles off of the shores of the States (not including U.S. territories and possessions). In other words, the OCSLA is interpreted by the Department of the Interior as applying to the 200 mile EEZ off the states, including areas that are deepwater, areas never considered before the EEZ Proclamation as "Outer Continental Shelf." This is a sharply contested legal position. Nonetheless, the Department of Interior has recently finalized regulations under the OCSLA to govern marine mining throughout the entire EEZ.[19] The regulations, however, do not expressly take the Solicitor's position, and thus do not address the issue head on. Rather, the regulations apply only to the "Outer Continental Shelf." A court challenge may not be "ripe" until the Department actually leases a portion of the deep waters of the OCS. Nonetheless, the mere possibility of such litigation could chill any prospective deep seabed mining in the EEZ. Further, industry dissatisfaction with these new regulations, on commercial and policy grounds, will likewise chill ocean mining in shallow waters of the EEZ.

2. Offshore Garbage Incineration

One innovative idea discussed in the background materials is using a commercially unproductive, but still producing, offshore gas platform as a garbage incineration platform, with natural gas as the incinerating fuel. However, Congress's resource by resource approach to ocean law, as noted, does not serve to promote such a venture. There is no "offshore garbage incineration act." Thus, this venture would have to be founded on a body of related laws, none of which are directly germane to the venture's purpose.

Thus, using an offshore gas platform for waste incineration raises the question of the applicability of the OCSLA. The Clean Air Act, Clean Water Act, and the Ocean Dumping Act, among many others, likewise would be applied to such a venture.

a. Application of the OCSLA

1. Purpose of OCSLA leases

The Secretary of the Department of the Interior is authorized to lease OCS lands in order to "explore, develop, and produce the oil and gas contained within the lease area."[20] The definitions of the terms "exploration," "development" and "production" do not clearly include the use of an offshore facility, under the OCSLA, for such a consumptive use of natural gas for incineration.[21] Could an existing platform, sitting on an expired lease tract, be re-leased by the Secretary for the incineration of garbage, a purpose not listed in the OCSLA? If the authority does exist, would additional regulations be required?

2. Transferability of an OCS Lease

Could a current lease holder transfer his lease on a commercially unproductive gas platform? The OCSLA provides that lease transfers are prohibited without Secretarial approval.[22] Can the Secretary approve a lease transfer from gas production to one of gas consumption? Should the Secretary be authorized to do so?

b. Would the Ocean Dumping Act Apply?

The incineration at sea of hazardous waste has been considered an activity governed by the Ocean Dumping Act (ODA).[23] Would the incineration of municipal garbage likewise fall within the scope of the ODA?

The ODA defines "dumping" to mean disposition of material in the ocean waters by any citizen of the United States,[24] and "material" as including incinerator residue.[25] Thus, it appears that an operator of an offshore municipal waste incinerator would likewise need to obtain a federal permit under the ODA to conduct this offshore venture.

The legal uncertainty surrounding this proposed venture is further increased by the lack of implementing regulations. In 1986, a commercial waste management company, desiring to burn hazardous waste at sea, sued the Environmental Protection Agency (EPA) over EPA's withdrawal of proposed incineration regulations.[26] The Court ruled that EPA's withdrawal of the proposed regulations was lawful. As a result, to date, no regulations are on the books governing the incineration at sea of waste, whether hazardous or non-hazardous.

c. Air Quality Regulations

The OCSLA provides that the Department of the Interior has the authority, under the OCSLA, to set air pollution emission standards for offshore oil and gas platforms.[27] In nearly all other instances, however, EPA sets the air pollution standards in accordance with the Clean Air Act (CAA). Would an offshore waste incineration platform fall under the OCSLA or the CAA in terms of air pollution control? The answer is not readily apparent.

CONCLUSION

This brief discussion serves to caution that, even with the full technological capability and capital requirements, the surrounding legal environment for new ocean ventures is quite uncertain. An "Ocean Enterprise" as envisioned in the background documents could not, alone, surmount this uncertainty.

It is very possible that, with the Territorial Sea Proclamation, Congress will revisit the entire field of national ocean law and policy. Some legal scholars argue that Congress must act to implement the Territorial Sea Proclamation. It is this author's premise that Congress should act to implement the Territorial Sea extension, as well as revisit this entire field of law and policy, whether required or not.

Any future Ocean Enterprise concept, no matter how it is structured and enacted, must thus be a part of a new, emerging legal regime, rather than being something that is to act under the current "risky" legal regime.

REFERENCES

1. Coastal States and the U.S. Exclusive Economic Zone, Coastal States Organization, April, 1987.

2. (Id.)

3. 1978 U.S.C.C.A.N. 1648.

4. Presidential Proclamation No. 5928, December 27, 1988.

5. Atlantic Tuna Convention, at 16 U.S.C. 971, 972
United States Fishery Zone, at 16 U.S.C. 1091
Marine Mammal Protection Act, at 16 U.S.C. 1362
Coastal Zone Management Act, at 16 U.S.C. 1451, 1453, 1456(A)
Endangered Species Act, at 16 U.S.C. 1538
Fishery Conservation and Management Act, at 16 U.S.C. 1802, 1811, 1812, 1822, 1829, 1851, 1856
Salmon and Steelhead Conservation and Enhancement Act, at 16 U.S.C. 3302
North Atlantic Salmon Fishing Act, at 16 U.S.C. 3606
Tariff Act of 1930, at 19 U.S.C. 1401, 1590
Protection of Vessels on the High Seas, at 22 U.S.C. 1971, 1972
International Narcotics Control Act, at 22 U.S.C. 2291
Deep Seabed Hard Mineral Resources Act, at 30 U.S.C. 1403
Navigation Rules for Inland Waters, 33 U.S.C. 191
Sea Grant Act, at 33 U.S.C. 1122
Ports and Waterways Safety Act, at 33 U.S.C. 1223
Clean Water Act, at 33 U.S.C. 1311, 1321, 1343, 1344, 1362
Ocean Dumping Act, at 33 U.S.C. 1401, 1402, 1411, 1416
Deepwater Ports Act, at 33 U.S.C. 1502, 1518
International Regulations for Preventing Collisions at Sea, at 33 U.S.C. 1601
Ocean Pollution Research and Development and Monitoring Act, at 33 U.S.C. 1702
Ocean Thermal Energy Conversion Act, at 42 U.S.C. 9101, 9102, 9111, 9119, 9163
Comprehensive Environmental Response, Compensation and Liability Act, at 42 U.S.C. 9601, 9611
Outer Continental Shelf Lands Act, at 43 U.S.C. 1331, 1811, 1813
Vessels and Seamen Act, at 46 U.S.C. 2101, 12108 Appx
Drug Abuse Prevention on Board Vessels, at 46 U.S.C. 1902
Territories and Insular Possessions, at 48 U.S.C. 1681
Independent Safety Board Act of 1974, at 49 U.S.C. Appx 1903

6. Clean Water Act, at 33 U.S.C. 1362(8)
Comprehensive Environmental Response, Compensation and Liability Act, at 42 U.S.C. 9601(30).

7. MEMORANDUM FOR ABRAHAM D. SOFAER, Legal Advisor, U.S. Department of State, by Kmiec, Acting Assistant Attorney General, et al., October 4, 1988.

8. By 1983, without international agreement on the question, many states claimed various breadths of their territorial seas.

Breadth (nautical miles)	Number of Nations
3	25
4	2
6	4
12	78
15	1
20	1
30	2
35	1
50	3
70	1
100	1
150	1
200 *	15

*Some of these 200 nautical mile territorial sea declarations did not claim jurisdiction over traditional freedoms of high seas and thus can be characterized as early assertions of exclusive economic zones.

Source: National Advisory Committee on Oceans and Atmosphere, The Exclusive Economic Zone of the United States: Some Immediate Policy Issues, May, 1984.

9. The United States had no contention with the Territorial Sea provisions of the Signatory Draft of the LOS Convention. These provisions eventually became the final language in the 1982 U.N. LOS Convention. The LOS Convention has not yet entered into force, although the United States has stated internationally that it will abide by the non-Deep Seabed portions of the Convention.

10. Part II, article 3, Breadth of the Territorial Sea. "Every State has the right to establish the breadth of its territorial sea up to a limit not exceeding 12 nautical miles, measured from baselines determined in accordance with this Convention."

11. Proclamation 2667, September 28, 1945.

12. "Neither this order nor the aforesaid Proclamation shall be deemed to affect the determination by legislation or judicial decree of any issue between the United States and the several states, relating to the ownership or control of the subsoil and sea bed of the continental shelf within or outside of the three-mile limit." Executive Order 9633, Sept. 28, 1945.

13. The House Report on the passage of the Coastal Zone Management Act (H. Rep. no. 1049, 92d Cong. 2d sess. 2 (1972)) provides that the coastal zone extends seaward:

"To the outer limit of the territorial sea which, under the present posture of international law, means three miles from the base line from which the territorial sea of the United States is measured. Should the United States, by future action, either through international agreement or by unilateral action, extend the limits of the United States territorial sea further than the present limits, the coastal zone would likewise be expanded, at least to the extent that the expanded water area and the adjacent shore lands would strongly influence each other...".

14. 16 U.S.C. 1802.

15. 33 U.S.C. 1502.

16. 43 U.S.C. 1331.

17. 49 U.S.C. 1903(a)(1)(E).

18. 1953 U.S.C.C.A.N. ----.

19. Federal Register, January 18, 1989.

20. 43 U.S.C. 1331(c); 1337(b)(4).

21. See 43 U.S.C. 1331.

22. 43 U.S.C. 1337(e).

23. 33 U.S.C. 1401 et seq.

24. 33 U.S.C. 1402(f).

25. 33 U.S.C. 1402(c).

26. *Chemical Waste Management, Inc. v. United States Environmental Protection Agency*, Fed. Dis. Court, District of Columbia (1986).

27. See 30 C.F.R. 250.33(b)(9); 250.33(b)(12); 250.45; and 250.46.

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Presidential Documents

Title 3—

The President

Proclamation 5928 of December 27, 1988

Territorial Sea of the United States of America

By the President of the United States of America

A Proclamation

International law recognizes that coastal nations may exercise sovereignty and jurisdiction over their territorial seas.

The territorial sea of the United States is a maritime zone extending beyond the land territory and internal waters of the United States over which the United States exercises sovereignty and jurisdiction, a sovereignty and jurisdiction that extend to the airspace over the territorial sea, as well as to its bed and subsoil.

Extension of the territorial sea by the United States to the limits permitted by international law will advance the national security and other significant interests of the United States.

NOW, THEREFORE, I, RONALD REAGAN, by the authority vested in me as President by the Constitution of the United States of America, and in accordance with international law, do hereby proclaim the extension of the territorial sea of the United States of America, the Commonwealth of Puerto Rico, Guam, American Samoa, the United States Virgin Islands, the Commonwealth of the Northern Mariana Islands, and any other territory or possession over which the United States exercises sovereignty.

The territorial sea of the United States henceforth extends to 12 nautical miles from the baselines of the United States determined in accordance with international law.

In accordance with international law, as reflected in the applicable provisions of the 1982 United Nations Convention on the Law of the Sea, within the territorial sea of the United States, the ships of all countries enjoy the right of innocent passage and the ships and aircraft of all countries enjoy the right of transit passage through international straits.

Nothing in this Proclamation:

(a) extends or otherwise alters existing Federal or State law or any jurisdiction, rights, legal interests, or obligations derived therefrom; or

(b) impairs the determination, in accordance with international law, of any maritime boundary of the United States with a foreign jurisdiction.

IN WITNESS WHEREOF, I have hereunto set my hand this 27th day of December, in the year of our Lord nineteen hundred and eighty-eight, and of the Independence of the United States of America the two hundred and thirteenth.

Ronald Reagan

[FR Doc. 89-515
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OCEAN ENTERPRISES IN THE 1990'S ENVIRONMENTAL, ECONOMIC, SOCIAL AND POLITICAL CONSTRAINTS TO DEVELOPMENT

by
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INTRODUCTION

This paper will examine the current status of environmental, economic, social, and political constraints to development for emerging ocean enterprises. Since the focus of this workshop is how to structure a successful ocean enterprise in those areas that are not today commercial ventures, it is important to understand how such developments may be constrained. Some of the current constraints could possibly be modified under a new structure; others could be recognized and planned for; still others could be avoided. Constraints to development may establish the levels of acceptability of a project or put limits on its development. If limits and acceptability can be determined early in the development process, then both planning and implementation can be facilitated.

Since the workshop will explore new and innovative structures to foster development of fledgling enterprises, the types of activities that will be discussed are those that, today, are not commercially viable, but that have the promise of future viability. Excluded from the list are, therefore, the traditional and dominant ocean businesses such as: oil and gas production; shipping; fishing; current military uses; and a range of current recreational uses. This leaves a myriad of both extractive and non-extractive uses of the ocean that are difficult to categorize and may have few common elements. The selections for workshop discussion include hard minerals developments, ocean thermal energy production, development of ocean platforms for missile and aircraft bases, and several proposals for offshore waste disposal operations. These selections should serve only as examples because, with different participants or at a different time, the selections could expand in many directions. When discussing constraints, however, it is necessary to find the common elements among these selections as well as among the wide variety of other possible emerging ocean enterprises.

If new structures for developing ocean enterprises can allow for consideration of constraints at many stages in the development process, then there may be opportunities for facilitation. This paper will first discuss some common aspects of the development process and then the notion of constraints. Finally, the paper will conclude with comments about some specific constraints associated with the selected development topics.

THE DEVELOPMENT PROCESS

Before a project can proceed through a normal development process, it is useful to subject it to a series of tests that may help determine what constraints may be applied and whether they will seriously affect the outcome. The following tests could be considered.

1. The commercial justification test:

To the extent that a project would be a viable commercial enterprise on its own, it must be financially viable in the commercial world. Usually this means that it must generate an acceptable rate of return on investment compared to other ventures with equal risk for a typical investor. Any project needs to pass the commercial justification test unless it is a candidate for partial or total public financing.

2. The public support test:

Whether a project can, should, or will receive some public support is difficult to determine precisely because forms of public support can be applied in a variety of ways. For example, tax incentives, government sponsored research, government sponsored data collection and dissemination, import duties or restrictions, subsidies, insurance or loan guarantees, etc. are all forms of public support.

Public support can be justified when, and only when, broad and general national interest in a project can be demonstrated, the benefits to the public are clear and substantive, the project has a high priority compared to other needs for public funds, and the support does not create unfairness in allocation of public support among the private sector. Since the test for public support is so complex, it is often decided in the political arena and thus becomes a political decision that may be influenced by public benefit analyses but not totally so.

3. The public acceptance test:

Even if public support is not sought for a project, the possibility of opposition from various sectors is always a concern and there is a need to foster public acceptance. The fact that the ocean is public space and the resources are publicly owned creates the basic need for public acceptance in almost every new proposal for both extractive and non-extractive use of the ocean. Possibly the most important test of public acceptance for ocean use today is the test of whether environmental harm or degradation might be expected from a project. Environmental opposition to certain ocean developments is well known. If a project can be shown to have environmental benefits, support form environmental advocates may be expected. Another example of the need for public acceptance in ocean developments is in the area of competing ocean uses and the need to allocate exclusive or shared use of certain space. As in the case with public support, public acceptance also often is decided in the political arena.

4. The political support test:

The need for political support for a new development can be on a number of levels. Minimal political support may be necessary for a project that is strictly a commercial enterprise and that easily meets the public acceptance test. However, if either public support is necessary to make it viable, or, if public acceptance must be won to prevent opposition, then political support may be necessary. The first test of political support is whether both understandable public benefits can be projected and whether clear public needs can be demonstrated. To gain political support usually requires a wide and strong constituent base. Some projects naturally fit into an existing political constituency while others may be so unique in concept that a new constituency must be developed. Whether an existing government agency structure can accommodate a new project is usually a good indication of whether an existing political constituency is available. Another test is whether a formal regulatory system and approval process is available for a new project. Political support can usually be developed for a good idea, but often at a considerable cost in time and effort.

The above discussion may help to establish a context for considering the normal development process as well as the possibility of a process that would use some innovative structure that is the subject of this workshop.

Any development process can be characterized through a series of logical phases such as:

1. The Conceptual Phase
2. Planning and Evaluation
3. Testing and Demonstration
4. Engineering Design and Costing
5. Financing
6. Construction and Installation
7. Operation

The conceptual phase may be long or short depending on whether the project evolves from basic or applied research or whether it is more of a commercial idea that makes use of existing technologies and knowledge. A concept, however, is an idea that needs to be developed and tested. It could be a solution to a general problem that makes use of ocean space and technology, such as the use of offshore platforms for waste disposal, or it could be the harvesting of a resource that has either just been discovered or whose value has recently increased, such as the mining of alluvial gold deposits.

The planning and evaluation phase includes making some preliminary estimates about the viability of a proposed project. In this phase, some ideas about technical and financial feasibility must be developed. Some decisions must be made about needs for public and private support, for public acceptance and for political support. Plans must be made for needed testing and demonstration. Organizational structures for making the process work must be set in place. This is the phase where innovative structures can begin to be helpful and is probably the phase that this workshop should give most attention to.

A testing and demonstration phase may be needed if the project utilizes new technology or existing technology under new settings or conditions. This phase will be used to prove technical and/or economic feasibility if it is subject to question or uncertainty. Sometimes this testing phase may overlap the planning phase or cause further plans and evaluations to be made especially if the tests turn up new information.

The final four phases--engineering design, financing, construction, operation--are fairly standard in any commercial development and are only noted here to show that this aspect requires the major investment of time, money, and talent. Here is where the key technical and financial decisions are made but can only be made if the earlier phases produce positive results.

Constraints to development can affect the process during any of the above phases, but the key notion of this workshop review is that constraints can and should be defined in the early phases--most likely in the planning and evaluation phase. If an organizational structure can deal with constraints at this phase, then the following phases can build on both a good commercial support base and a sound public support and acceptance base.

CONSIDERATION OF CONSTRAINTS

This section will discuss the four categories of constraints--environmental, economic, social and political. In the discussion, the key questions about each will be addressed.

Environmental Constraints

Environmental constraints may introduce a high degree of uncertainty into the development process because questions about environmental impacts can require much more data to answer than is ever generally available. Therefore, agreements about environmental constraints tend to stress a thorough and careful process of evaluation rather than absolute answers about specific impacts. This does not mean that specific impacts are not addressed when they can be and much time and effort can be devoted to investigations of primary and secondary impacts for any proposed ocean development project.

For environmental constraints, process is important and a detailed process for evaluating impacts is in common use. Because of the prescribed process under the National Environmental Policy Act (NEPA), disclosure of a project's details during early stages of design and planning is important. It is also important to provide for as much environmental data as possible--both baseline data and data on effects of any changes to the environment. Because of the complex nature of investigating environmental impacts, permitting any new venture may be both costly and time-consuming, even if little environmental harm can be proven.

Among the key questions about new ventures that need attention under environmental constraints are:

1. What numbers and types of facilities are contemplated? How are their designs different from or similar to existing facilities? What is the scale of start-up operations and how will it grow in the future?

2. What types of processes and materials will be used? How extensive will the construction efforts be? What input materials and quantities will the processes require?

3. What types and amounts of effluents will be generated? How will effluents be handled--both from primary and support facilities?

4. How and where will the facilities be located? What siting criteria will be established? What is known and not known about the existing environment at proposed sites?

5. Has the concept been developed far enough to make accurate estimates about environmental impacts, and if not, when in the development process will such data become available?

6. If impacts can be estimated, what are the primary effects, secondary effects, and chronic effects to be expected? What mitigating measures may be used?

7. What alternatives to the proposed project could be followed and how would these alternatives (comparatively) affect the environment?

Naturally, the above questions are neither exhaustive nor always equal in importance, but they do serve to illustrate the general nature of investigating environmental constraints. During the development process, environmental reviews are necessary in the form of requirements for impact statements, permits, and other procedures to prove compliance with applicable laws and regulations. If a project is not too different, it will be a simple matter to plan for and comply with these regulations. If changes in environmental regulation is sought, however, a long and tedious process may be anticipated.

Economic Constraints

The standard commercial tests for economic viability of a new venture--adequate return on investment and low risk--have been mentioned above. If a new project is in an early stage of development, sources of funding are usually limited to either venture capital or the government. Therefore, economic constraints are really related to the degree of proof of financial viability or the soundness of the case that can be made for government support or both.

In the 1990's, substantial constraints to funding by the government for any new project will probably continue because of the limits on budgetary growth. Justification for government support for new developments has also shifted during the Reagan administration and will probably continue. For example, there has been some growth in budgets for basic research programs but funding for demonstration projects has been mostly eliminated. The theory is that demonstration projects should be supported by private industry, and, if private industry cannot justify support, it should not be funded. This notion of the proper role of government vs. private industry will make it very difficult to gain any substantial support from the Federal government for any development which is beyond the early planning and evaluation stage.

Constraints to development from the standpoint of commercial investment viability are clear and direct. Business investment requires proof of adequate markets, good cost data, proof of technical feasibility and minimal risk of failure or outages. Estimates of risk always require a degree of judgement, however, higher risks will always require a higher commensurate return.

Social Constraints

Social constraints to development are both difficult to quantify and to evaluate. In general, these considerations have to do with impacts of development on employment, local communities, States or regions as well as secondary effects on lifestyles, attitudes, safety, and well being. Job opportunities that may come from certain developments are always a major concern. Job impacts may be seen as a constraint when a development would reduce jobs absolutely or just in one sector or region in favor of another. Impacts on local communities could include the need for new or added infrastructure to support a development. Aesthetic impacts from developments can also be a local concern. Worker health and safety is generally covered by regulation but could be a concern for certain ocean projects.

The methods used to evaluate social constraints are not formalized to the extent that environmental and economic factors are. Therefore, it may be more of an uncertainty than a strong deterrent to development.

Political Constraints

Political constraints are most significant either if a project has a significant level of opposition or if it requires significant political support to make it happen. Opposition could be in the form of concern for environmental impacts or because of competing uses for the space. By establishing a development process that considers potential opposition and then works to make modifications that minimize the impacts, this constraint can diminish.

The major political question for a new project is whether there is an organized and recognized constituency that would support a development. If the constituency has both a significant power base and a history of getting its message to the government policy-makers, then the politics are straightforward. It is important to know where decisions are made in specific government agencies and how they are made. If project approvals follow standard procedures, they may only need expediting. If new procedures must be considered, then much more time is involved. In this case political constraints are involved not because of opposition but because of the inherent difficulty of making changes in a large, slow moving bureaucracy.

If it is necessary to build a political constituency to influence policy-making in support of a new project, then significant effort will be necessary. The key to success for such an effort is a clear and convincing message that can bring wide support.

EXAMPLES OF OCEAN DEVELOPMENTS AND RELATED CONSTRAINTS

It may be constructive to review some specific examples of new ocean projects or enterprises and the constraints that may affect their development. The Office of Technology Assessment has conducted a number of such analyses covering topics such as offshore oil and gas development, fisheries, shipping and shipbuilding, and other more traditional ocean businesses as well as some of the more speculative ventures. Since this workshop is focused on the future of newer developments, this paper will review three ventures that have been the subject of OTA assessments and are also close to the category of emerging technologies or speculative ventures. These are Ocean Thermal Energy Conversion (OTEC), Marine Minerals Development in the EEZ, and Ocean Incineration. The following will highlight OTA's findings about the constraints for these ventures. For more detail about OTA's assessments, please see the full reports listed in the references to this paper.

OTEC

In general, the constraints to OTEC development center around economic questions. While Federal funding for OTEC development totaled over $200 million during 1975-85, commercialization of this technology has yet to be seriously considered within the major industries that may be users. At the same time, Federal funding for OTEC has been reduced to very low levels because of many factors that have diminished economic justification for government support. Environmental and social constraints to OTEC development have not been a major factor. Political constraints have, however, been a factor inhibiting Federal support for OTEC in recent years, as compared to the late 1970's because of an overall change in public policy toward the notion that the private sector should be responsible for developing most new energy technologies beyond the stage of initial research.

The economic potential of a future OTEC plant has been the subject of many studies. In general, both the high first cost and the risks of cost growth have been a significant deterrent to commercial investment. Past proposals for commercial power generation have usually assumed rising future energy costs. In fact, the trend of rising energy costs during the early 1980's has reversed itself in recent years. It is now very difficult to predict when conventional energy costs will begin to rise again. This situation has affected the competitive position of many other renewable energy systems as well.

Even though a significant amount of design work and several component tests on OTEC systems were accomplished over the past 10 years or more, a complete pilot plant that could demonstrate acceptable risks for a commercial operator was never built. Since OTEC requires a large capacity and high capital expenditures for efficient operation, industry is reluctant to invest without a convincing demonstration of technical and economic feasibility with reasonable certainty.

In general, the cost of OTEC-produced electrical power is significantly higher than conventional sources, except, perhaps, on small tropical islands. In this case, conventional power is very expensive, but the market is also too small to justify large research and demonstration expenditures that would be necessary for an OTEC project.

It may be that OTEC will not prove economically feasible in the commercial world for many years. In that case, and because it may have other benefits as a future energy source, it could be a candidate for government support and, as stated above, it did, at one time, enjoy substantial government backing. In the 1970's, OTEC was promoted by some of the ocean community as well as some of the solar energy lobby. Funding by the U.S. Department of Energy was on the rise for many types of alternative energy technologies. During the 1980's, however, budgets for all such projects were curtailed and those that required major funding for large demonstration plants were affected most. The Reagan Administration supported the notion that the private sector in energy development is better able to evaluate risks and choose the best new systems for support than is the Federal government. Under this theory, the government should support only the research phase of new technologies. For OTEC, this meant the end of significant government support and no inclination by industry to continue any development effort.

Environmental and social constraints to OTEC development were never much of a factor but they have been investigated. OTEC is considered to offer a number of overall environmental benefits as a renewable energy source with few undesirable emissions. Environmental concerns with OTEC have mostly to do with possible very large scale operations making some changes to ocean temperature patterns.

Political support for OTEC was significant during the energy crisis and when Federal money for energy projects was increasing. When the budget deficit replaced the energy crisis as front page news, the OTEC political base diminished. OTEC is now mostly a dormant venture. It is a good example of the effect of economic constraints and a changing political climate. At present, there is very little justification for expanded government funding for OTEC. The modest research work underway will probably continue and add valuable data to the knowledge base that can be used if and when viable commercial enterprise emerges.

Marine Minerals Development in the EEZ

In 1987 the Office of Technology Assessment completed a study of the potential for developing mineral resources in the United States Exclusive Economic Zone (EEZ). The study examined current knowledge about the hard mineral resources, reviewed the economic and security potential of seabed resources, evaluated the technologies for exploration and recovery, and identified key issues and options. While only a very small portion of the EEZ has been explored for minerals to date, the commercial prospects for developing most marine minerals within the EEZ appear to be remote for the foreseeable future. The exceptions to this statement are mainly such minerals as sand and gravel, and some precious metal placer deposits.

There is no currently operational domestic seabed mining industry per se, although some international mining consortia have a continuing interest in certain U.S. EEZ prospects. Sand is being mined off the U.S. east coast and a gold mining dredge has been operating in Alaskan state waters for the past few years. Other commercial ocean mining interest has been sporadic because of economic risks. The OTA study concluded that some preliminary exploration by Federal agencies and assurances that the government will provide an appropriate administrative framework and economic climate to conduct business offshore, will probably be needed to interest the private sector in future development. At present, neither the support for an exploration program nor the initiation of an adequate Federal administrative system is under serious consideration.

The issues identified in the OTA report included: the need to support and coordinate a national effort to explore and gather knowledge about the vast expanse of the EEZ and possible minerals potential; the need to establish a workable Federal system to encourage development and grant access to the private sector to further explore and develop seabed minerals; the need to improve the use of the nation's EEZ data and information; the need to provide for some access and use of classified EEZ data; and the need for assistance to the States in preparing administrative systems for future seabed mining.

From the above, it can be seen that economic constraints are the most significant barrier to developing whatever hard mineral resources that have been identified in the EEZ. When mineral deposits have been located, the economic potential has not been favorable when compared to alternative sources of supply for most mineral commodities. To be competitive, marine minerals probably must either prove to exist in large, high-quality deposits and/or be cheaper to mine and process than their onshore counterparts. Given our present state of knowledge, neither seems to be the case, and pure private investment in seabed minerals development is not favorable.

As in the case of OTEC, there may be future national benefits to be gained by encouraging seabed minerals exploration and development in the EEZ, but no political consensus has evolved to push for public support for these kind of ventures. Consequently, no justification for public support other than for basic research has been put forward.

While no significant social constraints appear to inhibit EEZ minerals development, some attention has been given to possible environmental constraints. Environmental concerns have been identified in the case of sand and other alluvial mining in shallow water because the process is closely related to both harbor and offshore dredging operations that have been practiced for some time. However, little direct experience exists to estimate the potential for environmental damage from long-term and extensive ocean mining operations. Anticipating and avoiding high-risk, sensitive areas and minimizing damage through equipment design appear to be some of the approaches that would be useful to adopt. A considerable amount of environmental baseline data has already been collected in parts of the EEZ and could be used in future planning of offshore mining operations if it were available in a useful form to the States and private parties of interest.

It appears that a new structure for ocean enterprises could be established for developing certain new seabed minerals projects in a way that would address many of the above constraints. Such a project would probably be one where an economically viable operation was clearly possible with only minimal government support and the other constraints to development were reasonably easy to identify and quantify.

Ocean Incineration

The Office of Technology Assessment completed a comprehensive examination of ocean incineration technology with a report in 1986. That assessment addressed the burning of hazardous wastes at sea and included consideration of the adequacy of regulations, risks to human health and the environment, existing and emerging alternatives, the capabilities and limitations of ocean incineration, and how its use may affect efforts to develop superior waste treatment and reduction practices. Ocean incineration of hazardous wastes was and is now vigorously opposed by some environmental groups and other public interest organizations with both public health and environmental concerns. Such concerns, or constraints, led to a stalemate in the development of this technology and it is not clear if and when the debate will be resolved and ocean incineration will be permitted.

The hazardous wastes under consideration for disposal by burning at sea are, of course, very different than the nonhazardous waste products under consideration for processing and disposal at sea within some newer ventures proposed. However, some of the same types of concerns and constraints may be raised.

Environmental constraints to development, when coupled with human health concerns, are in the forefront of inhibiting ocean incineration projects. While some parties consider ocean incineration either an interim option for managing certain hazardous wastes or one of a number of available options, opponents have mostly stressed the direct risks posed by ocean incineration proposals. Since these projects required permitting before they could operate, the best way to stop them was to curtail the permitting process. OTA's report concluded that, even though ocean incineration appeared to be a lower risk disposal method than some currently used practices, to ensure that the shift toward the use of better practices is not impeded, any program for ocean incineration should be regarded as interim. Because of an unclear overall waste management strategy, the role of ocean incineration was even more unclear.

Environmental constraints and public health concerns led to both economic and social constraints. The economic viability of an ocean incineration venture could be shown if operating under a regulatory framework that was clear, certain and not unreasonable. The uncertainty of permitting and regulatory standards made commercial financial planning impossible. Public concerns about the social impact of ocean incineration were many and varied. These included concerns about both land and sea transportation, the consequences of accidents and spills, the liability of ocean incinerators, enforcement of regulations and public access to information about the future operations.

The debate about whether or not to permit ocean incineration operations thus became a political constraint to move forward on the project. While the industry put forth what it considered clear and convincing arguments favoring the venture, they did not diminish the opposition which had a significant political support base. Future ocean waste disposal projects must find a better approach toward addressing such powerful constraints to development.

CONCLUSIONS

This paper has discussed constraints to development of ocean enterprises first through identifying the process and defining the nature of constraints that are usually present, and then, by giving some examples of past development ventures and how they were affected by these constraints. No one best approach can be advocated, but, by examining the principles and past history perhaps a future development process can anticipate the constraints and factor them in. Many successful ocean enterprises can offer useful guidance to new proposed projects as well. These are mostly in the category of traditional ocean industries and any new enterprise structure may be well advised to take some lessons from this sector also.

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OCEAN ENTERPRISES IN THE 1990'S: TECHNICAL AND ENGINEERING CONSTRAINTS TO DEVELOPMENT

by
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PROJECT DEVELOPMENT AND THE DESIGNER

There is an old saying that all designers take as an axiom: "Form follows function." Especially in today's world where designers must be sensitive to economics, an extension to the old saying might be: "Cost follows form." This then leads directly to a global economic test of project viability: Benefits flowing from the project function must be sufficient to recover life cycle costs and yield a satisfactory return on investment.

As pointed out in a companion paper by Peter Johnson (1988), the economic test is only one of several that must be applied during today's project development process. Other tests would involve environmental, social, political, and legal constraints. From the very start, all of these constraints will come to bear in varying degrees, depending on the individual project. The designer must have the flexibility to adjust the form of his solution throughout the development process such that all constraints and tests can be satisfied.

Johnson expresses the project development process as a sequence of phases suggested in Figure 1. The challenge to the designer is to produce solutions that satisfy all the key constraints at each phase. One must recognize that the key constraints may, and probably will, change both in time and space. For example, economics may not be critical at the concept definition phase, but they can be a showstopper at the financing phase. Further, the whole investment climate may change in the time it takes to go from concept definition to financing. This happened to OTEC during the oil boom-bust of the 1970's and 1980's. Even though a commercial scale OTEC has yet to become a reality, its designers have continued to cycle the early phases and broaden the concept definition to include applications to fresh water production and mariculture.

OTEC is a classic example of a project development opportunity caught in the "No Man's Land" of the "Turner Curve" of Figure 2. In the prevailing climate of political thought noted by Johnson, public sector funding agencies consider that sufficient research has been done to move to commercial development. However, private sector investors remain unable to justify the perceived risks to investment against the prospective economic payoff. Research funds continue to flow at a moderate rate, and designers continue to hone the concept towards a day when commercial development can be justified.

CONSTRAINTS AS TECHNICAL DRIVERS

By nature, most designers love to get their teeth into the meat of a good technical problem. The challenge of OTEC, as an example, is quite straightforward. Make the economics work. Setting aside any adjustments for investment risk or tax considerations, the economics can be viewed at the extremes as being either revenue driven or cost driven. As a pure energy play, OTEC is cost driven. Even though the ocean is home to vast amounts of environmentally desirable, non-polluting energy, that energy is rather diffuse.

The cost of hardware to extract that energy is presently seen as being too high relative to the market value of the energy actually extracted. Work continues to improve and demonstrate cost-effectiveness of the hardware, and also to extract maximum economic benefit from the cold water resource.

Occasionally projects come along that are revenue driven. Such projects promise very attractive returns on investment, provided that the enabling technologies can be made available. This happened in the North Sea during the oil boom years of the 1970's. At the apogee in the 1979-80 time frame when $100 a barrel oil price projections were voiced in the land, selected projects such as the Conoco Hutton Tension Leg Platform and the Exxon Lena Guyed Tower Platform were consciously authorized as technology development vehicles. Even though lower-cost platform design solutions were available, long-term focus was on developing and demonstrating deepwater technology on a commercial scale. Few such projects are in prospect today.

Certain lessons drawn from offshore platform design experience can provide insights into the technical drivers posed by economic constraints. Cost estimates for offshore platforms are commonly built up through an extended calculation that involves the construction materials selected, the unit costs of those materials and the gross quantities of materials required. Materials selection will be strongly influenced by the available technology base. For example, there is an historically well-developed steel industry in the United Kingdom, and that infrastructure was readily adapted by the British to construct steel offshore platforms in the North Sea. Prior to oil development in their sector of the North Sea, the Norwegians had developed specialized concrete technologies. They adapted their skills in slip-forming techniques to construction of concrete offshore platforms. Inasmuch as jobs and political constituencies are coupled into the technology base, economic and political constraints associated with alternative materials are comparable within acceptable limits.

Offshore platform experience says that simple geometric size poses a driving influence on construction cost. Once size is set, the laws of physics take over and determine the quantities of materials required. Several factors can contribute to size, but among the most important are the space and load-carrying requirements associated with the function of topsides facilities. Some of the first offshore platforms in the Gulf of Mexico were extraordinarily expensive because they required very large deck areas to accommodate land drilling rigs. As oil and gas facilities designers were able to modularize drilling and production equipment into reasonably compact packages, deck sizes came down and corresponding reductions in platform construction costs were achieved.

In this sense, present day discussions of Airfields at Sea can be viewed as a throwback to the days of land drilling rigs on offshore platforms. To achieve economically justifiable solutions, designers from both the aerospace and the offshore communities will have to come together and re-examine functional requirements from first principles. Marine structural designers can probably accommodate runway, taxiway and terminal functions in a space-efficient and novel manner. However, this may require aircraft designers to improve take-off and landing distances and to incorporate design features that recognize the rigors of the marine environment. The problem is workable in principle, but it will require cross-disciplinary interaction among communities that may not have worked together previously.

Airfields at Sea can further be generalized into a set of industrial-strength activities that are typically viewed as "noxious" by their neighbors. Such activities can be ugly and they are capable of emitting things such as noise, chemical substances and traffic, to name a few. Examples under current discussion would include municipal waste treatment facilities and power plants. In densely populated coastal communities, new capacity additions are candidates for location in offshore waters. Each type of facility has a generally well-developed technology base for on-land applications. Innovations to that technology base may be expected through interaction with the offshore design community.

Although moving noxious activities offshore promises to create some welcome "breathing space" between them and their neighbors, facilities designers must be every bit as environmentally sensitive as they would be on land. Recent times have been characterized by conflict among the various constituencies affected by proposed projects, whether onshore or offshore. These constituencies include private enterprise groups, public interest groups, and governmental entities. One proposed contributing factor to this conflict is a lack of trust among the various groups. The phenomenon of trust is discussed in detail by Bella et al (1988). They suggest a need for organizational and decision-making processes that all groups can accept. Inasmuch as ocean enterprise projects covered by this discussion will be located on "wet" territory that is by its nature public property, there is an opportunity to start with an organizational "clean sheet of paper." Designers will be among the key participants in the decision-making process.

The challenge then posed to designers is that they must grow beyond the pure self-indulgence of getting caught up in technology for its own sake. In the words of Wilson (1988), "they must become much more effective at understanding what society wants and what it can use in a broad context....The new social constraints may be imprecise and fuzzy, but they are just as real as the technological constraints engineers are used to. If we as engineers don't listen to and develop an understanding of society's concerns and then address them in creative ways, we'll find ourselves prevented from exploring and using technology."

CONCLUSIONS

The technology base for various proposed ocean enterprise projects generally exists in discrete form within sectors of the technical community. Further innovations and enhancements will likely ensue as these sectors interact with one another. The greatest challenge to designers will be to function effectively in organizational settings and decision-making processes where they are drawn into the fuzzy world of social and political constraints.

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Figure 1
PROJECT DEVELOPMENT PROCESS

PHASE	CONSTRAINT: Environmental	Economic	Social	Political
CONCEPT DEFINITION				
PLANNING & EVALUATION				
TESTING & DEMONSTRATION				
ENGINEERING DESIGN & COSTING				
FINANCING				
CONSTRUCTION & INSTALLATION				
OPERATION				

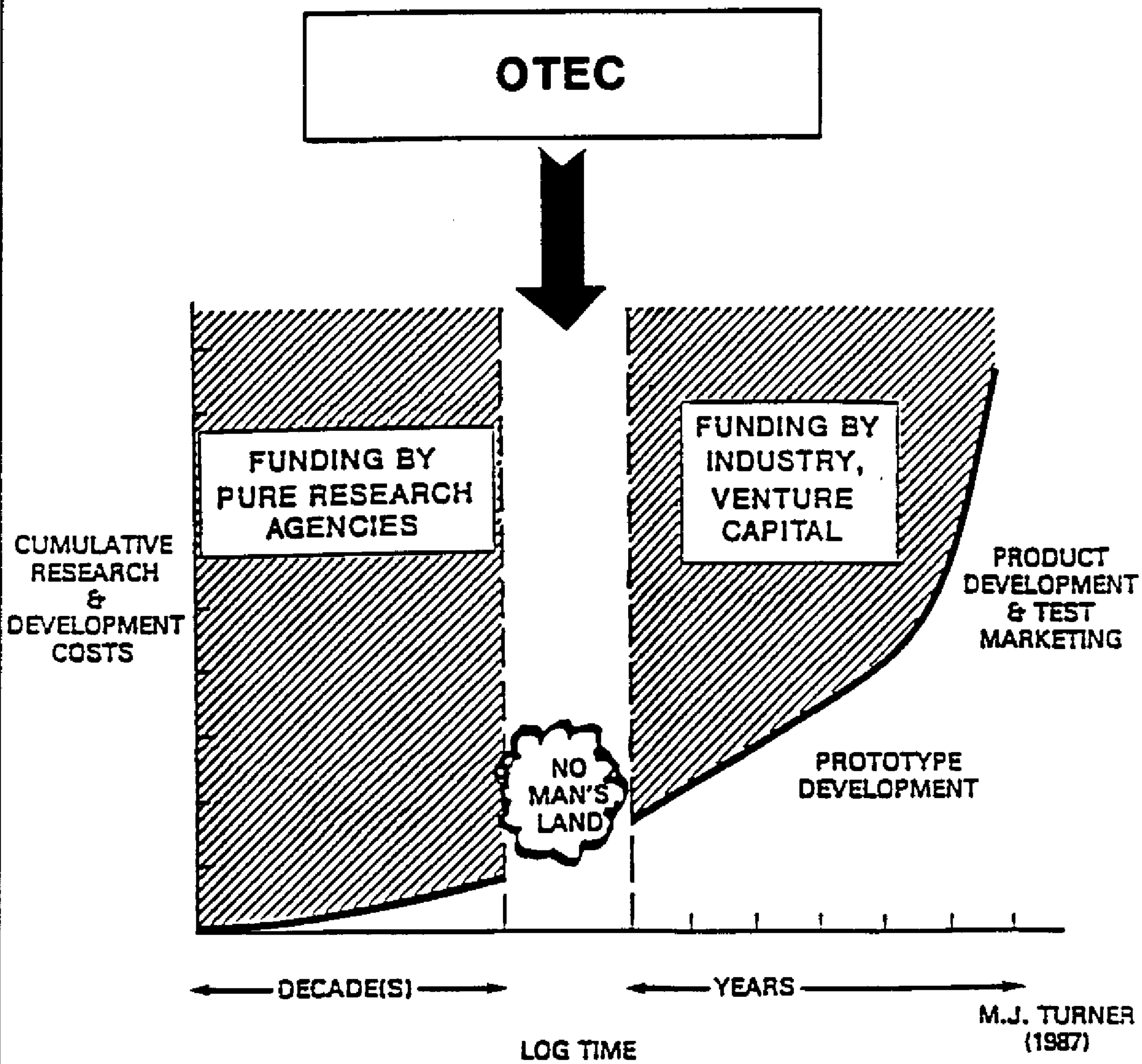

Figure 2
OTEC DEVELOPMENT IN THE CONTEXT OF THE TURNER CURVE